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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 4 DECEMBER 1993 VOLUME 2 OF 4 DRAFT FINAL

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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 4

DOE/EIS - 0195D

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 2 OF 4

DECEMBER 1993

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

DRAFT FINAL

FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 4

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DRAFT FINAL

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5.0 COMPARATIVE ANALYSIS

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5.1 INTRODUCTION

Section 5.0 presents a comparative analysis of the final remedial action alternatives for Operable Unit 4 with respect to the CERCLA evaluation criteria described in Section 4.0. This analysis is the second stage of the detailed evaluation process and provides information which forms the basis for selecting a preferred remedial alternative for Operable Unit 4. The Proposed Plan, which is issued concurrently with this FS-EIS, will identify DOE's preference for an Operable Unit 4 remedial action alternative and will solicit public comments as part of the modifying criteria evaluation used to document the selection of the final remedial alternative in the ROD. For this analysis, the evaluation criteria include two categories, threshold and primary balancing. More information concerning the evaluation criteria can be found in Section 4.1.2, Overview of the Detailed Analysis. The modifying criteria of state and community acceptance will not be addressed in this comparative analysis. Because formal state and community comments will not be received until after the FS/PP-EIS has been issued for public review, these two modifying criteria will be addressed in the responsiveness summary and ROD that will be prepared following the public comment period.

The threshold category contains the two criteria that must be satisfied by the selected alternative:

- Overall protection of human health and the environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

These criteria are of greatest importance in the comparative analysis because they reflect the key statutory mandates of CERCLA, as amended. If an alternative does not satisfy both of these criteria, it cannot be carried forward to the primary balancing category and is not eligible to be selected as the final remedy.

The primary balancing category contains the five criteria under which the relative advantages and disadvantages of the alternatives are compared to determine the most appropriate remedy:

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

The first and second criteria address the statutory preference for treatment as a principal element of the remedy and the bias against off-site land disposal of untreated material. Together with the third and fourth criteria, they form the basis for determining the general feasibility of each potential remedy and determining whether costs are proportional to the overall effectiveness, considering both the cleanup period and the time following cleanup. By this means, it can be determined whether a potential remedy is cost effective.

Consistent with the format of the detailed analysis of alternatives in Section 4.0, a comparative analysis under the threshold and primary balancing criteria for Subunits A, B, and C is presented in Sections 5.2, 5.3, and 5.4, respectively. Tables 5-1 through 5-3 summarize the comparative analysis for each subunit. Table 5-4 presents a comparison of the environmental impacts associated with each alternative. Table 5-5 summarizes the long-term and short-term radiological incremental lifetime cancer risks estimated for each alternative. Short-term risks are provided to assess the potential impacts to the public and remedial action workers during implementation of the alternative. The basis for determining the risks are detailed in Appendix D. The results of the comparative analysis are summarized in Appendix G.

The preferred alternative for Operable Unit 4 to be described in the Proposed Plan is assembled by combining the preferred alternatives selected from each of Subunits A, B, and C. This comparative analysis provides the basis for the selection.

5.2 SUBUNIT A

Subunit A alternatives compared include:

- Alternative 0A - No Action
- Alternative 2A - Removal, Stabilization (Cem/Vit), On-Property Disposal
- Alternative 3A.1 - Removal, Stabilization (Cem/Vit), Off-Site Disposal at NTS

A summary of the Subunit A comparative analysis results is presented in Table 5-1.

5.2.1 Threshold Criteria

TABLE 5-1

SUBUNIT A - COMPARATIVE ANALYSIS

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present Worth Cost
0A - No Action	Not protective	Does not meet all ARARs	Not effective or permanent	No treatment	High	Reliable Technology Easy	-0-
2A/Vit - Removal, Vitrification, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces toxicity, mobility, and volume	Medium	Innovative Technology Moderately Difficult	$43.6M
2A/Cem - Removal, Cement Stabilization, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduction of mobility	Medium	Reliable Technology Easy	$74.0M
3A.1/Vit - Removal, Vitrification, Off-Site Disposal - Nevada Test Site	Protective	Complies with all ARARs	Effective and most reliable	Reduces toxicity, mobility, and volume	Medium	Innovative Technology Moderately Difficult	$43.5M
3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - Nevada Test Site	Protective	Complies with all ARARs	Effective and most reliable	Reduces mobility	Medium	Reliable Technology Difficult	$71.4M

[1]Assessment of protectiveness adopts the use of continued federal government ownership and evaluates risk to the off-property farmer.
[2]Assumes substantive technical requirements for the State of Ohio disposal facility siting are met.

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TABLE 5-2

SUBUNIT B - COMPARATIVE ANALYSIS

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present Worth Cost
0B - No-Action	Not protective	Does not meet all ARARs	Not effective or permanent	No treatment	High	Reliable Technology Easy	-0-
2B/Vit - Removal, Vitrification, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces toxicity, mobility, and volume	Medium	Innovative Technology Moderately Difficult	$28.0M
2B/Cem - Removal, Cement Stabilization, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces mobility	Medium	Reliable Technology Easy	$37.4M
3B.1/Vit - Removal, Vitrification, Off-Site Disposal - NTS	Protective	Complies with all ARARs	Effective and most reliable	Reduces toxicity, mobility, and volume	Medium	Innovative Technology Moderately Difficult	$27.9M
3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - NTS	Protective	Complies with all ARARs	Effective and most reliable	Reduces mobility	Medium	Reliable Technology Difficult	$35.4M
4B - Removal, On-Property Disposal	Protective	Complies with all ARARs[2]	Effective but least reliable	No treatment	Medium	Reliable Technology Easy	$22M

[1]Assessment of protectiveness adopts the use of continued federal government ownership and evaluates risk to recreational users and the off-property farmer.
[2]Assumes substantive technical requirements for the State of Ohio disposal facility siting are met.

TABLE 5-3

SUBUNIT C - COMPARATIVE ANALYSIS

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence Through Treatment	Reduction of Toxicity, Mobility, or Volume	Short-Term Effectiveness	Implementability	Present Worth Cost
0C - No-Action	Not protective	Does not meet all ARARs	Not effective or permanent	No treatment	High	Reliable Technology Easy	-0-
2C - Demolition, Removal, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and most reliable	No treatment	High	Reliable Technology Easy	$34.3M
3C.1 - Demolition, Removal, Off-Site Disposal - NTS	Protective	Complies with all ARARs	Effective and most reliable	No treatment	Medium	Reliable Technology Moderately Difficult	$68.9M
3C.2 - Demolition, Removal, Off-Site Disposal - Permitted Commercial Disposal Site	Protective	Complies with all ARARs	Effective and most reliable	No treatment	Medium	Reliable Technology Moderately Difficult	$44M

[1]Assessment of protectiveness adopts the use of continued federal government ownership and evaluates the risk to the off-property farmer.
[2]Assumes substantive technical requirements for the State of Ohio disposal facility siting are met.

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TABLE 5-4

SUMMARY OF ENVIRONMENTAL IMPACTS FOR REMEDIAL ALTERNATIVES

ALTERNATIVE	SOIL AND GEOLOGY[1]	WATER QUALITY AND HYDROLOGY	AIR QUALITY	BIOTIC RESOURCES	WETLANDS AND FLOODPLAINS	SOCIOECONOMICS AND LAND USE	CULTURAL RESOURCES	TRANSPORT IMPACTS
SUBUNIT A								
0A	No Impacts	Potential release to surface and groundwater	Potential release to ambient air	Potential exposure to ecological receptors	Potential release to 0.32 ha of wetlands	• Restriction of site's future use • No impact on energy resources	No impacts	No impacts
2A/Vit	4.3 ha temporarily disturbed 2.8 ha committed to disposal	Minor impacts assuming monitoring and controls wastewater recycled	Fugitive dust emissions Minor impacts assuming controls (e.g., HEPA)	4.3 ha disturbed 2.8 ha terrestrial habitat lost	5.0 ha forested wetlands lost	• Up to 5.0% increase in CMSA revenue • Restricted site use • 18,521,530 KWHR used	No impact due to identification of management	Fugitive dust due to on-property movement
3A/Vit	1.5 ha temporarily disturbed Approximately 5.0 ha committed at NTS	Minor impacts due to geology at NTS Wastewater recycled	Fugitive dust emissions Minor impacts assuming controls (e.g., HEPA)	3.2 ha disturbed Minor impacts at NTS	No impacts	• Up to 5.0% increase in CMSA revenue • 18,521,530 KWHR used	No impact due to identification and management	ILCR of 8.3×10^{-10} along route to NTS
2A/Cem	5.8 ha temporarily disturbed 4.3 ha committed to disposal	Minor impacts assuming monitoring and controls	Minor impacts assuming monitoring and controls	5.8 ha disturbed 4.3 ha committed	6.0 ha forested wetlands lost	• Up to 5.0% increase in CMSA revenue • Restricted site use • 11,575,780 KWHR used	• Up to 5.0% increase in CMSA revenue • Restricted site use • 11,575,780 KWHR used	Fugitive dust due to on-property movement

See footnote at end of table.

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TABLE 5-4
(Continued)

ALTERNATIVE	SOIL AND GEOLOGY[1]	WATER QUALITY AND HYDROLOGY	AIR QUALITY	BIOTIC RESOURCES	WETLANDS AND FLOODPLAINS	SOCIOECONOMICS AND LAND USE	CULTURAL RESOURCES	TRANSPORT IMPACTS
3A/Cem	1.5 ha temporarily disturbed Approximately 5.0 ha committed at NTS	Minor impacts due to geology at NTS	Minor impacts due to geology at NTS	5.8 ha disturbed Minor impacts at NTS	No impacts	• Up to 5.0% increase in CMSA revenue • 11,575,780 KWHR used	Up to 5.0% increase in CMSA revenue • 11,575,780 KWHR used	ILCR of 4.3×10^{-10} along route to NTS

See footnote at end of table.

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TABLE 5-4
(Continued)

ALTERNATIVE	SOIL AND GEOLOGY[1]	WATER QUALITY AND HYDROLOGY	AIR QUALITY	-BIOTIC RESOURCES	WETLANDS AND FLOODPLAINS	SOCIOECONOMICS AND LAND USE	CULTURAL RESOURCES	TRANSPORT IMPACTS
SUBUNIT B								
0B	No impacts	Potential release to surface and groundwater	Potential release to ambient air	Potential exposure to ecological receptors	Potential release to 0.32 ha of wetlands	• Restriction of site's future use • No impact on energy resources	No impacts	No impacts
2B/Vit	3.9 ha temporarily disturbed 2.4 ha committed to disposal	Minor impacts assuming monitoring and controls Wastewater recycled	Fugitive dust Minor impacts assuming controls (e.g., HEPA)	3.9 ha disturbed 2.4 ha terrestrial habitat lost	5.0 ha forested wetlands lost	• Up to 4.0% increase in CMSA revenue • Restricted site use • 7,232,243 KWHR used	No impact due to identification and management	Fugitive dust due to on-property movement
3B/Vit	1.5 ha temporarily disturbed Approximately 5.0 ha committed at NTS	Minor impacts due to geology at NTS	Fugitive dust Minor impacts assuming controls (e.g., HEPA)	1.5 ha habitat disturbed Minor impacts at NTS	No impacts	• Up to 4.0% increase in CMSA revenue • 7,232,243 KWHR used	No impact due to identification and management	ILCR of 17×10^{-11} along route to NTS
2B/Cem	4.5 ha temporarily disturbed 3.0 ha committed to disposal	Minor impacts assuming monitoring and controls	Minor impacts assuming monitoring and controls	4.5 ha disturbed 3.0 ha terrestrial habitat lost	6.0 ha forested wetlands lost	• Up to 4.0% increase in CMSA revenue • Restricted site use • 3,858,593 KWHR used	• Up to 4.0% increase in CMSA revenue • Restricted site use • 3,858,593 KWHR used	Fugitive dust due to on-property movement

See footnote at end of table.

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TABLE 5-4
(Continued)

ALTERNATIVE	SOIL AND GEOLOGY[1]	WATER QUALITY AND HYDROLOGY	AIR QUALITY	BIOTIC RESOURCES	WETLANDS AND FLOODPLAINS	SOCIOECONOMICS AND LAND USE	CULTURAL RESOURCES	TRANSPORT IMPACTS
3B/Cem	1.5 ha temporarily disturbed Approximately 5.0 ha committed at NTS	Minor impacts due to geology at NTS	Minor impacts due to geology at NTS	1.5 ha habitat disturbed minor impacts at NTS	No Impacts	• Up to 4.0% increase in CMSA revenue • 3,858,593 KWHR used	• Up to 4.0% increase in CMSA revenue • 3,858,593 KWHR used	ILCR of 1.9×10^{-11} along route to NTS
4B	4.3 ha temporarily disturbed 2.8 ha committed to disposal	Minor impacts assuming monitoring and controls	Fugitive dust	4.3 ha disturbed 2.8 ha terrestrial habitat lost	6.0 ha forested wetlands lost	• Up to 4.0% increase in CMSA • Restricted site use • Minimal energy impacts	• Up to 4.0% increase in CMSA • Restricted site use • Minimal energy impacts	Fugitive dust due to on-property movement

See footnote at end of table.

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TABLE 5-4
(Continued)

ALTERNATIVE	SOIL AND GEOLOGY[1]	WATER QUALITY AND HYDROLOGY	AIR QUALITY	BIOTIC RESOURCES	WETLANDS AND FLOODPLAINS	SOCIOECONOMICS AND LAND USE	CULTURAL RESOURCES	TRANSPORT IMPACTS
SUBUNIT C								
0C	No impacts	Potential runoff to surface water	Potential for airborne contamination	Potential exposure to ecological resources	Potential runoff to 0.32 ha of wetlands	Restriction of site's future use Restricted site use No energy impacts	No impacts.	No impacts
2C	5.7 ha temporarily disturbed 4.7 ha committed to disposal at FEMP	Minor impacts assuming monitoring and controls	Fugitive dust Minor impacts assuming controls	4.7 ha terrestrial habitat lost	0.20 ha drainage ditch wetlands lost	Up to 4.0% increase in CMSA revenue Minimal energy impacts	No impact due to identification and proper management if required	Fugitive dust due to on-property movement
3C.1	1.0 ha temporarily disturbed Approximately 5.0 ha committed at NTS	Minor impacts due to geology at NTS	Fugitive dust Minor impacts assuming controls	Minor impacts at NTS	No impacts	Up to 4.0% increase in CMS revenue Minimal energy impacts	No impact due to identification and proper management if required	ILCR of 4.8×10^{-12} along route to NTS
3C.2	1.0 ha temporarily disturbed Approximately 5.0 ha committed at off-site permitted commercial disposal site	Minor impacts due to geology at off-site permitted commercial disposal site	Minor impacts at off-site permitted commercial disposal site	Minor impacts at off-site permitted commercial disposal site	No impacts	Up to 4.0% increase in CMSA revenue Minimal energy impacts	No impact due to identification and proper management if required	ILCR of 2.4×10^{-12} along route to off-site permitted commercial disposal site

[1]Commitment of acres is at the FEMP unless indicated otherwise.

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TABLE 5-5

SUMMARY OF LONG-TERM AND SHORT-TERM RADIOLOGICAL INCREMENTAL LIFETIME CANCER RISKS

Alternative	Future Land use w/continued Federal Ownership	Future Land Use w/o Cont. Federal Ownership	Short-term Risks	
	Off-Property Farmer	On-Property Farmer	Public	Worker[a]
SUBUNIT A - SILOS 1 AND 2 CONTENTS				
0A - No Action	1.0×10^{-4}	≈1[c]	N/A	N/A
2A/Vit - Removal, Vitrification, On-Property Disposal	B.S.L.[e]	B.S.L.	3.2×10^{-7}[i]	4.0×10^{-4}
2A/Cem - Removal, Cement Stabilization, On-Property Disposal	B.S.L.	B.S.L.	3.2×10^{-7}[i]	4.0×10^{-4}
3A.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS	N/A[f]	N/A[f]	8.3×10^{-10}	4.0×10^{-4}
3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - at NTS	N/A[f]	N/A[f]	4.3×10^{-10}	4.0×10^{-4}
SUBUNIT B - SILO 3 CONTENTS				
0B - No-Action	1.0×10^{-4}	≈1[c]	N/A	N/A
2B/Vit - Removal, Vitrification, On-Property Disposal	B.S.L.	B.S.L.	3.2×10^{-7}[i]	4.1×10^{-5}
2B/Cem - Removal, Cement Stabilization, On-Property Disposal	B.S.L.	B.S.L.	3.2×10^{-7}[i]	4.1×10^{-5}
3B.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS	N/A[f]	N/A[f]	1.7×10^{-11}	4.1×10^{-5}
3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal at NTS	N/A[f]	N/A[f]	1.9×10^{-11}	4.1×10^{-5}
4B - Removal, On-Property Disposal	B.S.L.	B.S.L.	3.2×10^{-7}[i]	4.5×10^{-6}

See footnote at end of table.

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TABLE 5-5
(Continued)

Alternative	Future Land use w/continued Federal Ownership	Future Land Use w/o Cont. Federal Ownership	Short-term Risks	
	Off-Property Farmer	On-Property Farmer	Public	Worker[a]
SUBUNIT C - SILOS 1, 2, AND 3 STRUCTURES, SOILS AND DEBRIS				
0C - No-Action	1.0×10^{-4}	1×10^{-1}	N/A	N/A
2C - Demolition, Removal, On-Property Disposal	B.S.L.	B.S.L.	3.2×10^{-71}	2.9×10^{-7}
3C.1 - Demolition, Removal, Off-Site Disposal at NTS	N/A[f]	N/A[f]	4.8×10^{-12}	2.9×10^{-7}
3C.2 - Demolition, Removal, Off-Site Disposal at a Permitted Commercial Disposal Site	N/A[f]	N/A[f]	2.4×10^{12}	2.9×10^{-7}

[a]Worker receiving highest risk (worker near the soil/berm excavation activities or remediation worker).
[b]Total radiological ILCR from air and groundwater pathways, assuming the future source term scenario. ILCR includes contributions from Subunits A and B combined.
[c]Total radiological ILCR from groundwater, air, silo contents, and soil exposure pathways, assuming the future source term scenario. ILCR includes contributions from Subunits A and B combined.
[e]Below screening level (10^{-6} excess cancer risk and HICI).
[f]Long-term risk pathways are eliminated because the material is disposed of off property.
[g]Total radiological ILCR from air exposure pathways impacted by Subunit C source term, assuming the current source term scenario.
[h]Long-term risk pathway eliminated by cap depth and institutional actions.
[i]Exposure to public from radon.

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5.2.1.1 Overall Protection of Human Health and the Environment

Assessment of protectiveness for Operable Unit 4 alternatives assumes a reasonable future land use scenario which incorporates passive institutional controls. Under this scenario, the FEMP site is assumed to remain under the ownership of the federal government, precluding such activities as homesteading, farming, and the installation of domestic wells. Three potential receptors examined under this scenario are an off-property farmer, expanded trespasser and trespassing child.

To assess each alternative's long-term effectiveness for maintaining protective levels, a less restrictive future land use scenario was assumed. Under this scenario, the federal government loses control of the FEMP site and the facility is assumed to revert to the primary use of the surrounding land, the family farm. For this scenario, an on- and off-property farmer receptor are examined. Appendix D provides detail on the assumptions used to develop the scenarios and examine risks to the receptors.

Table 5-5 summarizes both the long-term and short-term radiological incremental lifetime cancer risks for each subunit alternative. Short-term risks are provided to assess the potential impacts to the public and remedial action workers during implementation of each alternative.

All of the Subunit A alternatives, except 0A - No Action, would provide overall protection of human health and the environment. All of the action alternatives (2A/Vit, 2A/Cem, 3A.1/Vit, and 3A.1/Cem) would limit exposures to contaminants by removing the sources of contamination, treating the source materials, and placing the treated materials either in an on-property above-grade disposal vault or an off-site facility (NTS) owned by DOE. The basic differences among the action alternatives are the treatment options (vitrification or cement stabilization) and the disposal options (on property or off site).

Both treatment options provide a stabilized material which reduces the potential for contaminant migration. Treatability study results demonstrate that the vitrified residue form would be expected to have greater durability over time, thereby reducing the potential for contaminant migration to human and ecological receptors. Short-term risks to the public and workers associated with the implementation of both treatment options are similar. Vitrification is considered to pose a higher risk to workers because of high operating temperatures and limited field experience.

The off-site disposal location would be the NTS facility, which has been used selectively by DOE for disposal of low-level radioactive waste. The NTS incorporates engineering and institutional controls

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to ensure protectiveness and is located in a climatic, demographic, and hydrogeologic setting which favors minimization of contaminant migration to both human and environmental receptors. In the long-term event of degradation of engineered features or loss of institutional controls, these site characteristics coupled with the treated residue would ensure continued protectiveness.

The on-property disposal option would employ an above-grade disposal vault designed for a life of years with no active maintenance. The vault would prevent exposure to direct radiation and would minimize infiltration of water and subsequent leaching of contaminants from the treated material into the Great Miami Aquifer. The vault design would incorporate an intruder barrier to inhibit purposeful or inadvertent human destruction of its protective features. The FEMP site demographic characteristics, as compared to NTS, would provide a higher probability of purposeful or inadvertent intrusion into the vault. Potential direct radiation doses to the intruder could be significant.

As the result of additives which increase the volume of untreated residue by up to 216 percent, Alternative 2A/Cem would provide more protection from direct radiation than Alternative 2A/Vit in the event of a breach of the intruder barrier. The tradeoff is that the increased waste volume requires a much larger, more costly disposal vault.

Short-term risks to the public and workers are slightly greater for the off-site disposal option due to the increased risks of transportation accidents resulting in injuries or radiation exposure. The greatest short-term risk of this type is associated with Alternative 3A.1/Cem because of the increased volume of treated material requiring transportation off site.

The nature and extent of impacts to biota from implementing Alternatives 2A/Vit and 2A/Cem would be similar. Both alternatives involve site preparation and construction for a processing facility and disposal vault, construction of a hydraulic mining device work platform, removal of the Silos 1 and 2 contents, and stabilization of the contents. Potential environmental impacts associated with implementing Alternatives 2A/Vit and 2A/Cem include the permanent loss of some on-property habitats. Short-term impacts include the temporary loss of habitats at the FEMP site and possible impacts of accidental spills of construction and operational materials. Mitigative measures would be employed to minimize these short-term risks.

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Environmental impacts associated with implementing alternatives 3A.1/Vit and 3A.1/Cem include those identified with alternatives 2A/Vit and 2A/Cem, in addition to potential impacts from transportation to and disposal activities at NTS.

Alternative 0A would not provide adequate overall protection of human health and the environment. Alternative 0A would not eliminate, reduce, or control the migration of contaminants to human and environmental receptors. Based on the results of the Baseline Risk Assessment presented in the RI Report for Operable Unit 4 (DOE 1993c), the no-action alternative would not be adequately protective. Over the long term, risks to human health and the environment would increase with loss of current site access controls.

5.2.1.2 Compliance with ARARs

Except for Alternative 0A - No Action, the attainment of pertinent ARARs under each of the Subunit A alternatives would be comparable. A comprehensive list of potential ARARs is presented in Appendix F. Key requirements are discussed in Section 4.0 within the evaluation of each alternative against this criterion. The following summarizes those evaluations.

Chemical-Specific ARARs

All of the action alternatives (2A/Vit, 2A/Cem, 3A.1/Vit, and 3A.1/Cem) for Subunit A meet the chemical-specific ARARs associated with potential releases to groundwater, air, and surface water. As demonstrated by fate and transport modeling, the Subunit A action alternatives would attain the SDWA concentration-based limits for specific chemicals under 40 CFR § 141.11 et al., and 40 CFR § 264.94. Additionally, dose-based requirements for the protection of potential public receptors using affected groundwaters are defined in DOE Order 5400.5. DOE Order 5400.5 limits the allowable annual effective dose equivalent from exceeding 100 mrem from all pathways, including groundwater, to any member of the public.

Guidance is provided in 40 CFR § 264.94 as to the point of compliance for demonstrating whether the groundwater protection requirements for inorganic and organic contaminants would be attained. 40 CFR § 264.94 requires the disposal vault to meet the concentration-based limits in the uppermost aquifer underlying the waste management area beyond the point of compliance. The uppermost aquifer is the Great Miami Aquifer. One thousand year fate and transport modeling of uranium, the principal groundwater constituent of concern, indicates that the uranium concentration would not exceed the proposed 20 µg/L MCL, defined in 40 CFR § 141, at the point of compliance.

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The most critical chemical-specific ARAR relative to airborne releases for Subunit A materials relates to radon. The maximum permissible surface release rate of radon-222, as specified in National Emissions Standards for Hazardous Air Pollutants (NESHAP), 40 CFR § 61 Subpart Q, is 20 $pCi/m^2/s$, surface averaged. This requirement is supplemented by 40 CFR § 192.02(b), which requires that the concentration of radon-222 in air at or above any location outside the disposal site not increase the annual average by more than 0.5 pCi/L above background. Requirements for other radionuclides are established in 40 CFR § 61 Subpart H and DOE Order 5400.5, Chapter III. Compared to the untreated Subunit A materials, the vitrified waste form is more effective in reducing radon emanation than the cement stabilized form. Engineered barriers and packaging associated with the disposal of treated materials, in either form, would effectively control the radon flux. A radon treatment system would be employed during treatment operations for both Alternative 2A/Vit and 2A/Cem to control radon release over the short term.

Alternative 0A - No Action would not meet 40 CFR § 61 Subpart Q radon flux requirements based on the profected deterioration of Silos 1 and 2. Also, several criteria for the protection of groundwater would not be met. In the event existing access controls were discontinued and a family farm was established on the FEMP site, exposure limits embodied within DOE Order 5400.5 for members of the general public could be exceeded.

Location-Specific ARARs

Alternatives 3A.1/Vit and 3A.1/Cem would comply with all pertinent location-specific ARARs identified for these alternatives. Included would be those associated with the protection of wetlands (10 CFR § 1022 and 40 CFR § 258.12) and endangered species (50 CFR § 200 and § 204) during the on-property treatment of materials. Disposal facility location requirements would not be relevant and appropriate to Alternatives 3A.1/Vit and 3A.1/Cem since they propose off-site disposal.

Alternatives 2A/Vit and 2A/Cem would meet all of the ARARs cited above; in addition, they would meet the ARARs associated with construction of an on-property disposal vault. In particular, the State of Ohio maintains a number of solid waste disposal design considerations within Ohio Administrative Code (OAC) 3745-27-07. Through the definition of a Corrective Action Management Unit (CAMU) for Operable Unit 4, which includes the area encompassing the operable unit boundary and any proposed on-property treatment and disposal areas, these requirements would be considered relevant and appropriate to the implementation of Alternatives 2A/Vit and 2A/Cem. The OAC requirements contain setback requirements pertaining to the distance of the disposal vault from the property line as

well as the distance from the nearest domicile or water supply well. An additional requirement specifies a distance of 4.5 m (15 ft) from the bottom of the liner system and the top of the uppermost aquifer.

OAC 3745-27-07 (B)(5) prohibits solid waste disposal facilities from being constructed over sole-source aquifers. Exemptions to this requirement have been granted on the basis of technical considerations including: presence of a significant thickness of low permeability material between the disposal vault liner and the aquifer; no significant interconnection between the aquifer and any significant zones of saturation that exist above the aquifer; and, no adverse impact to human health or the environment. The disposal facility proposed for Alternatives 2A/Vit and 2A/Cem would meet these technical considerations. A discussion of the data to support this position is in Section 3.2.2.1 and Appendix D.

Alternative 0A - No Action would meet all location-specific ARARs identified for this alternative. The Ohio requirements for location of a solid waste disposal facility contained in OAC 3745-27-07 are not an ARAR for this alternative.

Action-Specific ARARs

All Subunit A action alternatives would comply with all pertinent action-specific ARARs identified for these alternatives. For Alternatives 2A/Vit and 2A/Cem, the above-grade disposal vault would incorporate the design requirements for the disposal of uranium mill tailings (40 CFR § 192) and hazardous waste under RCRA [i.e., the Treatment, Storage, and Disposal Facility (TSDF) requirements under 40 CFR § 264]. As a result of elevated direct penetrating radiation associated with the treated Subunit A residues, the prescriptive intruder protection requirements defined in 10 CFR § 61.7 have been adopted for on-property disposal.

The design of the on-property disposal vault would also include appropriate engineered features that satisfy the requirements of the Clean Water Act (40 CFR § 125.100 and § 104), the Ohio Water Quality Standards, and RCRA Subtitle C - Hazardous Waste (40 CFR § 262.11, § 261.7, and the other § 264 requirements identified in Appendix F).

An action-specific ARAR and to be considered (TBC) requirement particular to on-property disposal of Subunit A material at the FEMP site is 40 CFR § 191 (Standards for the Management, Storage, and Disposal of Spent Nuclear, High Level, and Transuranic Wastes). In October 1990, EPA directed

DOE to consider 40 CFR § 191 Subpart A (dealing with the storage and management of waste) as an ARAR to the on-property portions of remedial activities involving the K-65 residues, and to consider Subpart B (pertaining to waste disposal) as a TBC requirement for on-property Subunit A disposal alternatives.

40 CFR § 191 Subpart A specifies a public dose limit to be complied with during waste storage and remediation operations. Estimates of the dose to the public calculated for the short-term risk assessment indicate that exposures would be a small fraction of the one mrem/yr limit (Appendix D). Alternatives 2A/Vit and 2A/Cem would comply with all pertinent provisions of 40 CFR § 191.

Alternatives 3A.1/Vit and 3A.1/Cem would comply with all pertinent action-specific ARARs identified in Appendix F, including 40 CFR § 191 Subpart A. Hazardous waste transport requirements would be complied with by following the regulations under 40 CFR § 262 and § 263, and the appropriate Department of Transportation (DOT) shipping standards under 49 CFR § 172 and § 173.

5.2.2 Primary Balancing Criteria

Those alternatives that satisfy the threshold criteria comparative analysis are carried forward for further comparative analysis under the primary balancing criteria. The no-action alternative, Alternative 0A, will be carried forward as the baseline alternative for comparison purposes in accordance with the NCP. Alternatives that will be carried forward will include:

- Alternative 0A - No Action
- Alternative 2A/Vit - Removal, Vitrification, On-Property Disposal
- Alternative 2A/Cem - Removal, Cement Stabilization, On-Property Disposal
- Alternative 3A.1/Vit - Removal, Vitrification, and Off-Site Disposal at NTS
- Alternative 3A.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal at NTS

5.2.2.1 Long-Term Effectiveness and Permanence

All Subunit A alternatives, with the exception of Alternative 0A - No Action, would ensure long-term protectiveness to human health and the environment. For all alternatives, projected FEMP site residual risk to viable receptors (off-property farmer and recreational user) would be less than 10^{-6} ILCR, and no non-carcinogenic effects (HI less than 0.2) would be indicated for either receptor.

Alternatives 3A.1/Vit and 3A.1/Cem include removal and treatment of the source materials, followed by transportation and off-site disposal at NTS. Removal and treatment of the Subunit A materials eliminate the potential for exposure to direct radiation and mitigates the migration of constituents to the air, soil, and water. Treatability studies demonstrated that both the vitrified and the cement-stabilized material exhibits reduced leachability of constituents compared to the untreated materials. Both treated materials have TCLP results below RCRA limits. Vitrification of the untreated materials reduced radon emanation significantly and reduced the residue volume by approximately 50 percent.

Vitrification is an innovative technology which has not been previously applied to the stabilization of waste materials at the same scale as contemplated under Alternative 2A/Vit. The results of treatability tests have repeatedly demonstrated consistent reductions in the leachability of radionuclides and other inorganics. Cement stabilization is a proven technology that has been previously applied to the stabilization of similar waste materials as those contemplated under Alternative 2A/Cem. The performance characteristics of the cement-stabilized material in reducing leachability are generally comparable to those of the vitrified material; however, degradation and leachability results for some constituents indicate that cement stabilization is not an irreversible treatment process.

Off-site disposal at NTS would provide protection by eliminating access to the treated materials and preventing migration of constituents from the materials. The NTS disposal facility is located in a sparsely populated, arid environment with a reduced potential for leachate generation, contaminant migration, and direct contact with contaminants. Because NTS is maintained by DOE and utilized for the disposal of selected low-level wastes from other DOE sites, the uncertainties associated with institutional controls are low. As the result of a low average annual precipitation and depths to groundwater ranging from 157 - 600 m (515 - 2000 ft) below ground surface, impacts to human health and the environment would be mitigated in the event that engineering and institutional controls fail.

Long-term environmental impacts under Alternatives 3A.1/Vit and 3A.1/Cem would include those associated with the removal and treatment activities performed at the FEMP and disposal activities at NTS. There are no long-term environmental impacts at the FEMP site pertaining to the removal and treatment processes. Long-term environmental impacts at NTS would include some permanent disturbance of soils (i.e., acquisition of borrow material) associated with disposal activities. No significant long-term impacts would be expected for water quality and hydrology, air quality, biotic resources, socioeconomics and land use, or cultural resources. No wetland or floodplain areas have been delineated at the NTS.

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Alternatives 2A/Vit and 2A/Cem include the removal and treatment of source materials followed by on-property disposal in an above-grade disposal vault. The long-term effectiveness afforded by the removal and treatment processes would be identical for both Alternatives 2A/Vit and 2A/Cem. The design features of the disposal vault would provide effective long-term containment of the treated material. The vault would use proven technologies and materials of construction. Similar disposal systems are currently being employed for the encapsulation of hazardous wastes, low-level radioactive waste under both DOE and NRC programs, and uranium mill tailings under the DOE UMTRCA and FUSRAP. Fate and transport modeling was performed to assess leaching of constituents under degradation of the facility (slight degradation of components over 1,000 years). The results of this modeling, based on conservative assumptions for infiltration rates, show that the leaching of constituents would not pose a risk to off-site receptors. Loss of institutional controls in combination with disposal vault failure over the long term (more than 1000 years) could result in potential contaminant migration or direct exposure to the treated material by future human and ecological receptors. Exposures to receptors through these pathways would be expected to initially be minimal due to the positive attributes of the treated materials. Direct radiation exposure could be significant in the event that the disposal vault is breached.

Long-term environmental impacts associated with construction of the on-property disposal vault for Alternatives 2A/Vit and 2A/Cem include permanent disruption of up to 5.8 ha (14.3 acres) of land. No significant long-term impacts are expected for water quality and hydrology, air quality, socioeconomics, or cultural resources. A potential habitat for threatened and endangered species has been identified in the area proposed for the disposal vault. This same area has been identified as forested wetlands. No floodplains would be permanently altered as the result of implementing either of these two alternatives.

Alternative 0A - No Action would not be protective of human health and the environment in the long term because it would not prevent exposure to the Silos 1 and 2 residues. Silo collapse and subsequent loss of containment would lead to increased contamination levels in air, soils, groundwater, surface water, and sediments. Based on the results of the baseline risk assessment, Alternative 0A-No Action would not be adequately protective under all evaluated land use scenarios, except current land use conditions with continuation of access controls. For these land use scenarios, at least one receptor receives risks which are calculated to exceed 10^{-4}.

5.2.2.2 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 2A/Vit, 2A/Cem, 3A.1/Vit, and 3A.1/Cem would employ one of two treatment processes for the Subunit A residues. Alternatives 2A/Vit and 3A.1/Vit would use vitrification to physically bind the constituents in a glass-like matrix, which would significantly reduce contaminant mobility. Vitrification would also significantly reduce radon emanation significantly. Treatability tests of the vitrification process have demonstrated that an overall material volume reduction of about 59 percent could be expected. The high operating temperatures of the vitrification process have also been shown to effectively destroy any organic compounds present in the residue matrix. The effects of vitrification as a treatment are essentially irreversible.

TCLP tests were conducted on both the untreated and vitrified form of the residues. The results showed that the leachate concentrations of hazardous metals were below regulatory limits for all glasses made during the bench-scale tests. Product Consistency Tests (PCT) were also performed on the vitrified materials. PCT leach testing demonstrated a high degree of durability for the vitrified materials. Literature data on the leachability of the vitrified product from a variety of material types indicate similar leach resistance. Data on the long-term stability of vitrified material are not available, and the life expectancy of the vitrified product is difficult to estimate from short-term leach rates; however, on the basis of the longevity of volcanic glass (a natural analog to the vitrified product), the vitrified product would be expected to withstand environmental exposure for thousands of years.

Alternatives 2A/Cem and 3A.1/Cem would use the cement stabilization process to treat the Subunit A residues. Cement stabilization would reduce the mobility of constituents by binding them into a cement mixture. Radon emanation would be reduced somewhat, but not as much as through the vitrification process. Various reagents would be added to the mixture to improve the characteristics of the final treated material, e.g., improved metals adsorption, increased leachability resistance, and decreased effects of process inhibitors. The addition of reagents to the untreated residues causes an overall increase in volume ranging from 136 to 216 percent.

TCLP tests were conducted on both the untreated and cement stabilized form of the residues. The results showed that the leachate concentrations of RCRA metals were below regulatory limits for all cement stabilized forms produced during the bench-scale tests.

Treatability tests have been performed to determine the best formulations resulting in a product having the most favorable leach resistance and durability characteristics. Static leach tests were generally the

same order of magnitude as for the TCLP leachate results. Degradation and durability testing indicate that cement stabilization is not an irreversible process.

In summary, the primary differences between vitrification and cement stabilization performance are:

- Vitrification significantly reduces volume
- Cement stabilization significantly increases volume
- Cement stabilization is reversible

Alternative 0A - No Action does not include treatment; therefore, it does not provide any reduction in toxicity, mobility, or volume of contaminants.

5.2.2.3 Short-Term Effectiveness

For the Subunit A action alternatives, the various removal, treatment, and disposal activities would result in increased short-term exposures compared with Alternative 0A. The short-term effectiveness of removal is expected to be the same among the alternatives for Subunit A that include removal. The risks from transportation accidents would be incrementally higher for the cement stabilization alternatives than for the vitrification alternatives because of the larger volume of material.

Short-term impacts associated with the action alternatives would include temporary disruption of approximately 3.2 ha (7.8 acres) of land at the FEMP site. Increased fugitive dust during excavation activities and the potential for minor impacts to biota and wetlands [0.36 ha (0.9 acre)] does exist. However, the appropriate engineering controls would minimize these potential short-term impacts. All transportation to NTS would be in compliance with DOT and DOE guidelines.

The time required to implement any of the removal and treatment alternatives is estimated to be approximately six to seven years.

The short-term effectiveness for Alternative 0A would remain unchanged from current conditions so that no significant changes in potential exposure are expected. The estimated risks are summarized in Appendix G.

5.2.2.4 Implementability

The removal and treatment activities in Alternatives 2A/Cem and 3A.1/Cem could be implemented using standard equipment, procedures, and readily available resources. Hydraulic removal is a

standard mining technology that is normally reliable and uses readily available equipment. The cement stabilization technology has been applied successfully at a number of remedial sites. EPA considers cement stabilization a demonstrated treatment technology and has approved its use in the final remedy for many NPL sites. This technology has also been applied at other sites that are radioactively contaminated. The cement stabilization process would require large quantities of cement, flyash, and blast furnace slag, which are available.

Alternatives 2A/Vit and 2A/Cem would require on-property disposal vaults. Alternatives 3A.1/Vit and 3A.1/Cem would not require on-property disposal vaults. Off-site transportation would be technically straightforward, and the necessary resources are available. For disposal, NTS has the resources and capacity to accept the treated Subunit A material. However, off-site transport and disposal would be subject to various state and federal requirements; therefore, administrative feasibility may require increased coordination efforts with jurisdictional agencies for off-site disposal. A Waste Certification Acceptance Program for the Subunit A materials would be required to be prepared and approved for shipment to NTS. Public acceptance and approval of treated material shipment by the State of Nevada must be obtained for these alternatives. Opposition by the State of Nevada may require extensive negotiations with the Nevada Division of Environmental Protection to facilitate the disposal at NTS.

Although removal and disposal are the same for Alternative 2A/Vit as for Alternative 2A/Cem and for Alternative 3A.1/Vit as for Alternative 3A.1/Cem, the vitrification process is more difficult to implement than the cement stabilization process. The vitrification process would require fewer chemical reagents than for the cement stabilization process but larger amounts of energy (electricity). In addition, the vitrification process equipment would be more complex to construct and operate than that of the cement stabilization process. There is limited experience available for the types and quantities of the material from the silos and decant sump tank on which to base an assessment of the likely performance of the vitrification technology. The vitrification technology is not as widely available as the cement stabilization technology. Off-gas treatment is also an additional complexity with vitrification where delays could occur. The combination of these complexities makes implementation of Alternatives 2A/Vit and 3A.1/Vit more difficult than Alternatives 2A/Cem and 3A.1/Cem. However, operational experience is being gained as part of the structured treatability studies and vitrification pilot facility planning currently in progress.

Because there are no actions required, Alternative 0A would be easy to implement.

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5.2.2.5 Cost

Cost estimates are used in the feasibility study process under the CERCLA to eliminate those remediation alternatives which are significantly more expensive than competing alternatives but do not offer commensurate performance or overall protection of human health and the environment. The cost estimates developed are order-of-magnitude estimates with an intended accuracy range of -30 to +50 percent. Estimates are considered to be order-of-magnitude because of the uncertainties in the information used to develop the estimates. Final costs would depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final scope, final schedule, final engineering design, and other variables.

The categories of costs developed were capital, short-term Operation and Maintenance (O&M) (during remediation), and long-term O&M (post-remediation). Total present worth costs were developed for each alternative, assuming a discount rate of seven percent, so that all alternatives with costs incurred over differing time periods could be compared on an equivalent basis. Capital and O&M costs for each Subunit A alternative evaluated in the detailed analysis (Section 4.0) are presented in Table 5-6.

There are no capital or O&M costs associated with Alternative 0A-No Action. Alternative 3A.1/Vit is the least expensive action alternative. The present worth cost of Alternative 2A/Vit is approximately $0.2M higher than that of Alternative 3A.1/Vit. This is due to the higher cost of constructing an on-property above-grade disposal vault as compared to off-site transportation and disposal at NTS. Alternatives 3A.1/Cem and 2A/Cem are approximately 64 percent and 70 percent more expensive, respectively, than Alternative 3A.1/Vit. The alternatives that include cement stabilization are more expensive than the vitrification alternatives primarily due to the additional packaging, transportation (for Alternative 3A.1/Vit), and disposal of the larger volume of cement-stabilized material. Use of the cement stabilization treatment process results in over six times the volume that the vitrification process generates.

Sensitivity Analysis of Present Worth Costs

Some factors that can greatly impact present worth costs are the extent of remediation required, i.e., scope of project, duration of construction, remediation or O&M, and discount rate. The quantity of material included in Subunit A (Silos 1 and 2 material) is fairly well defined. A detailed construction schedule was developed for the duration of construction and remediation, so these factors are not likely to change significantly. Since the relative cost of post-remediation O&M is relatively low in comparison to the capital and short-term O&M costs, a change in the post-remediation time period is not likely to have a major impact on present worth cost. Therefore, discount rate is one factor that

TABLE 5-6

SUBUNIT A ALTERNATIVE COSTS

Alternative	COST[a]			
	Capital	O&M During Remediation	Post-Remediation O&M	Total Present Worth
0A	0	0	0	0
2A/Vit	36,537,400	11,692,500	3,425,400	43,601,900
2A/Cem	71,238,200	11,715,700	3,582,000	74,038,600
3A.1/Vit	37,986,600	11,692,500	0	43,452,700
3A.1/Cem	69,865,400	11,715,700	0	71,536,300

[a]Values are given in dollars ($).

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can be varied at this time to provide a sensitivity analysis on present worth costs.

A range of three to ten percent for the discount rate was analyzed, and the results are provided in Table 5-7. The sensitivity analysis indicates that the relative cost comparison presented for a discount rate of seven percent does not significantly change for the other discount rates evaluated in the sensitivity analysis.

5.3 SUBUNIT B

Subunit B alternatives compared include:

- Alternative 0B - No Action
- Alternative 2B/Vit 2B/Cem - Removal, Stabilization, On-Property Disposal
- Alternative 3B.1/Vit 3B.1/Cem - Removal, Stabilization, Off-Site Disposal at NTS
- Alternative 4B - Removal, On-Property Disposal

A summary of the Subunit B comparative analysis is presented in Table 5-2.

5.3.1 Threshold Criteria

5.3.1.1 Overall Protection of Human Health and the Environment

All of the Subunit B alternatives, except 0B-No Action, provide for the protection of human health and the environment. Table 5-5 summarizes both the long-term and short-term incremental lifetime cancer risks for each alternative. Long-term risks represent the residual risks to the hypothetical RME receptor potentially remaining at the site following implementation of the alternative. Short-term risks are provided to assess the potential impacts to the public and remedial action workers during implementation of the alternative. All of the action alternatives, except Alternative 4B, would limit exposures to contaminants by removing the residues from the deteriorated silo structure, treating the materials (using either vitrification or cement stabilization) to reduce the mobility of the radiological and inorganic chemical constituents, and placing the treated materials in an on-property, above-grade disposal vault or off-site facility (NTS) owned by DOE. Alternative 4B would mitigate the migration of contaminants and prevent direct access to the residues by removing the residues and placing them in an above-grade disposal vault.

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TABLE 5-7

SENSITIVITY ANALYSIS
SUBUNIT A PRESENT WORTH COSTS

Discount Rate (%)	PRESENT WORTH COST[a]			
	Alternative 2A/Vit	Alternative 2A/Cem	Alternative 3A.1/Vit	Alternative 3A.1/Cem
3	47,718,700	80,565,800	46,847,400	76,931,000
4	46,587,100	78,797,000	45,953,200	75,462,500
5	45,531,800	77,129,900	45,092,100	74,048,400
6	44,544,500	75,555,500	44,264,100	72,688,800
7	43,601,900	74,038,600	43,452,700	71,356,300
8	42,714,900	72,601,600	42,674,300	70,078,200
9	41,863,000	71,212,200	41,912,600	68,827,300
10	41,059,000	69,894,400	41,184,000	67,630,700

[a]Values are given in dollars ($).

FER/OU4FS/ABM.TABLE5-7.WK1/12-05-93

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For alternatives that include treatment, both the vitrification and cement stabilization treatment processes provide a waste form which significantly reduces the potential for contaminant migration and radon emanation. The results of treatability studies completed on the two treatment processes for Silo 3 residues demonstrate that the vitrified residue form would be expected to be more durable over the long term, with both a reduced volume and radon emanation rate. These factors would contribute to the conclusion that the vitrified material better supports the overall goal of providing for the long-term protection of human health and the environment than does the cement stabilized material. Short-term risks to the public, workers, and the environment associated with the implementation of the treatment process would be expected to be similar.

As a result of the necessary additives to facilitate cement stabilization, the volume of waste requiring disposal for alternatives including this treatment technology would be expected to increase by over 62 percent. The vitrification process would reduce the volume of contaminated material requiring disposal by 55 percent. Since no treatment would be performed in Alternative 4B, the volume of residue material to be disposed is not impacted for this alternative.

The off-site disposal location would be the NTS facility, which has been used for FEMP low level waste disposal since August 1985. NTS disposal methods include engineering and institutional control measures to preclude contact with the waste and minimize the potential for migration of contaminants from the disposed wastes. These controls, when coupled with the climatic, demographic, and hydrogeologic setting of the NTS site, provide assurance of the long-term protection of human health and the environment.

Alternatives 2B and 4B include an on-property disposal vault. The on-property disposal option would employ an above-grade disposal vault designed for a life of 1000 years with the requirement for no active maintenance. The disposal vault would prevent exposure to direct radiation and minimize infiltration of water and subsequent leaching of contaminants to the underlying clays and ultimately to the Great Miami Aquifer. Disposal vault design features would inhibit purposeful or inadvertent intrusion into the disposed residues. In the event intrusion did occur, the exposures and resultant risks to these intruders would not be expected to be significant for Alternative 2B due to the characteristics of the treated residues. For Alternative 4B, loss of institutional controls in combination with disposal vault failure over the long term could result in potential contaminant migration or direct exposure to the untreated material by human and ecological receptors. Exposures to receptors through these pathways in the event of disposal vault failure would be expected to be significant due to the lack of

treatment of the residues. The FEMP site demographic features, as compared to NTS, provide a higher probability of intrusion into the disposed residues.

Short-term risks to the public and workers are slightly greater for the off-site disposal option due to the increased risks of transportation accidents resulting in injuries or radiation exposure. The greatest short-term risk of this type is associated with Alternative 3B.1/Cem because of the increased volume of treated material requiring transportation off site.

Table 5-4 provides a summary of the environmental impacts associated with the implementation of each of the remedial alternatives. The potential short-term environmental impacts associated with each of the alternatives are comparable. Short-term impacts include the temporary loss of habitats at the FEMP site and possible impacts of accidental spills of construction and operation materials. Mitigative measures would be employed to minimize these impacts.

Long-term environmental impacts associated with each of the treatment alternatives are comparable and would not be expected to be significant. Impacts from implementing Alternatives 2B/Vit and 2B/Cem would include the permanent loss of some on-property habitats.

Alternative 0B would not provide adequate overall protection of human health or the environment. Alternative 0B would not adequately eliminate, reduce, or control the migration of contaminants to human and environmental receptors. Based on the results of the baseline risk assessment presented in the RI Report for Operable Unit 4 (DOE 1993c), the no-action alternatives would not be adequately protective. Risks to human health would increase in the event current access controls were lost.

5.3.1.2 Compliance with ARARs

Except for Alternative 0B - No Action, all Subunit B alternatives would attain all pertinent chemical, location, and action-specific ARARs and TBCs. A comprehensive list of potential ARARs is presented in Appendix F. Key requirements are discussed in Section 4.0 within the evaluation of each alternative against this criterion. The following summarizes those evaluations.

Chemical-Specific ARARs

All of the action alternatives (2B/Vit, 2B/Cem, 3B.1/Vit, 3B.1/Cem, and 4B) for Subunit B meet the chemical-specific ARARs associated with potential releases to groundwater, air, and surface water. As demonstrated by fate and transport modeling, the Subunit B action alternatives, including on-property

presented in Appendix F. Key requirements are discussed in Section 4.0 within the evaluation of each alternative against this criterion. The following summarizes those evaluations.

Chemical-Specific ARARs

All of the action alternatives (2B/Vit, 2B/Cem, 3B.1/Vit, 3B.1/Cem, and 4B) for Subunit B meet the chemical-specific ARARs associated with potential releases to groundwater, air, and surface water. As demonstrated by fate and transport modeling, the Subunit B action alternatives, including on-property disposal, would attain the SDWA concentration-based limits for specific chemicals under 40 CFR § 141.11 and et al., 40 CFR § 264.94, and dose-based requirements for the protection of potential public receptors defined in DOE Order 5400.5.

Guidance is provided in 40 CFR § 257.3-4 and 40 CFR § 264.94 as to the point of compliance for demonstrating whether the groundwater protection requirements for inorganic and organic contaminants would be attained. The most restrictive requirements for these constituents appears in 40 CFR § 264.94, which requires the disposal vault to meet the concentration-based limits in the uppermost aquifer underlying the waste management area beyond the point of compliance. The uppermost aquifer is the Great Miami Aquifer. Fate and transport modeling of potential releases of uranium, the principal groundwater constituent of concern, from the on-property disposal vault indicates the uranium concentration would not exceed the proposed 20 μg/L MCL at the point of compliance during the 1000 year modeling horizon both for the treated or untreated residues.

The most critical chemical-specific ARAR relative to airborne releases for Subunit B materials relates to radon. The maximum permissible flux rate of radon-222, as specified in the NESHAP, 40 CFR § 61 Subpart Q, is 20 pCi/m^2/s, surface averaged. This requirement is supplemented by 40 CFR § 192.02(b), which requires that the concentration of radon-222 in air at or above any location outside the disposal site not increase the annual average by more than 0.5 pCi/L over background. Requirements for other radionuclides are established in 40 CFR § 61 Subpart H and DOE Order 5400.5, Chapter III. Compared to the untreated Subunit B materials, both the vitrified and the cemented residue forms are effective in reducing radon emanation from the treated residues to less than these prescriptive requirements. Engineered barriers associated with the disposal of treated materials, in either form, would provide additional controls to ensure these chemical-specific ARAR/TBCs are attained. Engineered barriers associated with disposal would provide control for untreated material (Alternative 4B)

Alternative 0B - No Action would not meet several requirements for the protection of groundwater used for drinking water supply. Also, in the event existing access controls were discontinued and a family farm was established on the FEMP site, exposure limits embodied within DOE Order 5400.5 for members of the general public could be exceeded.

Location-Specific ARARs

Alternatives 3B.1/Vit and 3B.1/Cem would comply with all pertinent location-specific ARARs. Disposal facility location requirements would not be relevant and appropriate to Alternatives 3B.1/Vit and 3B.1/Cem since the alternatives provide for off-site disposal of the treated residues.

Alternatives 2B/Vit, 2B/Cem and 4B would meet all of the location-specific ARARs, including those associated with the design and construction of an on-property disposal vault. As discussed in the comparative analysis section for Subunit A alternatives, the Subunit B alternatives which include on-property disposal will attain all State of Ohio solid waste disposal facility design considerations.

Alternative 0B - No Action would meet all location-specific ARARs identified for this alternative. The Ohio requirements for location of a solid waste disposal facility contained in OAC 3745-27-07 one not on ARAR for this alternative.

Action-Specific ARARs

All Subunit B action alternatives would comply with all pertinent action-specific ARARs identified for these alternatives. For Alternatives 2B/Vit, 2B/Cem, and 4B, the above-grade disposal vault would incorporate the design requirements for the disposal of uranium mill tailings (40 CFR § 192) and hazardous waste under RCRA (i.e., the TSDF requirements under 40 CFR § 264).

The design of the on-property disposal vault also would include appropriate engineered features that satisfy the requirements of the Clean Water Act (40 CFR § 125.100 and 104), the Ohio Water Quality Standards, and RCRA Subtitle C - Hazardous Waste (40 CFR § 262.11, 261.7, and the other 264 requirement identified in Appendix F).

Alternatives 3B.1/Vit and 3B.1/Cem would comply with all action-specific ARARs identified in Appendix F. Hazardous material transport requirements would be complied with by following the regulations under 40 CFR § 262 and § 263, and the appropriate DOT shipping standards under 49 CFR § 172 and 173.

5.3.2 Primary Balancing Criteria

Those alternatives that satisfy the threshold criteria comparative analysis are carried forward for comparative analysis under the primary balancing criteria. The no-action alternative, Alternative 0B, will be carried forward as the baseline alternative for comparison purposes in accordance with the NCP. Alternatives that will be carried forward include:

- Alternative 0B - No Action
- Alternative 2B/Vit - Removal, Vitrification, On-Property Disposal
- Alternative 2B/Cem - Removal, Cement Stabilization, On-Property Disposal
- Alternative 3B.1/Vit - Removal, Vitrification, Off-Site Disposal at NTS
- Alternative 3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal at NTS
- Alternative 4B - Removal, On-Property Disposal

5.3.2.1 Long-Term Effectiveness and Permanence

All Subunit B alternatives, with the exception of Alternative 0B - No Action, would ensure long-term protectiveness to human health and the environment. For all alternatives, projected FEMP site residual risk to viable receptors (off-property farmer and recreational user) would be less than 10^{-6} ILCR, and no non-carcinogenic effects (HI less than 0.2) would be indicated for either receptor.

Alternatives 3B.1/Vit and 3B.1/Cem include removal and treatment of the source materials, followed by transportation and off-site disposal at NTS. Removal and treatment of the Subunit B materials eliminates the potential for residual risks to remain at the FEMP site following completion of the actions.

Treatability studies demonstrated that both the vitrified and the cement-stabilized residue forms exhibit reduced leachability of constituents compared to the untreated materials. However, treatability data for the vitrification process option indicated that the ratio of the activity of uranium-238 in the leachate from the untreated Silo 3 material to the activity in the leachate from vitrified Silo 3 material was one. Both treated forms exhibited TCLP leachate concentrations for hazardous constituents that were below relevant and appropriate limitations defined in RCRA. Vitrification and cement stabilization both reduced radon emanation significantly. The vitrification alternatives are anticipated to achieve a better than 50 percent reduction in volume requiring disposal. The cement stabilization

alternatives would increase volumes requiring disposal by greater than 55 percent due to the addition of additives. No treatment (Alternative 4B) does not impact volume requiring disposal.

Vitrification is an innovative technology which has not been previously applied to the stabilization of waste materials on the same scale as contemplated under Alternative 2B/Vit and 3B/Vit. The results of treatability tests have repeatedly demonstrated consistent reductions in the leachability of radionuclides and other inorganics for the exception noted above. Cement stabilization is a proven technology that has been previously applied to the treatment of similar waste materials. The performance characteristics of the cement-stabilized material in reducing leachability are generally comparable to those of the vitrified material. Vitrification provides added flexibility in processing not afforded by cementation, because glass exhibiting unacceptable characteristics can be remelted and reformed.

Off-site disposal at NTS would provide protection by eliminating access to the treated materials and preventing migration of constituents from the materials. The NTS disposal facility is located in a sparsely populated, arid environment with a reduced potential for leachate generation, contaminant migration, and direct contact with contaminants. Because NTS is maintained by DOE and utilized for the disposal of selected low-level wastes from other DOE sites, the uncertainties associated with institutional controls are low. As the result of a low average annual precipitation and depths to groundwater ranging from 157 - 600 m (515 - 2000 ft) below ground surface, impacts to human health and the environment would be mitigated in the event that engineering and institutional controls fail.

Long-term environmental impacts under Alternatives 3B.1/Vit and 3B.1/Cem would include those associated with the removal and treatment activities performed at the FEMP site and disposal activities at the NTS. There are no long-term environmental impacts at the FEMP site pertaining to the removal and treatment processes. Long-term environmental impacts at NTS would include some permanent disturbance of soils (i.e., acquisition of borrow material) associated with disposal activities. No significant long-term impacts would be expected for water quality and hydrology, air quality, biotic resources, socioeconomics and land use, or cultural resources. No wetland or floodplain areas have been delineated at the NTS.

Alternatives 2B/Vit and 2B/Cem include removal and treatment of Subunit B source materials followed by placement in an above-grade disposal vault. The long-term effectiveness afforded by the

removal and treatment processes would be identical for both Alternatives 2B/Vit and 2B/Cem. Alternative 4B includes the removal of Silo 3 residues followed by placement in an above-grade disposal vault. Since no treatment would be provided, the long-term effectiveness of this alternative is less certain. For all three alternatives, the design features of the disposal vault would provide effective long-term containment of the treated or untreated residue forms. The vault would use proven technologies and materials of construction. Similar disposal systems are currently being employed for the encapsulation of hazardous wastes, low-level radioactive waste, and uranium mill tailings. Fate and transport modeling was performed to assess leaching of constituents under degradation of the vault (slight degradation of components over 1000 years). The results of this modeling, based on conservative assumptions for infiltration rates, show that the leaching of constituents would not pose a risk to off-site receptors. Exposures to receptors in the event institutional controls were lost would not be expected to be significant due to characteristics of the treated residue.

Long-term environmental impacts associated with construction of the on-property disposal vault for Alternatives 2B/Vit, 2B/Cem, and 4B include permanent disruption of 2.4 ha (5.9 acres), 4.5 ha (11.1 acres), and 2.8 ha (6.9 acres) of land, respectively. No significant long-term impacts are expected for water quality and hydrology, air quality, socioeconomics, or cultural resources. A potential habitat for threatened and endangered species has been identified in the area proposed for the disposal vault. This same area has been identified as forested wetlands. No floodplains would be permanently altered as the result of implementing these three alternatives.

Alternative 0B - No Action would not be protective of human health and the environment in the long term because it would not prevent exposure to the silo residues. Silo collapse and subsequent loss of containment would lead to increased contamination levels in air, soils, groundwater, surface water, and sediments. Based on the results of the Baseline Risk Assessment, Alternative 0B would not be adequately protective under all evaluated land use scenarios, except current land use conditions with continuation of access controls. For these land use scenarios, at least one receptor receives risks which are calculated to exceed 10^{-4}.

5.3.2.2 Reduction of Toxicity, Mobility, or Volume

Alternatives employing vitrification would exhibit a greater overall reduction in the toxicity, mobility, and volume of the material. Alternatives 2B/Vit and 3B.1/Vit use the vitrification process to treat the contaminated material. This technology will physically bind the contaminants in a glass-like matrix,

which will significantly reduce contaminant mobility and material volume. Mobility would be reduced since the contaminants would be bound in the matrix and the volume of the treated material would be approximately 62 percent of the untreated Subunit B material volume. Although most contaminants in the treated material would be incorporated into the vitrified product to reduce mobility over the long term, some contaminants would be released during the vitrification process and must be treated through the off-gas treatment system. The material generated through the off-gas treatment system may require additional stabilization to limit subsequent contaminant mobility.

Alternatives 2B/Cem and 3B.1/Cem use the cement stabilization process to treat the contaminated material. This technology would physically and chemically bind the contaminants in a cement-like matrix, so the mobility of contaminants via leaching from this treated material would be greatly reduced. However, the inherent toxicity of the material would not be reduced because no contaminants would be destroyed, and the total volume of material would increase by approximately 50 to 68 percent as a result of adding the cement stabilizing and setting agents.

No treatment occurs under Alternatives 0B and 4B; therefore, these alternatives do not provide any reduction of toxicity, mobility, or volume of contaminated material.

5.3.2.3 Short-Term Effectiveness

Alternative 2B/Cem provides fewer short-term impacts due to reduced emissions during treatment and minimal transportation related risks. The short-term effectiveness of removal is higher for Alternatives 3B.1/Vit and 3B.1/Cem than Alternatives 2B/Vit and 2B/Cem due to the additional risks of transporting the treated material to NTS. Alternative 3B.1/Cem will have higher risk due to transporting the larger volume of treated material to NTS.

Under Alternatives 2B/Vit, 2B/Cem, 3B.1/Vit, 3B.1/Cem, and 4B, short-term disturbance of soil would occur. Fugitive dust and exhaust emissions as a result of excavation and construction activities could temporarily result in minimal impacts to air quality and water quality at the FEMP site and/or NTS. However the proper engineering controls and mitigative measures should limit these impacts. Minimal impacts to biotic resources is expected at both NTS and/or the FEMP site. In addition, minimal impacts to wetlands and floodplains would occur.

The time required to implement either treatment alternative is approximately six years. Alternative 4B would require two years.

The short-term effectiveness for Alternative 0B would remain unchanged from the current conditions so that no significant changes in potential exposure are to be expected. The estimated risks are summarized in Appendix G.

5.3.2.4 Implementability

Alternative 4B would be the most implementable action alternative since no treatment would be performed. Alternative 2B/Cem represents the most implementable alternative of all treatment alternatives due to use of proven treatment and disposal technology in addition to use of existing FEMP site controlled property for disposal.

The removal and treatment activities in Alternatives 2B/Cem and 3B.1/Cem could be implemented with standard equipment, procedures, and readily available resources. Pneumatic removal is a standard technology that is normally reliable and uses readily available equipment. The cement stabilization technology has been applied successfully at a number of remedial sites. EPA considers cement stabilization a demonstrated treatment technology and has approved its use in the final remedy for many NPL sites. This technology has been also applied at other sites that are radioactively contaminated. The cement stabilization process would require large quantities of cement, flyash, and blast furnace slag, which are readily available.

Although the removal and disposal aspects are the same for Alternatives 2B/Vit and 3B.1/Vit as for Alternatives 2B/Cem and 3B.1/Cem, the treatment component (vitrification) of these alternatives is more difficult to implement. The vitrification process would require fewer chemical reagents than for the cement stabilization process but larger amounts of energy (electricity). In addition, the vitrification process equipment would be more complex to construct and operate than that of the cement stabilization process. There is limited experience available for the types and quantities of the material from the silo on which to base an assessment of the likely performance of the vitrification technology. The vitrification technology is not as widely available as the cement stabilization technology. Off-gas treatment is also an additional complexity with vitrification where delays could occur. The combination of these complexities makes implementation of Alternatives 2B/Vit and 3B.1/Vit more difficult than Alternatives 2B/Cem and 3B.1/Cem. However, operational experience is being gained as part of the structured treatability studies and from the vitrification pilot facility currently in start-up.

Alternative 2B/Vit, 2B/Cem, and 4B are less difficult to implement due to the straightforward disposal vault design. Administrative feasibility is less difficult than Alternatives 3B.1/Vit and 3B.1/Cem because no outside state agencies or regional EPA office agencies would become involved.

Alternatives 3B.1/Vit and 3B.1/Cem would not require an on-property disposal vault. Off-site transportation would be technically straightforward, and the necessary resources are available. For disposal, NTS has the resources and capacity to accept the treated Silo 3 material. Off-site transport and disposal would be subject to coordination with various state and federal agencies to address transport. Approval to dispose the Silo 3 11(e)2 by-product material at NTS would need to be received from NTS and DOE-HQ.

5.3.2.5 Cost

The categories of costs developed were capital, short-term O&M (during remediation), and long-term O&M (post-remediation). Total present worth costs were developed for each alternative, assuming a discount rate of seven percent, so that all alternatives with costs incurred over differing time periods could be compared on an equivalent basis. Capital and O&M costs for each Subunit B alternative evaluated in the detailed analysis (Section 4.0) are presented in Table 5-8.

There are no capital or O&M costs associated with Alternative 0B-No Action. Alternative 4B is the least expensive action alternative. The present worth cost of Alternatives 2B/Vit and 3B.1/Vit treatment are approximately the same, and are about $5.5M higher than that of Alternative 4B. This is due to the component of those alternatives that is not included in Alternative 4B. Alternatives 3B.1/Cem and 2B/Cem are approximately 27 percent and 34 percent more expensive, respectively, than the corresponding vitrification alternatives.

Alternative 3B.1/Cem is more expensive than Alternative 3B.1/Vit primarily due to the additional packaging, transportation, and disposal of the larger volume of the cement-stabilized material. Use of the cement stabilization treatment process results in over six times the volume that the vitrification process generates.

Sensitivity Analysis of Present Worth Costs

Some factors that can greatly impact present worth costs are the extent of remediation required, i.e., scope of project, duration of construction, remediation or O&M, and discount rate. The quantity of material included in Subunit B (Silo 3 material) is fairly well defined. A detailed construction

TABLE 5-8

SUBUNIT B ALTERNATIVE COSTS

Alternative	COST[a]			
	Capital	O&M During Remediation	Post-Remediation O&M	Total Present Worth
0B	0	0	0	0
2B/Vit	25,221,500	4,923,000	3,162,000	27,971,300
2B/Cem	35,932,600	4,923,000	3,207,000	37,358,600
3B.1/Vit	26,610,900	4,923,000	0	27,878,700
3B.1/Cem	36,129,000	4,056,000	0	35,393,200

[a]Values are given in dollars ($).

schedule was developed for the duration of construction and remediation, so these factors are not likely to change significantly. Since the relative cost of post-remediation O&M is relatively low in comparison to the capital and short-term O&M costs, a change in the post-remediation time period is not likely to have a major impact on present worth cost. Therefore, discount rate is one factor that can be varied at this time to provide a sensitivity analysis on present worth costs.

A range of three to ten percent for the discount rate was analyzed. Results are provided in Table 5-9. The sensitivity analysis indicates that the relative cost comparison presented for a discount rate of seven percent does not significantly change for the other discount rates evaluated in the sensitivity analysis.

5.4 SUBUNIT C

Subunit C alternatives compared include:

- Alternative 0C - No Action
- Alternative 2C - Demolition, Removal, On-Property Disposal
- Alternative 3C.1 - Demolition, Removal, Off-Site Disposal at NTS
- Alternative 3C.2 - Demolition, Removal, Off-Site Disposal at a Permitted Commercial Disposal Site

A summary of the Subunit C comparative analysis is presented in Table 5-3.

5.4.1 Threshold Criteria

5.4.1.1 Overall Protection of Human Health and the Environment

Assessment of protectiveness for Operable Unit 4 alternatives adopts the use of continued federal ownership of the FEMP site and evaluates risk to the expanded trespasser for the on-property disposal alternatives; the assessment also evaluates risk to the expanded trespasser and off-site resident for off-site disposal alternatives. The summary of remedial alternatives and both short-term and long-term radiological ILCRs is provided in Table 5-5.

All of the Subunit C alternatives, except 0C - No Action, would provide overall protection of human health and the environment. All of the action alternatives (Alternatives 2C, 3C.1, and 3C.2) would limit exposure to contaminants by decontaminating, demolishing, and removing the material to either

TABLE 5-9

SENSITIVITY ANALYSIS
SUBUNIT B PRESENT WORTH COSTS

Discount Rate (%)	PRESENT WORTH COST[a]			
	Alternative 2B/Vit	Alternative 2B/Cem	Alternative 3B.1/Vit	Alternative 3B.1/Cem
3	30,629,900	40,759,900	29,874,300	38,008,000
4	29,888,400	39,822,100	29,351,000	37,321,200
5	29,199,600	38,944,800	24,848,900	36,654,400
6	28,565,600	38,129,800	28,352,700	36,015,700
7	27,971,300	37,358,600	27,878,700	35,393,200
8	27,410,600	36,628,300	27,417,500	34,790,700
9	26,875,800	35,927,800	26,965,100	34,200,200
10	26,377,200	35,270,900	26,535,400	33,637,800

[a]Values are given in dollars ($).

an on-property disposal vault or off-site disposal facility, as well as excavation of contaminated soils and placement of a clean cover over residual contaminated subsurface soils. These alternatives would prevent direct access to contaminated soil and debris and would mitigate the migration of contaminants to the air, surface soil, and groundwater. Exposure to direct radiation above protective levels would also be prevented. The basic difference between the action alternatives is the disposal options. On-property disposal would be an above-grade disposal vault. Off-site disposal options include NTS, a DOE-owned facility (for Alternative 3C.1), or disposal at a permitted commercial disposal site (for Alternative 3C.2).

The on-property disposal vault design would include sufficient barrier to withstand 1000 years of potential erosion with little or no maintenance. Permanent markers would be used to deter purposeful or inadvertent human destruction of the facility's engineered protective features. Although long-term effectiveness is uncertain because of eventual degradation of the facility cap and leachate collection system, fate and transport modeling using conservative assumptions concludes that long-term protection would still be maintained.

NTS and the commercial disposal facility incorporate engineering controls to ensure protectiveness. Both are located in a climatic, demographic, and hydrogeologic setting which favors minimization of contaminant migration to human or environmental receptors. In the event of degradation of engineered features or loss of institutional controls, these site characteristics would help to ensure continued protectiveness.

Alternative 0C would not provide protection of human health and the environment. Long-term risks to on-property receptors would not be within the 10^{-4} to 10^{-6} acceptable risk range.

Short-term risks to the public and workers are slightly greater for the off-site disposal options due to the increased risks of transportation accidents resulting in injuries or radiation exposure.

5.4.1.2 Compliance with ARARs

Alternatives 2C, 3C.1, and 3C.2 would meet all pertinent ARARs identified for these alternatives. Appendix F includes a comprehensive list of potential ARARs and TBCs and describes how each alternative meets the regulatory requirement. For the on-property disposal option, compliance with the OAC 3745-27-07 requirements for the location of a solid waste disposal facility over a sole-source aquifer would be based on demonstrating attainment of the substantive technical criteria for an

exemption to this requirement. In addition, because the material associated with Subunit C poses fewer hazards than the material in Subunits A and B, the on-property disposal vault would require less stringent engineering designs to meet the requirements established in 40 CFR § 192.

Alternative 0C would not comply with all pertinent chemical-, location-, and action-specific ARARs.

5.4.2 Primary Balancing Criteria

Those alternatives that satisfy the threshold criteria of compliance with ARARs and overall protection of human health and environment were carried forward for comparative analysis under the primary balancing criteria. The no-action alternative was carried forward for comparison purposes in accordance with the NCP. Those alternatives include:

- Alternative 0C - No Action
- Alternative 2C - Demolition, Removal, On-Property Disposal
- Alternative 3C.1 - Demolition, Removal, Off-Site Disposal at NTS
- Alternative 3C.2 - Demolition, Removal, Off-Site Disposal at a Permitted Commercial Disposal Site

5.4.2.1 Long-Term Effectiveness and Permanence

All action alternatives, Alternatives 2C, 3C.1, and 3C.2, provide long-term effectiveness associated with contaminated material. The application of each of the action alternatives reduces the residual risk (under continued federal ownership of land) to viable receptors (off-property resident farmer, trespassing child and expanded trespasser) to a HI of less than 0.3 and an ILCR of less than 10^{-5}. The residual contamination would remain at the site in the soil, the level of risk from the residual soil would be mitigated by excavating soil that exceeds proposed final remediation levels.

The difference between the action alternatives is the final disposition of contaminated materials. The issues with the different disposal options are the adequacy and reliability of controls and the long-term environmental impacts. The disposal vault in Alternative 2C significantly reduces leachate formation by limiting infiltration and consequently exfiltration. Institutional controls would preclude the establishment of an on-property residence or farm. In the absence of institutional controls, the on-property vault would continue to provide adequate protection from the most highly contaminated Operable Unit 4 soils. However, off-site disposal at NTS has enhanced reliability because the facility is currently used by DOE for low-level radioactive waste disposal. The institutional controls and

potential for adequate facility maintenance are likely to be more reliable at NTS and the permitted commercial disposal site than on property. Also, the climatic, hydrologic, and geologic characteristics at both off-site disposal facilities would considerably reduce the potential for contaminant migration in the event of a release.

Construction of the on-property disposal vault would permanently disturb 4.7 ha (11.6 acres) of property at the FEMP site. Off-site disposal would result in permanent disturbance at the respective facilities rather than at the FEMP site.

Alternative 0C does not provide risks within the acceptable 10^{-4} to 10^{-6} range for either the on-property or off-property receptors.

5.4.2.2 Reduction of Toxicity, Mobility, or Volume

Alternatives 0C, 2C, 3C.1, and 3C.2 do not include treatment of the contaminated silo structures, berm material, or soils. Therefore, no reduction in toxicity, mobility, or volume would be achieved through treatment. However, as part of the remedial action work plan preparation for the action alternatives (Alternatives 2C, 3C.1, and 3C.2), an approach would be developed to reduce the volume of material requiring management as radioactive waste. Following decontamination, some of the concrete and other structural materials might be suitable for free-release and could be reused, recycled, or disposed in a solid waste landfill.

It should be recognized that the volume of contaminated soils and rubble being addressed under Subunit C is less than one percent of the volumes of similar contaminated materials anticipated to be generated and handled on a sitewide basis under the five FEMP operable units. In the development of all remedial alternatives for Subunit C materials, this FS has considered the integration of several treatment programs currently under development, which potentially can offer waste minimization opportunities in the near future. Operable Unit 3 is currently developing pilot plant programs which focus upon the treatment of rubble and debris prior to disposal. Likewise, Operable Unit 5 is currently evaluating technologies and alternatives which have the potential to treat the Operable Unit 4 contaminated soils.

To ensure the proper integration of sitewide cleanup strategies, activities and the responsible expenditure of available resources, interim storage of Operable Unit 4 generated soils, rubble, and debris may be necessary for a period of time. Interim storage would be provided to enable full

utilization of projected treatment systems (e.g., Operable Unit 5 soil washing) and to provide for consistency in FEMP waste management strategies. Interim storage facilities and practices would be consistent with approved removal action procedures, identified ARARs and other direction provided by EPA.

As discussed in Section 4.2.2, the overlapping remedial action schedules for Operable UnitS 3, 4, and 5 would provide an excellent opportunity to integrate FEMP site-wide cleanup activities in an manner consistent with CERCLA preferences for treatment, minimization of wastes destined for land disposal, and cost-effectiveness.

In the unlikely event unforeseen circumstances preclude the integration of Operable Unit 4 rubble and debris with the Operable Unit 3 Record of Decision and the Operable Unit 4 soils with the Operable Unit 5 Record of Decision, a disposal decision for Operable Unit 4 rubble, debris, and soils could be documented in an Explanation of Significant Differences (ESD) or a ROD amendment for Operable Unit 4 in accordance with Section 117(c) of CERCLA and EPA guidance. The ESD or ROD amendment would provide the public and the EPA further opportunity to review and comment on the selected disposal option for Operable Unit 4 rubble and debris.

5.4.2.3 Short-Term Effectiveness

This evaluation criterion addresses the effects of alternatives during the construction and implementation of the remedial action. For the no-action alternative (Alternative 0C), no remedial action will be taken; therefore, there would be no increase in short-term risks. For the action alternatives (Alternatives 2C, 3C.1, and 3C.2), the various demolition and removal activities would result in increased short-term exposures compared with the no-action alternative (Alternative 0C). However, through a combination of engineering controls and access controls, all of the action alternatives would be protective of the community during implementation.

There would be added risk to the public through transporting the soil and debris off site (Alternatives 3C.1 and 3C.2). Because of the overall low radiological activity of the soil and debris, there would be no estimated increase in radiation to the public during transportation to NTS or the permitted commercial disposal site.

5.4.2.4 Implementability

Implementability includes technical feasibility, administrative feasibility, and availability of services and materials. The technical feasibility of all other alternatives would be similar, and all alternatives should not be difficult to implement. Alternative 0C would be the easiest to implement in the short term because no construction activities are required.

Alternatives 3C.1 and 3C.2 are more administratively difficult to implement than Alternative 2C because of the off-site disposal involved and agency approvals and coordination that would be required for interstate shipments of material to the off-site facilities. Opposition by the public and state

agencies may require extensive negotiations with the regulatory agencies to facilitate the use of this facility. There would be no long-term maintenance associated with Alternatives 3C.1 and 3C.2 at the FEMP site.

5.4.2.5 Cost

The categories of costs developed were capital, short-term O&M (during remediation), and long-term O&M (post-remediation). Total present worth costs were developed for each alternative, assuming a discount rate of seven percent, so that all alternatives with costs incurred over differing time periods could be compared on an equivalent basis. Capital and O&M costs for each Subunit C alternative evaluated in the detailed analysis (Section 4.0) are presented in Table 5-10.

There are no capital or O&M costs associated with Alternative 0C-No Action. Alternative 2C, which includes an on-property disposal, is the least expensive action alternative. Transportation to NTS (Alternative 3C.1) or to a permitted commercial disposal facility (Alternative 3C.2) are both more expensive than constructing an on-property vault. However, the overall cost of disposal at a permitted commercial disposal facility is anticipated to be approximately 64 percent lower than the cost of disposal at a DOE-owned facility. This is primarily due to the packaging requirements of the DOE-owned facility. The commercial disposal facility accepts bulk shipment of material. The unit cost for disposal at a DOE-owned facility is approximately 67 percent of the unit cost for disposal at a commercial facility.

TABLE 5-10

SUBUNIT C ALTERNATIVE COSTS

Alternative	COST[a]			
	Capital	O&M During Remediation	Post-Remediation O&M	Total Present Worth
0C	0	0	0	0
2C	36,340,200	0	3,567,000	34,327,000
3C.1	76,219,700	0	0	68,902,600
3C.2	48,650,600	0	0	43,980,100

[a]Values are given in dollars ($).

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Sensitivity Analysis of Present Worth Costs

Some factors that can greatly impact present worth costs are the extent of remediation required, i.e., scope of project, duration of construction, remediation or O&M, and discount rate. The quantity of material included in Subunit C, particularly, could not be well defined based on the existing soils analytical data. Excavation of surface soils to a depth of 15 cm (6 in.) was assumed for cost estimating purposes since analytical data indicated the presence of contamination at this depth at various parts of the site.

A detailed construction schedule was developed for the duration of construction and remediation, so these factors are not likely to change significantly. Since the relative cost of post-remediation O&M is relatively low in comparison to the capital and short-term O&M costs, a change in the post-remediation time period is not likely to have a major impact on present worth cost. Therefore, the discount rate is another factor that can be varied at this time to provide a sensitivity analysis on present worth costs.

Sensitivity analyses varying soil quantities or discount rate were performed. Total present worth costs were estimated for each alternative assuming excavation of surface soils to a depth of 0.3 m (1 ft) and and 0.45 m (1.5 ft) (using a seven percent discount rate). As indicated in Table 5-11, increasing the quantity of surface soils has an impact on present worth costs because surface soil is a major component of Subunit C materials.

A range of three to ten percent for the discount rate was analyzed. Results are provided in Table 5-12. The sensitivity analysis indicates that the relative cost comparison presented for a discount rate of seven percent does not significantly change for the other discount rates evaluated in the sensitivity analysis.

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TABLE 5-11

SENSITIVITY ANALYSIS-
IMPACT OF SURFACE SOIL VOLUME
SUBUNIT C PRESENT WORTH COSTS

Surface Soil Excavation Depth (inches)	PRESENT WORTH COST[a]		
	Alternative 2C	Alternative 3C.1	Alternative 3C.2
6	34,327,000	68,902,600	43,980,100
12	35,077,000	70,402,600	44,730,100
18	35,827,000	71,902,600	45,480,100

[a]Values are given in dollars ($), estimated assuming seven percent discount rate.

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TABLE 5-12

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SENSITIVITY ANALYSIS-
IMPACT OF DISCOUNT RATE ON
SUBUNIT C PRESENT WORTH COSTS

Discount Rate (%)	PRESENT WORTH COST[a]		
	Alternative 2C	Alternative 3C.1	Alternative 3C.2
3	37,089,800	72,904,100	46,534,300
4	36,324,800	71,875,200	45,877,500
5	35,605,900	70,846,200	45,220,700
6	34,942,500	69,855,400	44,588,300
7	34,327,000	68,902,600	43,980,100
8	33,735,900	67,949,900	43,372,000
9	33,182,800	67,035,200	42,788,200
10	32,664,200	66,158,700	42,228,700

[a]Values are given in dollars ($).

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APPENDIX A

OPERABLE UNIT 4 REMEDIAL INVESTIGATION DATA SUMMARY

APPENDIX A

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A.1.0 INTRODUCTION

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A.1.1 Purpose

Appendix A summarizes and presents data from the Remedial Investigation (RI) Report for Operable Unit 4. All data presented in this appendix were reported and discussed in detail in the RI Report for Operable Unit 4. The primary objective of data collection conducted for the RI Report for Operable Unit 4 was development of a detailed understanding of the nature of the wastes stored in Operable Unit 4, their impacts on the surrounding environment, and the threat posed to human health and the environment by Operable Unit 4. This detailed understanding was successfully developed to the degree necessary to: (1) support the decision on whether remedial action for Operable Unit 4 is warranted; and (2) support the evaluation of available remedial action alternatives in the Feasibility Study (FS).

A.1.2 Description of Summary Tables

The data presented here are summarized and arranged according to the appropriate subunits which are defined in Chapter 1 of this FS Report. Summary statistics were performed on the extremely large volume of RI data collected and reported in the RI Report for Operable Unit 4 to simplify presentation for this FS report. These summaries indicate the frequency of detection along with the number of rejected data points for each analyte. Also presented for each analyte are the mean concentrations, the upper 95 percent confidence intervals (CIs) on the mean, and the ranges of detection. Appendix A presents only that data from the RI which was determined through the data validation process and data useability assessment (both of which are described in detail in the RI Report for Operable Unit 4) to be useable for the purpose described in Section A.1.1. Subsequently, data validation qualifiers are not presented with this data, since qualifiers are only descriptive of and applicable to the discrete analytical results from which the data presented in this appendix are derived. Where appropriate, the summary data tables presented here contain descriptive notes which provide additional explanations to assist understanding of this information.

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APPENDIX A.1

FEASIBILITY STUDY SUBUNIT A
(SILOS 1 AND 2 CONTENTS AND DECANT SUMP TANK SLUDGE)

OPERABLE UNIT 4 SILOS 1 AND 2 CONTENTS
SUMMARY OF RADIOLOGICAL ANALYSES

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TABLE A.1-1

SUMMARY OF RADIONUCLIDE ANALYSES FOR SILOS 1 AND 2 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (pCi/g)[d]	Upper 95% CI on Mean[c] (pCi/g)[d]	Range of Detects[c] (pCi/g)[d]
SILO 1					
Actinium-227	13/20	0	5960	7670	4320-17390
Lead-210	20/20	0	165000	202000	48980-381400
Polonium-210	13/13	0	242000	281000	144000-434000
Radium-226	20/20	0	391000	477000	89280-890700
Thorium-228	2/20	0	422	2280	835-2280
Thorium-230	24/24	0	60000	68900	10569-105372
Thorium-232	8/20	0	424	1110	661-1106
Uranium-234	21/21	0	800	932	326-1548
Uranium-235/236	14/20	0	38	54	19.1-105
Uranium-238	20/20	0	642	693	387-920
SILO 2					
Actinium-227	11/14	0	5100	6640	2905-10450
Lead-210	14/14	0	145000	190000	58160-399200
Polonium-210	8/8	0	139000	231000	55300-241000
Protactinium-231	1/14	0	2350	4040	4041-4041
Radium-226	14/14	0	195000	263000	657-481000
Thorium-228	5/14	0	645	7360	411-7360
Thorium-230	15/15	0	48400	76200	8365-132800
Thorium-232	3/14	0	402	985	851-985
Uranium-234	13/13	0	961	1160	121-1465
Uranium-235/236	11/13	0	73	94	35.6-172
Uranium-238	14/14	0	912	1120	46-1925

[a]Sample numbers used in this data set include: (Silo 1) 99728, 99743, 99870, 99885, 99909, 99930, 99939, 99948, 99966, 99975, 100004, 100025, 100039, 100108 through 100114; and (Silo 2) 99359, 99710, 99774, 99802, 99811, 99831, 99846, 99861, and 100115 through 100120.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% confidence interval (CI) on mean have been rounded to show three significant figures. The mean is calculated using one-half the Sample Quantitation Limit (SQL) for nondetects.
[d]Values expressed in picoCuries per gram (pCi/g).

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TABLE A.1-2

INVENTORY OF K-65 RADIOLOGICAL CONSTITUENTS

	Silo 1[a]		Silo 2[b]	
Analyte	Mean Inventory[c] (Ci)	UCL Inventory[c] (Ci)	Mean Inventory[c] (Ci)	UCL Inventory[c] (Ci)
Actinium-227	40	52	30	39
Lead-210	1110	1360	844	110
Polonium-210	1630	1890	809	1340
Protactinium-231	ND[d]	ND[d]	14	24
Radium-226	2630	3210	1140	1530
Thorium-228	2.8	15.3	3.8	43
Thorium-230	403	463	282	444
Thorium-232	2.9	7.5	2.3	5.7
Uranium-234	5.4	6.3	5.6	6.8
Uranium-235/236	0.26	0.36	0.43	0.55
Uranium-238	4.3	4.7	5.3	6.5
Total Uranium[e]	12.9	14.1	15.9	19.5

[a]Based on a volume of 3280 cubic meters (m^3) and a dry mass density of 2.050 grams per cubic centimeter (gm/cm^3).
[b]Based on a volume of 2840 m^3 and a dry mass density of 2.050 gm/cm^3.
[c]Values for mean and Upper Confidence Limit (UCL) calculated using value taken from Table 4-2 of the Remedial Investigation Report for Operable Unit 4 (RI Report for OU4).
[d]ND - Analyte was not detected.
[e]Total uranium mass values in metric tons (MT). Calculated from the isotopic distribution of uranium.

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OPERABLE UNIT 4 SILOS 1 AND 2 CONTENTS AND DECANT SUMP TANK SLUDGE SUMMARY OF RADIOLOGICAL AND CHEMICAL ANALYSES

TABLE A.1-3

TCLP RADIOLOGICAL ANALYSES FOR SILOS 1 AND 2

Radiological Parameters	Silo 1[a] (pCi/L)									Silo 2[b] (pCi/L)								
	Zone A[c]			Zone B[c]			Zone C[c]			Zone A[c]			Zone B[c]			Zone C[c]		
Ac-227	7302	±	1648	7343	±	2111	5014	±	1371	4258	±	1220	2620	±	620	3400	±	780
Gross Alpha	N/A			N/A			227,000	±	54,000	NA			NA			NA		
Gross Beta	1,950,000	±	200,000	953,000	±	96,000	795,000	±	102,000	51,600	±	5400	1,180,000	±	120,000	1,060,000	±	110,000
Pb-210	1,670,000	±	170,000	997,000	±	103,000	509,000	±	54,000	104,000	±	13,400	220,000	±	25,000	119,000	±	15,000
Po-210	208,000	±	29,100	134,000	±	19,900	71,200	±	17,100	19,900	±	9000	36,200	±	7300	18,100	±	4930
Pa-231	<2800			<3100			<2900			<2000			<3300			<3300		
Ra-226	40,150	±	6050	66,370	±	9811	44,080	±	6609	24,410	±	3773	81,840	±	12,060	79,430	±	11,700
Ra-228	N/A			N/A			N/A			N/A			11	±	2.1	19.7	±	3.7
Th-228	14.9	±	5.3	40	±	14.6	49.8	±	16.4	24.7	±	10	204	±	67	113	±	46
Th-230	455	±	105	307	±	91	394	±	110	72.8	±	24	110	±	42	293	±	84
Th-232	5.65	±	2.72	6.53	±	3.86	8.42	±	4.34	1.87	±	1.94	<50			<50		
U-234	320	±	49	238	±	36	2480	±	460	417	±	67	2330	±	370	3860	±	640
U-235/236	14.1	±	3.5	9.74	±	2.69	133	±	81	19.2	±	4.8	95.6	±	28.3	158	±	44
U-238	332	±	51	246	±	37	2350	±	440	421	±	68	2400	±	380	4000	±	670

N/A - Data not available.
[a]Data from samples 100050 (11/12/92), 100051 (11/12/92), and 100052 (11/12/92).
[b]Data from samples 100065 (11/12/92), 100066 (11/12/92), and 100067 (11/12/92).
[c]The physical characteristics of the "Zones" are provided in Section 3.0 of the RI Report for OU4.

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TABLE A.1-4

K-65 DECANT SUMP TANK
RADIOLOGICAL RESULTS FOR SLUDGE SAMPLE

Analyte	Results (pCi/L)	2 Sigma
Actinium-227	5.8×10^3	603
Lead-210	1.2×10^5	1.2×10^4
Protactinium-231	<855	N/A[a]
Radium-224	<41	N/A[a]
Radium-226	1.3×10^5	6.4×10^3
Radium-228	<140	N/A[a]
Thorium-230	5.2×10^4	7.6×10^3
Total Uranium	<1255[b]	N/A[a]

[a]Value expressed in micrograms per liter (μg/L).
[b]N/A - Not Applicable.

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TABLE A.1-5

CHEMICAL ANALYSES
FOR SILOS 1 AND 2 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithemetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection (mg/kg)[d]
SILO 1					
General Chemistry					
Ammonia	4/7	0	1.19	8.9	1.1-8.9
Chloride	7/7	0	637	1340	269-1349
Fluoride	2/7	0	1	394	15-394
Nitrate	5/5	2	2930	4764	2216-4764
Oil and grease	7/8	0	3650	27000	11.7-27000
Phosphorus	8/8	0	1130	3290	0.4-3290
Sulfate	6/6	1	1300	3460	444-3460
Total Kjeldahl nitrogen	7/7	0	479	676	51.6-782.5
Total organic carbon	8/8	0	19200	26200	5166-34800
Total organic nitrogen	8/8	0	448	623	51.6-782
Metals					
Aluminum	13/19	0	1050	1320	450-2460
Antimony	11/12	7	21	26	13.3-46.2
Arsenic	18/19	0	22	55	3.1-68.4
Barium	19/19	0	11600	14200	1970-22100
Beryllium	17/19	0	1	1	0.59-2.8
Boron	12/12	0	46	50	23.8-61.7
Cadmium	11/18	1	2	4	0.56-8
Calcium	19/19	0	2960	3650	799-5700
Chromium	19/19	0	42	55	19.7-165
Cobalt	19/19	0	936	1100	349-1870
Copper	19/19	0	285	331	122-475
Cyanide	19/19	0	2	3	0.52-4.4
Iron	19/19	0	14700	21100	4280-75100
Lead	19/19	0	81700	95500	17400-133000
Magnesium	19/19	0	2880	3380	1500-6020
Manganese	19/19	0	72	97	25.6-257
Mercury	18/19	0	0.6	0.9	0.15-2.8

TABLE A.1-5
(Continued)

Analyte[a]	Frequency of Detection[b]	Rejected	Arithemetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection (mg/kg)[d]
Molybdenum	12/12	0	4850	6290	968-8600
Nickel	19/19	0	1790	2290	629-3380
Potassium	19/19	0	429	493	158-715
Selenium	19/19	0	287	340	58.5-2810
Silicon	12/12	0	723	853	359-1290
Silver	19/19	0	11	13	5-23.3
Sodium	19/19	0	8670	10700	360-16700
Thallium	8/18	1	0.3	1.4	0.09-1.4
Vanadium	19/19	0	136	161	63.1-293
Zinc	14/19	0	28	37	7.7-212
SILO 2					
General Chemistry					
Chloride	6/6	0	65	141	28-141
Nitrate	5/5	1	5430	8900	3490-8900
Oil and grease	4/4	0	301	541	207-541
Phosphorus	5/5	0	1130	1400	623-1400
Sulfate	6/6	0	8610	19300	2590-19300
Total Kjeldahl nitrogen	3/3	0	204	220	176-220
Total organic carbon	5/5	0	6090	24400	148-24400
Total organic nitrogen	4/4	1	232	289	176-289
Metals					
Aluminum	8/14	0	845	1110	363-2250
Antimony	7/8	6	26	44	14.4-77.4
Arsenic	14/14	0	432	1550	57.5-1960
Barium	14/14	0	6970	19900	89.2-19900
Beryllium	14/14	0	2	3	0.59-6
Boron	5/8	0	38	51	18.4-81.2
Cadmium	13/14	0	5	7	2-19.1
Calcium	14/14	0	33300	301000	64-301000
Chromium	14/14	0	40	51	0.207-83.1
Cobalt	14/14	0	984	2430	6.2-2430
Copper	13/13	1	531	818	220-1790

TABLE A.1-5
(Continued)

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Analyte[a]	Frequency of Detection[b]	Rejected	Arithemetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection (mg/kg)[d]
Cyanide	13/13	1	3	5	0.9-7.1
Iron	13/13	1	16500	28900	4010-40000
Lead	14/14	0	48200	299000	153-299000
Magnesium	14/14	0	3800	6410	805-8740
Manganese	14/14	0	163	259	40.6-403
Mercury	13/13	1	0.9	1.2	0.18-2.3
Molybdenum	8/8	0	291	440	148-479
Nickel	14/14	0	1380	1720	14.6-2640
Potassium	14/14	0	217	337	37.8-653
Selenium	13/13	1	110	124	49.6-155
Silicon	8/8	0	851	1148	507-1780
Silver	13/13	1	17	22	7.4-34.9
Sodium	14/14	0	2430	3200	226-4940
Thallium	9/12	1	1	2	0.33-5.7
Vanadium	14/14	0	237	298	21.9-535
Zinc	14/14	0	54	91	11.2-159

[a]Sample numbers used in this data set include: 99359, 99704-99806, 99711-99713, 99715, 99718, 99769-99771, 99775-99778, 99781, 99723-99725, 99729-99732, 99735, 99738-99740, 99745-99747, 99750, 99806-99808, 99812-99815, 99818, 99826-99828, 99832-99834, 99837, 99839, 99841-99843, 99847-99850, 99853, 94856-99858, 99865-99867, 99871-99874, 99877, 99880-99882, 99886-99889, 99904-99906, 99910-99913, 99916, 99925-99927, 99934-99936, 99940-99943, 99946, 99963-99965, 99980-99984, 99986, 99987, 99999, 100000, 100001, 100026-100029, 100032, 100034-100036, and 100115-100120.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.
[d]Values expressed in milligrams per kilogram (mg/kg).

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TABLE A.1-6

ORGANICS ANALYSES FOR SILO 1 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection[c] (mg/kg)[d]
PCBs and Pesticides					
4,4'-DDT	2/19	0	0.21	0.07	0.014-0.068
4,4'-DDE	2/19	0	0.22	0.12	0.029-0.12
Aldrin	1/19	0	0.09	0.056[e]	e
Aroclor-1248	3/17	2	1.2	2	1.7-10
Aroclor-1254	17/17	2	7.4	10	1.1-20
Aroclor-1260	2/19	0	2.6	3.5	1.3-3.5
Dieldrin	1/19	0	0.21	0.093[e]	e
Endosulfan-I	2/19	0	0.1	0.092	0.011-0.092
Endosulfan II	2/19	0	0.22	0.26	0.082-0.26
Endrin	1/19	0	0.2	0.089[e]	e
Heptachlor epoxide	2/19	0	0.11	0.2	0.022-0.2
Semivolatile Organics					
Benzoic acid	4/12	7	0.53	0.12	0.075-0.12
Bis(2-Ethylhexyl)phthalate	12/16	3	0.7	1.5	0.07-6
Di-n-butylphthalate	2/19	0	0.21	0.057	0.046-0.057
Di-n-octylphthalate	8/19	0	0.3	0.97	0.045-0.97
Dimethyl phthalate	5/12	7	0.16	0.16	0.068-0.16
N-nitroso-di-n-propylamine	1/12	7	0.24	0.059[e]	e
Phenol	1/12	7	0.28	0.4[e]	e
Tributyl phosphate	9/9	2	15	51	0.2-51
Volatile Organics					
2-Butanone	4/11	7	0.007	0.022	0.002-0.022
2-Hexanone	6/11	7	0.007	0.017	0.002-0.017
4-Methyl-2-pentanone	3/11	7	0.005	0.003	0.002-0.003
Acetone	6/11	7	0.05	0.15	0.064-0.15
Methylene chloride	2/11	7	0.02	0.19	0.0380-0.19
Toluene	4/11	7	0.02	0.05	0.002-0.19

[a]Sample numbers used in this data set include: 99733, 99875, 99914, 99931, 99944, 99722, 99733, 99737, 99748, 99864, 99875, 99879, 99890, 99903, 99914, 99924, 99931, 99933, 99944, 99958, 99959, 99977, 99979, 99890, 100009, 100019, 100030, 100033, 100040, and 100108 through 100114.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte was detected in a single sample.

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TABLE A.1-7

SUMMARY OF ORGANICS
ANALYSES FOR SILO 2 RESIDUES

Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection[c] (mg/kg)[d]
PCBs and Pesticides					
Aroclor-1254	8/8	6	6.6	15	0.42-15
Aroclor-1260	1/14	0	1.4	0.034[e]	e
Semivolatile Organics					
Benzoic acid	3/9	4	0.57	0.39	0.076-0.39
Bis(2-ethylhexyl)phthalate	8/8	5	0.55	1.2	0.19-1.9
Diethyl phthalate	1/7	6	0.24	0.41[e]	e
Fluoranthene	1/13	0	0.18	0.064[e]	e
N-nitroso-di-n-propylamine	3/7	6	0.17	0.26	0.083-0.26
Pyrene	1/13	0	0.17	0.047[e]	e
Tributyl phosphate	5/5	1	29	73	7.5-73
Volatile Organics					
2-Butanone	1/7	7	0.007	0.01[e]	e
Acetone	3/7	7	0.02	0.07	0.033-0.072
Carbon tetrachloride	1/8	6	0.005	0.17[e]	e
Methylene chloride	2/8	6	0.013	0.047	0.015-0.047
Tetrachloroethene	1/8	6	0.005	0.14[e]	e
Toluene	1/8	6	0.008	0.01[e]	e
Total xylenes	1/7	7	0.006	0.003[e]	e

[a]Sample numbers used in this data set include: 99359, 99701, 99702, 99768, 99779, 99796, 99803, 99805, 99816, 99825, 99835, 99840, 99851, 99855, 99862, and 100115-100120.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte detected in a single sample.

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TABLE A.1-8

SUMMARY OF EP TOXICITY RESULTS FOR SILOS 1 AND 2 RESIDUES - 1989[a]

Analyte[b]	Frequency of Detection	Mean (mg/L)	Standard Deviation (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Maximum Concentration of Contaminants[c] (mg/L)
Silo 1						
Arsenic	6/7	0.312	0.144	ND[d]	0.484	5.0
Barium	7/7	4.362	4.399	0.079	14.5	100.0
Cadmium	6/7	0.027	0.031	ND	0.1	1.0
Chromium	7/7	0.333	0.277	0.02	0.964	5.0
Lead	7/7	561	278	0.159	904	5.0
Mercury	0/7	ND	ND	ND	ND	0.2
Selenium	7/7	0.535	0.238	0.217	0.997	1.0
Silver	6/7	0.074	0.040	ND	0.121	5.0
Silo 2						
Arsenic	6/6	0.389	0.137	0.163	0.592	5.0
Barium	6/6	1.087	0.755	0.095	2.62	100.0
Cadmium	6/6	0.102	0.091	0.017	0.278	1.0
Chromium	4/6	0.380	0.365	ND	1.02	5.0
Lead	6/6	322	266	0.155	714	5.0
Mercury	0/6	ND	ND	ND	ND	0.2
Selenium	6/6	0.705	0.488	0.24	1.56	1.0
Silver	4/6	0.087	0.076	ND	0.213	5.0

[a]The data presented in table have not been validated.
[b]The sample numbers used in this data set include: (Silo 1) MM3336 through MM3343; (Silo 2) MM3340 through MM3348.
[c]Data obtained from 40 CFR 261.24.
[d]ND - Not detected

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TABLE A.1-9

SUMMARY OF TCLP METALS ANALYSES FOR SILO 1 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration
Aluminum	12/12	0	0.314	0.067	0.228-0.441	g
Antimony	12/12	0	0.093	0.019	0.067-0.129	g
Arsenic	1/11	1	0.002	e	e	5.0
Barium	12/12	0	0.868	0.402	0.348-1.83	100.0
Beryllium	6/12	0	0.002	0.0004	0.002-0.003	g
Boron	11/12	0	0.255	0.070	0.168-0.384	g
Cadmium	12/12	0	0.003	0.001	0.002-0.005	1.0
Calcium	12/12	0	55.4	33.6	17.6-108	g
Chromium	12/12	0	0.059	0.012	0.045-0.081	5.0
Cobalt	12/12	0	1.82	0.89	0.72-3.06	g
Copper	12/12	0	0.208	0.097	0.068-0.404	g
Iron	10/12	0	0.046	0.022	0.018-0.1	g
Lead	8/9	3	614	221	229-841	5.0
Magnesium	12/12	0	8.96	2.00	6.12-13.8	g
Manganese	12/12	0	0.163	0.070	0.067-0.308	g
Mercury	1/12	0	0.0002	e	e	0.2
Molybdenum	12/12	0	0.072	0.026	0.036-0.108	g
Nickel	12/12	0	3.18	1.39	1.32-5.57	g
Potassium	12/12	0	10.3	5.32	2.95-18.3	g
Selenium	11/11	1	0.135	0.088	0.015-0.306	1.0
Silicon	12/12	0	31.9	8.2	13.5-42.1	g
Silver	12/12	0	0.034	0.008	0.023-0.048	5.0
Thallium	9/12	0	0.005	0.003	0.002-0.009	g
Vanadium	12/12	0	0.023	0.005	0.017-0.032	g
Zinc	12/12	0	0.128	0.079	0.02-0.323	g

[a]The sample numbers used in this data set include: 99727,99742,99869,99884,99908, 99929,99938, 99967, 99985, 100003, 100024, and 100038.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in milligrams per liter (mg/L).
[e]Analyte was detected in a single sample.
[f]Data obtained from 40 CFR 261.24.
[g]No standard Maximum Allowable Concentrations (MAC) specified in 40 CFR 261.24.

TABLE A.1-10

SUMMARY OF TCLP ORGANICS ANALYSES FOR SILO 1 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Consentration[f]
PCBs and Pesticides						
None detected						
Semivolatile Organics						
4-Chloro-3-methylphenol	1/10	1	0.004	e	e	g
4-Nitrophenol	1/11	0	0.008	e	e	g
Benzoic acid	4/10	1	0.049	0.048	0.006-0.1	g
Bis(2-Ethylhexyl)phthalate	2/10	1	0.052	0.065	0.006-0.098	g
Di-n-octylphthalate	4/10	1	0.021	0.002	0.005-0.05	g
N-Nitroso-di-n-propylamine	4/10	1	0.127	0.116	0.018-0.28	g
Volatile Organics						
2-Butanone	7/9	2	0.005	0.003	0.001-0.01	200.0
4-Methyl-2-pentanone	8/11	0	0.002	0.003	0.001-0.01	g
Acetone	9/10	1	0.223	0.153	0.069-0.49	g
Methylene chloride	9/11	0	0.018	0.010	0.009-0.038	g
Tetrachloroethene	1/5	6	0.001	e	e	0.7
Toluene	5/11	0	0.002	0.002	0.001-0.005	g

[a]The sample numbers used in this data set include: 99726, 99734, 99741, 99749, 99868, 99876, 99883, 99891, 99907, 99915, 99928, 99932, 99937, 99945, 99960, 99962, 99976, 100010, 100023, 100031, 100037, and 100041.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d]Values expressed in milligrams per liter (mg/L).
[e]Analyte detected in a single sample.
[f]Data obtained from 40 CFR 261.24.
[g]No standard MAC specified in 40 CFR 261.24.

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TABL[illegible].1-11

SUMMARY OF TCLP METALS ANALYSES FOR SILO 2 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration[e]
Aluminum	7/7	0	1.29	0.763	0.462-2.75	f
Antimony	6/6	1	0.096	0.018	0.079-0.123	f
Arsenic	8/8	0	0.064	0.110	0.003-0.32	5.0
Barium	8/8	0	2.96	3.30	0.157-8.47	100.0
Beryllium	7/7	0	0.005	0.0007	0.003-0.006	f
Boron	4/4	0	0.69	0.58	0.24-1.5	f
Cadmium	7/7	1	0.047	0.028	0.010-0.077	1.0
Calcium	7/7	0	483	276	163-975	f
Chromium	8/8	0	0.129	0.036	0.086-0.207	5.0
Cobalt	7/7	0	3.02	2.11	1.18-6.16	f
Copper	7/7	0	1.41	1.41	0.274-3.86	f
Iron	7/7	0	0.076	0.012	0.053-0.090	f
Lead	7/7	1	516	348	117-1072	5.0
Magnesium	7/7	0	15.4	8.84	7.39-29.6	f
Manganese	7/7	0	0.776	0.466	0.409-1.62	f
Molybdenum	7/7	0	0.058	0.027	0.034-0.099	f
Nickel	7/7	0	3.48	1.45	2.04-5.77	f
Potassium	5/7	0	4.032	1.18	2.64-5.31	f
Selenium	8/8	0	0.114	0.184	0.026-0.568	1.0
Silicon	5/5	1	16.3	5.2	12.1-24.3	f
Silver	8/8	0	0.093	0.032	0.053-0.164	5.0
Thallium	6/7	0	0.009	0.011	0.0022-0.0288	f
Vanadium	5/5	1	0.053	0.006	0.046-0.060	f
Zinc	6/6	1	0.339	0.184	0.141-0.563	f

[a]The sample numbers used in this data set include: 99355, 99709, 99773, 99801, 99810, 99830, 99845, and 99860.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d]Values expressed in milligrams per liter (mg/L).
[e]Data obtained from 40 CFR 261.24.
[f]No standard MAC specified in 40 CFR 261.24.

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TABLE A.1-12

SUMMARY OF TCLP ORGANICS ANALYSES FOR SILO 2 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration[f] (mg/L)
PCBs and Pesticides						
alpha-BHC	1/6	1	0.0002	e	e	g
beta-BHC	3/6	1	0.0004	0.0002	0.0002-0.0006	g
Semivolatile Organics						
N-Nitroso-di-n-propylamine	1/7	0	0.005	e	e	g
Pentachlorophenol	1/7	0	0.018	e	e	100.0
Tributyl Phosphate	1/1	0	0.66	e	e	g
Volatile Organics						
2-Butanone	3/7	1	0.002	0.002	0.002-0.002	200.0
4-Methyl-2-pentanone	1/8	0	0.001	e	e	g
Acetone	2/8	0	0.0535	0.054	0.015-0.092	g
Carbon disulfide	1/8	0	0.004	e	e	g
Methylene chloride	2/8	0	0.03	0.023	0.014-0.046	g

[a]The sample numbers used in this data set include: 99707, 99708, 99772, 99780, 99800, 99804, 99809, 99817, 99829, 99836, 99844, 99852, 99859, and 99863.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d]Values expressed in milligrams per liter (mg/L).
[e]Analyte was detected in a single sample.
[f]Data obtained from 40 CFR 261.24.
[g]No standard MAC specified in 40 CFR 261.24.

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TABLE A.1-13

ESTIMATED INVENTORY OF K-65 SILOS METALS

	Silo 1[a]		Silo 2[b]	
Analyte	Mean Inventory[c] (MT)[d]	UCL Inventory[c] (MT)[d]	Mean Inventory[c] (MT)[d]	UCL Inventory[c] (MT)[d]
Aluminum	7.06	8.88	4.92	6.46
Antimony	0.14	0.17	0.16	0.27
Arsenic	0.15	0.37	2.52	9.02
Barium	78.0	95.5	40.6	116
Beryllium	0.007	0.007	0.01	0.02
Boron	0.31	0.35	0.22	0.30
Cadmium	0.013	0.027	0.029	0.04
Calcium	19.9	24.5	194	1750
Chromium	0.28	0.37	0.23	0.30
Cobalt	6.29	7.40	5.73	14.1
Copper	1.92	2.23	3.09	4.76
Cyanide	0.013	0.020	0.02	0.03
Iron	98.8	142	96.1	168
Lead	549	642	281	1740
Magnesium	19.4	22.7	22.1	37.3
Manganese	0.48	0.65	0.95	1.51
Mecury	0.004	0.006	0.005	0.007
Molybdenum	32.6	42.3	1.69	2.56
Nickel	12.0	15.4	8.03	10.0
Potassium	2.88	3.31	1.26	1.96
Selenium	1.92	2.29	0.64	0.72
Silicon	4.86	5.74	4.95	6.68
Silver	0.07	0.09	0.10	0.13
Sodium	58.3	71.9	14.1	18.6
Thallium	0.002	0.009	0.006	0.012
Vanadium	0.91	1.08	1.38	1.73
Zinc	0.17	0.25	0.31	0.53

[a]Based on a volume of 3280 m^3 and a dry mass density of 2.050 gm/cm^3.
[b]Based on a volume of 2840 m^3 and a dry mass density of 2.050 gm/cm^3.
[c]Values for mean and UCI concentrations taken from Table 4-4 of the RI Report for OU4.
[d]Units are in metric tons (MT).

APPENDIX A.2

FEASIBILITY STUDY SUBUNIT B
(SILO 3 CONTENTS)

OPERABLE UNIT 4 SILO 3 CONTENTS
SUMMARY OF SILO 3 RADIOLOGICAL ANALYSES

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TABLE A.2-1

SUMMARY OF RADIONUCLIDE CONCENTRATIONS IN SILO 3 RESIDUES

Analyte [a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (pCi/g)[d]	Upper 95% CI on Mean[c] (pCi/g)[d]	Range of Detection[c] (pCi/g)[d]
SILO 3					
Actinium-227	9/9	2	618	925	234-1363
Lead-210	11/11	0	2620	3480	454-6427
Protactinium-231	9/11	0	487	627	266-931
Radium-224	11/11	0	290	367	64-453
Radium-226	11/11	0	2970	3870	467-6435
Radium-228	9/11	0	297	406	82-559
Thorium-228	7/11	0	590	747	459-996
Thorium-230	11/11	0	51200	60200	21010-71650
Thorium-232	8/11	0	656	842	411-1451
Uranium-234	11/11	0	1480	1730	348-1935
Uranium-235/236	10/11	0	93.6	117	42-158
Uranium-238	11/11	0	1500	1780	320-2043

[a]Sample numbers used in this data set include: 100097 - 100107.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean have been rounded to show three significant figures. The mean is calculated using one-half the SQL for nondetects.
[d]Values expressed in picoCuries per gram (pCi/g).

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TABLE A.2-2

INVENTORY OF SILO 3
RADIOLOGICAL CONSTITUENTS

Analyte	Silo 3[a] Mean Inventory[b] (Ci)[c]	Silo 3[a] UCL Inventory[b] (Ci)[c]
Actinium-227	5.4	8.2
Protactinium-231	4.3	5.5
Lead-210	23.2	30.8
Radium-224	2.6	3.2
Radium-226	26.3	34.2
Radium-228	2.6	3.6
Thorium-228	5.2	6.60
Thorium-230	453	532
Thorium-232	5.8	7.4
Uranium-234	13.1	15.3
Uranium-235/236	0.83	1.04
Uranium-238	13.3	15.7
Total Uranium	39.9[d]	47.2[d]

[a]Based on a volume of 3900 m^3 and a dry mass density of 2.267 gm/cm^3.
[b]Values for mean and UCI concentrations taken from Table 4-19 of the RI Report for OU4.
[c]Values expressed in Curies.
[d]Total uranium mass values in MT. Calculated from isotopic distribution of uranium.

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TABLE A.2-3

TCLP RADIOLOGICAL ANALYSES FOR SILO 3 RESIDUES

Radiological Parameters[a]	Concentration (pCi/L)[b]
Actinium-227	5.54 ± 1.94
Gross alpha	3150 ± 830
Gross beta	670 ± 340
Lead-210	87.1 ± 9.2
Polonium-210	245 ± 110
Protactinium-231	< 647
Radium-226	2455 ± 558
Radium-228	< 110
Thorium-228	3.17 ± 1.42
Thorium-230	10.4 ± 2.8
Thorium-232	< 1
Uranium-234	92.2 ± 13.8
Uranium-235/236	5.09 ± 1.59
Uranium-238	86 ± 13

[a]Data from sample 100074 (11/12/92).
[b]Values for concentration taken from Table 4-22 of the RI Report for OU4, expressed in picoCuries per liter (pCi/L).

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OPERABLE UNIT 4 SILO 3 CONTENTS
SUMMARY OF CHEMICAL ANALYSES

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TABLE A.2-4

INVENTORY OF SILO 3 METALS

Analyte	Silo 3[a] Mean Inventory[b] (MT)[c]	Silo 3[a] UCL Inventory[b] (MT)[c]
Aluminum	152	175
Arsenic	17.2	28.0
Barium	1.92	2.46
Beryllium	0.21	0.26
Cadmium	0.53	0.83
Calcium	260	295
Chromium	2.55	3.49
Cobalt	18.6	25.6
Copper	22.5	29.5
Iron	334	462
Lead	15.3	21.0
Magnesium	518	609
Manganese	38.7	45.6
Mercury	0.004	0.006
Nickel	27.9	37.9
Potassium	64.2	124
Selenium	1.54	2.02
Silver	0.14	0.16
Sodium	319	361
Thallium	0.19	0.50
Vanadium	16.1	30.9
Zinc	3.98	4.73

[a]Based on a volume of 3900 cubic meters (m^3) and a dry mass density of 2.267 gm/cm^3.
[b]Values for mean and UCI concentrations taken from Table 4-20 of the RI Report for OU4.
[c]Units are expressed in metric tons (MT).

TABLE A.2-5

EP TOXICITY RESULTS FOR SILO 3 RESIDUES - 1989[a]

Analyte[b]	Frequency of Detection	Mean (mg/L)[d]	Standard Deviation (mg/L)[d]	Minimum (mg/L)[d]	Maximum (mg/L)[d]	Maximum Allowable Concentration[c] (mg/L)[d]
Silo 3						
Arsenic	9/11	9.481	12.393	ND[e]	41.5	5.0
Barium	11/11	0.080	0.046	0.02	0.156	100.0
Cadmium	11/11	0.847	1.740	0.108	6.32	1.0
Chromium	11/11	5.05	3.22	0.336	11.9	5.0
Lead	7/11	0.239	0.327	ND[e]	1.01	5.0
Mercury	2/11	0.0005	0.0009	ND[e]	0.003	0.2
Selenium	11/11	2.65	3.00	0.92	11.7	1.0
Silver	1/11	0.007	0.008	ND[e]	0.032	5.0

[a]The data presented in table have not been validated.
[b]The sample numbers used in this data set include: MM3325 through MM3335.
[c]Data obtained from 40 CFR 261.24.
[d]Values expressed in milligrams per liter (mg/L).
[e]ND - Not Detected.

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TABLE A.2-6

SUMMARY OF INORGANIC ANALYSES FOR SILO 3 RESIDUES

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Analyte[a]	Frequency of Detection[b]	Rejected	Arithmetic Mean[c] (mg/kg)[d]	Upper 95% CI on Mean[c] (mg/kg)[d]	Range of Detection[c] (mg/kg)[d]
Metals					
Aluminum	11/11	0	17200	19800	10800-23700
Antimony	1/1	10	5.5[e]	e	e
Arsenic	11/11	0	1950	3170	532-6380
Barium	11/11	0	217	278	118-332
Beryllium	11/11	0	24.2	29.1	10-39.9
Cadmium	11/11	0	60	94	21.5-204
Calcium	11/11	0	29400	33400	21300-39900
Chromium	11/11	0	288	395	139-560
Cobalt	10/10	1	2100	2890	1100-3520
Copper	11/11	0	2550	3340	1610-7060
Iron	11/11	0	37800	52200	13900-67600
Lead	11/11	0	1730	2380	646-4430
Magnesium	11/11	0	58600	68900	38200-80900
Manganese	11/11	0	4380	5160	2420-6500
Mercury	3/3	8	0.4	0.7	0.3-0.69
Nickel	10/10	1	3150	4290	1760-6170
Potassium	11/11	0	7260	14000	1300-22800
Selenium	11/11	0	174	229	101-349
Silver	11/11	0	16	18	9.2-23.8
Sodium	11/11	0	36100	40800	22900-51700
Thallium	10/10	1	21	56	4-73.9
Vanadium	11/11	0	1820	3490	418-4550
Zinc	11/11	0	450	535	301-672

[a]Sample numbers used in this data set include: 100097 through 100107.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R are excluded. The mean and upper 95% CI on mean has been rounded to show three significant figures.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte detected in a single sample.

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APPENDIX A.3

FEASIBILITY STUDY SUBUNIT C
(SILOS STRUCTURES, SOILS, DECANT SUMP TANK LIQUID, ANCILLARY PIPING AND EQUIPMENT)

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OPERABLE UNIT 4 DECANT SUMP TANK LIQUID
SUMMARY OF CHEMICAL ANALYSES

TABLE A.3-1

SUMMARY OF CHEMICAL ANALYSES FOR K-65 DECANT SUMP TANK LIQUIDS (1991)

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]
General Chemistry					
Ammonia	2/2	1	19.4	11.2	11.5-27.4
Chloride	2/2	1	105	2.54	103.4-107
Fluoride	3/3	0	54	57	20-120
Nitrate	3/3	0	1320	834	791.2-2280
Phenols	3/3	0	0.02	0.01	0.01-0.03
Phosporus	3/3	0	2.42	0.791	1.53-3.03
Sulfate	3/3	0	6590	2820	4605-9812.6
Total Organic Carbon	3/3	0	44.6	11.2	31.8-52.1
Total Organic Halides	3/3	0	0.225	0.053	0.164-0.261
Total Organic Nitrogen	2/2	0	12.4	17.1	0.309-24.55
Metals					
Aluminum	4/4	0	1.79	0.253	1.43-1.99
Antimony	4/4	0	0.226	0.037	0.188-0.26
Arsenic	4/4	0	0.612	0.082	0.5-0.683
Barium	4/4	0	0.036	0.020	0.0216-0.0658
Beryllium	4/4	0	0.010	0.001	0.008-0.012
Cadmium	4/4	0	0.010	0.003	0.005-0.014
Calcium	4/4	0	4.73	1.31	3.52-6.51
Chromium	4/4	0	0.38	0.05	0.31-0.43
Cobalt	4/4	0	0.072	0.005	0.066-0.079
Copper	4/4	0	0.122	0.042	0.088-0.184
Cyanide	3/3	0	0.352	0.066	0.310-0.429
Iron	4/4	0	0.476	0.376	0.272-1.04
Lead	4/4	0	0.284	0.214	0.138-0.602
Magnesium	4/4	0	3.53	0.45	3.19-4.19
Manganese	4/4	0	0.105	0.125	0.0286-0.293

TABLE A.3-1
(Continued)

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]
Molybdenum	4/4	0	6.90	0.80	6.17-7.74
Nickel	4/4	0	0.084	0.030	0.065-0.129
Potassium	4/4	0	35.6	5.10	28.3-40.1
Selenium	4/4	0	4.89	1.38	2.9-6.02
Silicon	3/3	0	77.9	12.3	68.5-91.8
Silver	4/4	0	0.20	0.03	0.16-0.23
Sodium	3/4	0	4473	2237	1900-5950
Vanadium	4/4	0	0.237	0.015	0.22-0.256
Zinc	4/4	0	0.166	0.214	0.031-0.486

[a]The sample numbers used in this data set include: 99411, 99412, 99415, and 99416.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d] Values expressed in milligrams per liter (mg/L).

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TABLE A.3-2

SUMMARY OF K-65 DECANT SUMP TANK LIQUID METALLIC CONSTITUENTS VERSUS TCLP AND EP TOXICITY RESULTS FOR SILOS 1 AND 2

	Decant Sump Tank		Silo 1 Residue 1990/1991 Sampling TCLP Metals		Silo 2 Residue 1990/1991 Sampling TCLP Metals		Silos 1 and 2 Residue 1989 Sampling EP Toxicity Metals	
Analyte	Mean (mg/L)[a]	Standard Deviation (mg/L)[a]	Mean (mg/L)[a]	Standard Deviation (mg/L)[a]	Mean (mg/L)[a]	Standard Deviation (mg/L)[a]	Silo 1 (4 Samples) (mg/L)[a]	Silo 2 (6 Samples) (mg/L)[a]
Antimony	0.226	0.037	0.093	0.019	0.096	0.018	-	-
Arsenic	0.612	0.082	0.002	0	0.064	0.110	ND-0.484	0.163-0.592
Barium	0.036	0.020	0.868	0.402	2.96	3.30	0.079-14.5	0.095-2.62
Beryllium	0.010	0.001	0.002	0.0004	0.005	0.0007	-	-
Cadmium	0.010	0.003	0.003	0.001	0.047	0.028	ND-0.1	0.017-0.278
Chromium	0.38	0.05	0.059	0.012	0.129	0.036	0.02-0.964	ND-1.02
Cobalt	0.072	0.005	1.82	0.89	3.02	2.11	-	-
Copper	0.122	0.042	0.208	0.097	1.41	1.41	-	-
Lead	0.284	0.214	614	221	516	348	0.159-904	0.155-714
Manganese	0.105	0.125	0.163	0.070	0.776	0.466	-	-
Molybdenum	6.90	0.80	0.072	0.026	0.058	0.027	-	-
Nickel	0.084	0.030	3.18	1.39	3.48	1.45	-	-
Selenium	4.89	1.38	0.135	0.088	0.114	0.184	0.217-0.997	0.24-1.56
Silver	0.20	0.03	0.034	0.008	0.093	0.032	ND-0.121	ND-0.213
Vanadium	0.237	0.015	0.023	0.005	0.053	0.006	-	-
Zinc	0.166	0.214	0.128	0.079	0.339	0.184	-	-

[a]Values for analytes expressed in milligrams per liter (mg/L).

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TABLE A.3-3

SUMMARY OF ORGANIC ANALYSES FOR K-65 DECANT SUMP LIQUIDS (1991)

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]
PCBs and Pesticides					
Aroclor-1242	2/3	0	0.001	0.000	0.001-0.0012
Semivolatile Organics					
2-Nitrophenol	1/1	2	0.11	e	e
2,4-Dinitrophenol	1/1	2	0.005	e	e
2,6-Dinitrotoluene	1/3	0	0.002	e	e
4-Nitrophenol	2/3	0	0.001	0.0007	0.001-0.002
4-Methylphenol	1/1	2	0.003	e	e
Benzoic acid	2/2	1	0.0015	0.0007	0.001-0.002
bis(2-Ethylhexyl)phthalate	1/3	0	0.002	e	e
Phenol	1/1	2	0.006	e	e
Volatile Organics					
2-Hexanone	1/3	0	0.003	e	e
4-Methyl-2-pentanone	2/3	0	0.003	0.0007	0.002-0.003
Carbon disulfide	1/3	0	0.004	e	e
Carbon tetrachloride	1/3	0	0.008	e	e
Chloroform	2/3	0	0.004	0.004	0.001-0.006
Ethyl benzene	1/3	0	0.001	e	e
Tetrachlorethene	1/3	0	0.003	e	e
Toluene	2/3	0	0.034	0.044	0.003-0.066
Total xylenes	1/3	0	0.007	e	e

[a]The sample numbers used in this data set include: 99412, 99415, and 99416.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded.
[d]Values expressed in milligrams per liter (mg/L).
[e]Analyte was detected in a single sample.

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OPERABLE UNIT 4 DECANT SUMP TANK LIQUID
SUMMARY OF RADIOLOGICAL ANALYSES

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TABLE A.3-4

SUMMARY OF K-65 DECANT SUMP TANK LIQUID RADIOLOGICAL RESULTS
(SAMPLING DURING THE REMOVAL ACTION)

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (pCi/L)[d]	Standard Deviation[c] (pCi/L)[d]	Range of Detects[c] (pCi/L)[d]
Lead-210	1/1	0	8660	f	f
Neptunium-237	1/2	1	1.2	f	f
Polonium-210	1/1	0	7080	f	f
Radium-226	4/4	0	1098	389	797-1640
Radium-228	2/4	0	6.80	2.82	4.81-8.8
Strontium-90	1/3	0	6.47	f	f
Technetium-99	1/3	0	43.8	f	f
Total Uranium	3/3	0	74300[e]	3560[e]	70400-77400[e]
Uranium-235	2/2	1	1190	167	1074-1310
Uranium-238	2/2	1	23200	3970	20390-26000
Thorium-228	1/2	0	2.72	f	f
Thorium-230	1/2	0	197	f	f

[a]The sample numbers used in this data set include: 99411, 99412, 99415, and 99416.
[b]Rejected data not included in total number of samples.
[c]Values qualified with a R or < are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in picoCuries per liter (pCi/L).
[e]Values expressed in micrograms per liter (μg/L).
[f]Analyte was detected in a single sample.

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OPERABLE UNIT 4 SURFACE SOIL
SUMMARY OF CHEMICAL ANALYSES

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TABLE A.3-5

SUMMARY OF SURFACE SOIL INORGANIC ANALYSES WASTE PIT AREA RUNOFF CONTROL PROJECT

Analytes[a]	Frequency of Detection	Rejected	Mean[b] (mg/kg)[c]	Standard Deviation[b]	Range[b] (mg/kg)[c]
Aluminum	10/10	0	81780	2051.51	4690-10900
Antimony	10/10	0	27.91	3.80	20.6-32.3
Arsenic	10/10	0	6.23	2.32	2.7-9.5
Barium	10/10	0	67.02	20.37	44.7-113
Beryllium	10/10	0	0.79	0.12	0.67-1
Cadmium	10/10	0	5.25	0.75	3.7-6.2
Calcium	10/10	0	81470	35625.55	23300-131000
Chromium	10/10	0	16.57	3.47	10.2-22.6
Cobalt	10/10	0	10.71	2.15	7.8-14.8
Copper	10/10	0	19.36	2.18	16.2-23.5
Cyanide	1/10	0	0.12	na	0.12-0.12
Iron	10/10	0	17660	4202.17	11100-26300
Lead	10/10	0	11.89	2.60	6.7-17
Magnesium	10/10	0	20560	5622.22	10800-26800
Manganese	10/10	0	551.30	208.98	372-1130
Molybdenum	10/10	0	4.26	0.55	3.2-4.9
Nickel	10/10	0	28.52	5.35	22.8-38.9
Potassium	10/10	0	940.20	247.78	530-1430
Selenium	7/10	0	0.48	0.04	0.43-0.54
Silver	10/10	0	8.50	1.13	6.6-9.7
Sodium	8/10	0	116.54	19.89	97.2-145
Thallium	7/10	0	0.47	0.03	0.43-0.51
Vanadium	10/10	0	22.54	3.45	15.9-27.7
Zinc	10/10	0	45.49	9.32	32.9-65.2

[a]The sample numbers used in this data set include: 61100, 61121, 61128, 61135, 61142, 61150, 61156, 61163, 61240, and 61254.
[b]Values qualified with a R or < are excluded.
[c]Values expressed in milligrams per kilogram (mg/kg).

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TABLE A.3-6

SUMMARY OF SURFACE SOIL ORGANIC ANALYSES
WASTE PIT AREA RUNOFF CONTROL PROJECT

Analyte[a]	Frequency of Detection	Rejected	Mean[b] (mg/kg)[c]	Standard Deviation	Range[b] (mg/kg)[c]
2-Butanone	3/8	0	.004	0.003	0.002 - .008
Acetone	3/8	0	0.03	0.04	0.004 - .079
Aroclor-1254	1/8	1	0.03[d]	c	0.03
Benzo(a)anthracene	2/8	0	2.38	3.28	.062 - 4.7
Benzo(a)pyrene	1/8	0	5.20[d]	c	5.2
Benzo(b)fluoranthene	2/8	0	4.93	6.75	0.15 - 9.7
Benzo(g,h,i)perylene	1/8	0	5.30[d]	c	5.3
Benzoic Acid	1/8	4	0.06[d]	c	0.059
Bis(2-thylhexyl)phthalate	3/8	0	0.59	0.87	0.075 - 1.6
Chrysene	2/8	0	1.78	2.43	0.062 - 3.5
Di-n-butylphthalate	1/8	0	0.19[d]	c	0.19
Dibenzo(a,h)anthracene	1/8	0	0.90[d]	c	0.9
Fluoranthene	3/8	0	2.27	3.83	0.04 - 6.7
Indeno(1,2,3-cd)pyrene	1/8	0	4.20[d]	c	4.2
Methylene chloride	1/8	0	0.03[d]	c	0.025
Phenanthrene	1/8	0	2.60[d]	c	2.6
Phenol	1/8	0	0.23[d]	c	0.23
Pyrene	3/8	0	2.78	4.69	0.045 - 8.2
Toluene	2/8	0	0.001	0.00	0.001 - 0.001

[a]The sample numbers used in this data set include: 61128, 61133, 61135, 61140, 61142, 61147, 61150, 61156, 61163, 61240, 61245, 61254, and 61258.
[b]Values qualified with a R or < are excluded.
[c]Values expressed in milligrams per kilogram (mg/kg).
[d]Analyte was detected in one sample.

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OPERABLE UNIT 4 K-65 AREA SURFACE SOIL
SUMMARY OF RADIOLOGICAL ANALYSES

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TABLE A.3-7

SUMMARY OF SURFACE SOIL RADIOLOGICAL ANALYSES[a] WASTE PIT AREA RUNOFF CONTROL PROJECT[a]

Analyte[b]	Frequency of Detection	Mean (pCi/g)[c]	Range of Detects (pCi/g)[c]	Standard Deviation (pCi/g)[c]
Radium-226	4/5	23.2	1.12-88	43.2
Radium-228	4/5	2.4	1.04-4.3	1.6
Thorium-228	12/13	1.8	.25-2.87	.76
Thorium-230	11/11	5.2	1.5-25	7.2
Thorium-232	11/13	8.5	2.8-29.9	7.7
Total Thorium	2/13	28.5[d]	24-33[d]	6.4[d]
Uranium-234	3/5	12.1	5.63-23.4	9.9
Uranium-235	4/5	.87	.22-1.7	.70
Uranium-238	4/5	4.1	.54-9.4	3.9
Total Uranium	7/11	75.3[d]	11-262[d]	91.1[d]

[a]These results have not been validated.
[b]The sample numbers included in this data set include: RC-0155, 0157, 0159, 0161, 0163, 0802, 0804, 0814, 0816, 0817, 0818, EM-1815, and EM-1819.
[c]Values expressed in picoCuries per gram (pCi/g).
[d]Results expressed in micrograms per gram (μg/g).

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TABLE A.3-8

SUMMARY OF SURFACE SOIL RADIOLOGICAL ANALYSES (RI/FS - DATA)

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (pCi/g)[d]	Standard Deviation[c] (pCi/g)[d]	Range[c] (pCi/g)[d]
Radium-226	7/7	3	1.24	0.54	0.6-2.3
Radium-228	7/7	3	1.17	0.39	0.5-1.7
Strontium-90	6/9	1	1.15	0.44	0.8-1.8
Technetium-99	2/10	0	2.4	1.7	1.2-3.6
Thorium-228	9/10	0	1.11	0.16	0.9-1.4
Thorium-230	10/10	0	3.1	1.09	1.4-4.8
Thorium-232	9/10	0	1.12	0.26	0.9-1.7
Total Uranium	6/6	3	17.5[e]	23.0[e]	4-64
Uranium-234	7/7	0	3.7	1.61	2.4-6.9
Uranium-238	7/7	0	8.3	6.93	2.4-20.8

[a]The sample numbers used in this data set include: 5423, 5644 through 5652, 5884, 5887, and 8188.
[b]Rejected data not included in total number of samples.
[c]Values qualified with a R or < are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in picoCuries per gram (pCi/g).
[e]Values expressed in micrograms per gram (μg/g).

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OPERABLE UNIT 4 BERM SOIL
SUMMARY OF RADIOLOGICAL ANALYSES

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TABLE A.3-9

SUMMARY OF BERM SOIL RADIOLOGICAL ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (pCi/g)[d]	Standard Deviation[c] (pCi/g)[d]	Range[c] (pCi/g)[d]
Cesium-137	1/7	0	0.23	e	e
Lead-210	23/23	0	19.6	86.6	0.62-417
Polonium-210	16/16	4	63.4	235	1.03-943
Protactinium-231	2/22	1	13.7	16.3	2.2-25.3
Radium-224	15/15	1	0.94	0.30	0.55-1.68
Radium-226	22/22	1	41.9	186	0.62-876
Radium-228	19/22	1	0.88	0.21	0.53-1.24
Thorium-228	23/23	0	1.93	2.84	0.93-14.9
Thorium-230	23/23	0	3.95	10.3	0.74-51.2
Thorium-232	19/23	0	0.94	0.19	0.64-1.45
Total Thorium	19/20	0	8.17[f]	2.09[f]	3.57-13.1[f]
Total Uranium	19/19	1	18.4[f]	40.7[f]	1.99-186[f]
Uranium-234	23/23	0	2.51	4.77	0.81-24.2
Uranium-235/236	1/23	0	1.31	e	e
Uranium-238	23/23	0	2.66	4.87	0.75-24.7

[a]The sample numbers used in this data set include: 99436 - 99438, 99462, 99482, 99487, 99500, 99532, 99537, 99549, 99554, 99571, 99576, 99592, 99601, 99606, 99618, 99623, 99633, 99653, 99658, 99670, and 99675.
[b]Rejected data not included in total number of samples.
[c]Values qualified with a D, DJ, R, or < are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in picoCuries per gram (pCi/g).
[e]Analyte was detected in a single sample.
[f]Values expressed in micrograms per gram (μg/g).

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OPERABLE UNIT 4 BERM SOIL
SUMMARY OF CHEMICAL ANALYSES

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TABLE A.3-10

SUMMARY OF BERM SOIL INORGANIC ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/kg)[d]	Standard Deviation[c] (mg/kg)[d]	Range[c] (mg/kg)[d]
Aluminum	12/12	0	9430	2370	4530-12100
Antimony	11/11	1	22.5	4.5	14.6-27.6
Arsenic	12/12	0	6.1	1.7	3.6-8.3
Barium	12/12	0	69.4	21.3	30.5-97.3
Beryllium	11/12	0	0.84	0.14	0.65-1.1
Cadmium	12/12	0	4.41	1.38	2.5-7.5
Calcium	12/12	0	64400	39900	11600-16100
Chromium	12/12	0	18.5	3.9	12.1-28.4
Cobalt	11/12	0	12.0	1.6	9.8-14.9
Copper	12/12	0	21.9	2.4	19.3-27
Cyanide	6/11	1	0.58	0.65	0.12-1.6
Iron	12/12	0	21000	4870	11200-27500
Lead	12/12	0	10.8	2.3	6.1-13.8
Magnesium	12/12	0	22800	12400	6390-50700
Manganese	12/12	0	489	172	228-880
Molybdenum	10/12	0	4.4	3.2	2.4-13.3
Nickel	12/12	0	28.0	3.9	21.7-33.7
Potassium	12/12	0	901	220	546-1230
Silver	12/12	0	8.4	4.2	3.6-19.2
Sodium	11/12	0	13.3	56.7	47.8-237
Thallium	1/12	0	0.71	e	e
Vanadium	12/12	0	25.5	3.2	17.4-28.4
Zinc	12/12	0	49.6	9.8	30.7-61

[a]The sample numbers used in this data set include: 99469, 99470, 99475, 99488, 99490, 99491, 99513 through 99515, 99540, 99542, 99543, 99557, 99559, 99560, 99580, 99581, 99583, 99594 -99596, 99607, 99609, 99610, 99624, 99626, 99627, 99659, 99661, 99662, 99676 through 99678, and 99686 through 99688.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte was detected in a single sample.

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TABLE A.3-11

SUMMARY OF BERM SOIL ORGANIC ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/kg)[d]	Standard Deviation[c] (mg/kg)[d]	Range[c] (mg/kg)[d]
Semivolatile Organics					
Bis(2-Ethylhexyl)phthalate	3/12	0	0.384	0.534	0.043-1
Di-n-butylphthalate	2/12	0	0.051	0.004	0.048-0.054
Di-n-octylphthalate	5/12	0	0.656	0.023	0.044-0.097
Diethyl phthalate	1/12	0	0.12	e	e
Phenol	2/12	0	0.155	0.06364	0.11-0.2
Volatile Organics					
2-Butanone	4/10	1	0.008	0.003	0.004-0.011
4-Methyl-2-pentanone	1/11	0	0.004	e	e
Acetone	3/11	0	0.033	0.027	0.012-0.064
Methylene chloride	3/11	0	0.005	0.001	0.004-0.006
Tetrachloroethane	1/11	0	0.004	e	e
Toluene	10/11	0	0.026	0.062	0.001-0.021
Total xylenes	1/11	0	0.069	e	e

[a]The sample numbers used in this data set include: 99462, 99468, 99483, 99489, 99501, 99517, 99533, 99541, 99550, 99558, 99572, 99579, 99588, 99593, 99602, 99608, 99619, 99625, 99660, 99669, 99676, 99684, and 99685.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte was detected in a single sample.

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TABLE A.3-12

SUMMARY OF BERM SOIL
TCLP ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration[f] (mg/L)
Metals						
Barium	4/4	0	1.17	0.355	0.705-1.57	100.0
Cadmium	1/4	0	11.4	f	f	1.0
Chromium	4/4	0	20.5	40.9	0.051-81.8	5.0
Silver	3/4	0	37.4	64.6	0.099-112	5.0
Semivolatile Organics						
Pentachlorophenol	2/4	0	0.0055	0.0007	0.005-0.006	100
Volatile Organics						
2-Butanone	1/4	0	0.006	0.000	0.006-0.006	200.0
Tetrachloroethene	1/4	0	0.002	0.000	0.002-0.002	0.7

[a]The sample numbers used in this data set include: 99493, 99495, 99496, 99550, 99562, 99563, 99600, 99612, 99654, and 99663.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in milligrams per liter (mg/L).
[e]Data obtained from 40 CFR 261.24.
[f]Analyte was detected in a single sample.

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OPERABLE UNIT 4 SUBSURFACE SOIL - SLANT BORINGS
SUMMARY OF RADIOLOGICAL ANALYSES

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TABLE A.3-13

SUMMARY OF SILO SLANT BORING SUBSURFACE SOILS RADIOLOGICAL ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (pCi/g)[d]	Standard Deviation[c] (pCi/g)[d]	Range[c] (pCi/g)[d]
Actinium-227	4/11	1	5.04	4.76	0.56-9.66
Lead-210	13/16	0	18.5	37.1	0.46-101
Polonium-210	12/12	0	15.3	28.7	0.938-86.5
Radium-224	12/12	0	1.06	0.31	0.67-1.71
Radium-226	16/16	0	33.2	70.5	0.613-206
Radium-228	13/16	0	0.86	0.26	0.485-1.24
Strontium-90	1/4	0	0.816	e	e
Thorium-228	14/14	1	1.42	0.341	0.768-2.06
Thorium-230	14/14	1	5.1	14.0	0.8-53.7
Thorium-232	11/14	1	0.97	0.291	0.62-1.5
Total Thorium	14/14	1	7.97[f]	2.88	3.34-13.6[f]
Total Uranium	11/16	0	34.9[f]	36.4	3.27-110[f]
Uranium-234	14/14	2	8.6	12.4	0.8-35.9
Uranium-235/236	3/14	2	2.49	0.98	1.37-3.17
Uranium-238	14/14	2	9.87	15.6	0.76-53.4

[a]The sample numbers used in this data set include: 64001, 64002, 64032, 64041, 64071, 64105, 64115, 64125, 64136, 64148, 64157, 66956, 66959, 66960, 66968, 66969, 66974, 66983, 66984, and 66992.
[b]Rejected data not included in total number of samples.
[c]Values qualified with a R or < are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in picoCuries per gram (pCi/g).
[e]Analyte was detected in a single sample.
[f]Values expressed in micrograms per gram (μg/g).

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OPERABLE UNIT 4 SUBSURFACE SOIL - SLANT BORINGS
SUMMARY OF CHEMICAL ANALYSES

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TABLE A.3-14

SUMMARY OF SILO SLANT BORING SUBSURFACE SOILS INORGANIC ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/kg)[d]	Standard Deviation[c] (mg/kg)[d]	Range[c] (mg/kg)[d]
Aluminum	13/13	0	9090	3550	4430-15700
Antimony	8/13	0	24.9	3.90	20.4-32.5
Arsenic	13/13	0	5.6	2.5	3-12.1
Barium	13/13	0	63.4	29.2	34.5-142
Beryllium	11/13	0	0.76	0.10	0.63-0.9
Cadmium	12/13	0	3.6	1.4	1.6-6.5
Calcium	13/13	0	80300	48500	2310-144000
Chromium	13/13	0	22.7	6.4	8.6-33.3
Cobalt	13/13	0	10.7	2.9	4.8-15.3
Copper	13/13	0	20.7	2.8	14.9-24.5
Cyanide	6/13	0	1.98	1.99	0.18-5
Iron	13/13	0	21400	6590	13800-32200
Lead	13/13	0	11.3	3.9	6.5-18
Magnesium	13/13	0	22900	11900	2510-37800
Manganese	13/13	0	447	146	235-746
Mercury	2/13	0	0.12	0.00	0.12-0.12
Molybdenum	12/13	0	12.5	7.0	3.6-29.9
Nickel	13/13	0	26.0	6.0	17.8-39.3
Potassium	13/13	0	1120	343	823-1890
Selenium	3/13	0	5.7	9.01	0.44-16.1
Silicon	1/1	0	514	e	e
Silver	10/13	0	12.5	3.58	6.6-17.6
Sodium	13/13	0	621	862	32.3-2730
Thallium	2/13	0	0.465	0.035	0.44-0.49
Vanadium	13/13	0	25.6	4.8	14.4-32.5
Zinc	13/13	0	48.9	11.0	33.5-66.7

[a]The sample numbers used in this data set include: 64030, 64039, 64067, 64102, 64112, 64123, 64134, 64146, 66957, 66966, 66981, 66990, and 66998.
[b]Rejected data not included in total number of samples.
[c]Values qualified with a U, R, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte was detected in a single sample.

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TABLE A.3-15

SUMMARY OF SILO SLANT BORINGS/SUBSURFACE SOILS
ORGANIC ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/kg)[d]	Standard Deviation[c] (mg/kg)[d]	Range[c] (mg/kg)[d]
Pesticides and PCBs					
None detected					
Semivolatile Organics					
Benzoic acid	1/12	1	0.084	e	e
Diethyl phthalate	1/13	0	0.19	e	e
bis(2-Ethylhexyl)phthalate	2/12	1	0.082	0.053	0.045-0.12
Volatile Organics					
2-Butanone	2/10	3	0.006	0.006	0.002-0.009
4-Methyl-2-pentanone	1/12	1	0.024	e	e
Acetone	3/12	1	0.037	0.016	0.022-0.053
Carbon disulfide	1/12	1	0.011	e	e
Methylene chloride	4/12	1	0.008	0.004	0.005-0.013
Toluene	1/12	1	0.002	e	e
Total xylenes	1/12	1	0.009	e	e

[a]The sample numbers used in this data set include: 64030, 64039, 64067, 64102, 64112, 64123, 64134, 64146, 66957, 66966, 66981, 66990, and 66998.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in milligrams per kilogram (mg/kg).
[e]Analyte was detected in a single sample.

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TABLE A.3-16

SUMMARY OF SILO SLANT BORINGS SUBSURFACE SOILS
TCLP ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Allowable Concentration[f] (mg/L)
Metals						
Arsenic	3/8	2	0.121	0.024	0.107-0.149	5.0
Barium	6/8	2	0.832	0.731	0.118-2.15	100.0
Cadmium	3/9	1	0.010	0.006	0.004-0.015	1.0
Chromium	5/8	2	0.110	0.840	0.017-0.245	5.0
Lead	2/8	2	0.153	0.074	0.1-0.205	5.0
Selenium	4/8	2	0.120	0.022	0.103-0.15	1.0
Silver	6/8	2	0.109	0.084	0.0135-0.232	5.0
Pesticides and PCBs						
None detected						
Semivolatile Organics						
Pentachlorophenol[01]	2/9	1	0.014	0.0001	0.014-0.015	100.0
Volatile Organics						
2-Butanone	3/9	1	0.003	0.003	0.001-0.006	200.0
Tetrachloroethene[E]	1/9	1	0.002	f	f	0.7

[a]The sample numbers used in this data set include: 64031, 64040, 64068, 64103, 64147, 66958, 66966, 66967, 66982, 66991, and 66999.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in milligrams per liter (mg/L).
[e]Data obtained from 40 CFR 261.24.
[f]Analyte was detected in a single sample.

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OPERABLE UNIT 4 SUBSURFACE SOIL - WELL BORINGS AND TRENCHING SAMPLES
SUMMARY OF RADIOLOGICAL ANALYSES

TABLE A.3-17

ELEVATION OF SLANT BORING SAMPLES

Boring	Sample No.	Slant Distance (ft)	Elevation (ft. msl)	Comments
1615	-	9.9	575.5	Encountered saturated zone in clay
	66956	13.2 - 17.5	574.9	Sample collected in moist silty clay
	66974	17.1 - 17.5	574.6	Encountered concrete liner-sample collected for radiological analysis
	66959	20.0 - 22.5	573.8	Sample collected in wet soft clay
	-	-	571.3	Water level in borehole in August 1991
	66968	40.0 - 42.5	570.2	Sample collected in saturated sandy clay
	-	57.5	566.9	Bottom of boring in saturated clayey sand
	-	-	570.5	Water level in borehole in August 1991
1616	64157	3.9 - 4.4	570.2	Sample collected in dry sandy clay
	64021	48.0	563.8	Borehole depth when upper leachate sample collected
	-	43.0 - 48.0	564.1	Encountered medium dense saturated sand
	-	68.0	560.5	Encountered loose sand, saturated
	64032	88.0 - 89.25	556.7	Collected sample in moist clay
	64041	105.5 - 106.2	553.4	Collected sample in moist clay
	-	119 - 120	550.9	Dry hard clay encountered - boring terminated
1617	66983	17.5 - 20.2	574.0	Sample collected in moist stiff clay
	66992	36.5 - 40.2	571.1	Sample collected in moist clayey sand
	-	46.5	569.6	Encountered wet clayey sand
	-	-	567.9	Water level in borehole in August 1991
	-	56.5	567.8	Termination of saturated/wet clayey sand
	64001	59.7 - 61.0	567.0	Sample collected moist to damp clayey sand
	-	68.5	565.4	Boring terminated in saturated clay/sand mixture
1618	64105	50.0 - 51.25	572.9	Sample collected in damp clay
	64115	70.0 - 71.25	571.4	Sample collected in damp silty clay
	-	-	570.5	Water level in borehole in August 1991
	64125	90.0 - 91.25	569.9	Sample collected in damp silty clay
	64136	105 - 107.5	568.5	Sample collected in damp moist clay
	64148	127.5 - 128.7	566.6	Sample collected in damp silty clay
	-	130	566.4	Boring terminated in damp silty clay
1619	64071	60 - 61.25	569.5	Sample collected in moist clay
	-	70.0	568.0	Encountered wet very fine sand
	-	110.0	561.2	Boring terminated while in zone of wet/saturated clay/sand/gravel mixture

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TABLE A.3-18

SUMMARY OF SUBSURFACE SOIL RADIOLOGICAL ANALYSES

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (pCi/g)[d]	Standard Deviation[c] (pCi/g)[d]	Range[c] (pCi/g)[d]
Radium-226	15/23	3	0.80	0.27	0.53-1.5
Radium-228	8/23	3	0.66	0.26	0.41-1.1
Strontium-90	4/19	8	1.18	1.09	0.5-2.8
Technetium-99	2/26	0	2.85	1.06	2.1-3.6
Thorium-228	12/26	0	0.850	0.206	0.631-1.3
Thorium-230	23/26	0	1.46	0.963	0.716-4.8
Thorium-232	6/26	0	0.808	0.262	0.6-1.3
Total Thorium	23/23	0	5.04[e]	3.50[e]	1.3-15[e]
Total Uranium	19/21	4	6.60[e]	7.92[e]	1.64-37.1[e]
Uranium-234	20/26	0	1.24	0.760	0.6-3.4
Uranium-238	23/26	0	1.79	2.98	0.6-15

[a]The sample numbers used in this data set include: 7407, 7504, 8188, 8272, 8279, 8854, 32456, 32465, 32766, 32773, 33083, 33090, 55998 through 56004, 56013 through 56021, 56023, 56025, and 56029.
[b]Rejected data not included in total number of samples.
[c]Values qualified with a R or < are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d]Values expressed in picoCuries per gram (pCi/g).
[e]Values expressed in micrograms per gram (μg/g).

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OPERABLE UNIT 4 - K-65 AREA

SUMMARY OF CHARACTERIZATION OF VADOSE AND PERCHED WATER

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TABLE A.3-19

GENERAL CHEMISTRY SAMPLE RESULTS FROM THE ADDITIONAL CHARACTERIZATION OF VADOSE AND PERCHED WATER IN THE K-65 AREA

Sample No.	108952		109032		109021		109026		109027		109189		109217	
Location	1892		1892		1894		1894		1896		1032		2032	
Parameters	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ
Ammonia	<.10 mg/L	U	.23 mg/L		NR		NR		NR		NR		<.10 mg/L	U
Chloride	52.11 mg/L		97.01 mg/L		NR		NR		NR		NR		23.20 mg/L	
Fluoride	.21 mg/L		.28 mg/L		NR		NR		NR		NR		.18 mg/L	
Nitrate	.77 mg/L		1.69 mg/L		NR		NR		NR		NR		2.10 mg/L	
Sulfate	141.17 mg/L		480.5 mg/L		NR		NR		NR		NR		48 mg/L	
Sulfide	2.95 mg/L		.5 mg/L	U	NR		NR		NR		NR		.5 mg/L	
Total Organic Carbon	2.96 mg/L		2.08 mg/L		NR		NR		NR		NR		1.4 mg/L	
Total Organic Halides	54.30 mg/L		10 mg/L	U	NR		NR		NR		NR		10.50 mg/L	
Total Organic Nitrogen	.30 mg/L		1.34 mg/L		NR		NR		NR		NR		.12 mg/L	
Total Phosphorous	8.68 mg/L		7.13 mg/L		NR		NR		NR		NR		.03 mg/L	
Total Kjeldahl Nitrogen	.30 mg/L		1.57 mg/L		NR		NR		NR		NR		.12 mg/L	
Alkalinity	480 mg/L		347 mg/L		NR		NR		NR		NR		238 mg/L	
Phenols	<.01 mg/L	U	.01 mg/L	U	NR		NR		NR		NR		<.01 mg/L	U

Note: These results have not been validated.
LQ-Laboratory Qualifier
NR-Not Requested

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TABLE A.3-20

INORGANIC SAMPLE RESULTS FROM THE ADDITIONAL CHARACTERIZATION OF VADOSE AND PERCHED WATER IN THE K-65 AREA

Sample No.	108952		109032		109021		109026		109027		109189		109217	
Location	1892		1892		1894		1894		1896		1032		2032	
Parameters	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ
Aluminum	1010 ug/L		399 ug/L		NR		219 ug/L		NR		NR		102 ug/L	B
Antimony	6.4 ug/L	BW	5 ug/L	UW	NR		5 ug/L	U	NR		NR		5 ug/L	U
Arsenic	2 ug/L	U	2.9 ug/L	BW	NR		2 ug/L	U	NR		NR		2 ug/L	UW
Barium	45.5 ug/L	B	53.7 ug/L	B	NR		14.7 ug/L	B	NR		NR		33.1 ug/L	B
Beryllium	2 ug/L	U	2 ug/L	U	NR		2 ug/L	U	NR		NR		2 ug/L	U
Cadmium	5 ug/L	U	5 ug/L	U	NR		5 ug/L	U	NR		NR		5 ug/L	U
Calcium	145000 ug/L		176000 ug/L	E	NR		96200 ug/L	E	NR		NR		84500 ug/L	
Chromium	10 ug/L	U	10 ug/L	U	NR		10 ug/L	U	NR		NR		10 ug/L	U
Cobalt	10 ug/L	U	10 ug/L	U	NR		10 ug/L	U	NR		NR		10 ug/L	U
Copper	14.6 ug/L	B	10 ug/L	U	NR		10 ug/L	U	NR		NR		10 ug/L	U
Iron	2320 ug/L		859 ug/L		NR		20 ug/L	U	NR		NR		20 ug/L	U
Lead	2 ug/L	U	2 ug/L	U	NR		2 ug/L	U	NR		NR		2 ug/L	U
Magnesium	43000 ug/L		62700 ug/L	E	NR		14600 ug/L	E	NR		NR		24400 ug/L	
Manganese	584 ug/L		116 ug/L		NR		31.7 ug/L		NR		NR		10 ug/L	U
Mercury	.20 ug/L	U	.2 ug/L	U	NR		.2 ug/L	U	NR		NR		.20 ug/L	U
Nickel	20 ug/L	U	20 ug/L	U	NR		20 ug/L	U	NR		NR		20 ug/L	U
Potassium	2500 ug/L	B	3560 ug/L	B	NR		2340 ug/L	B	NR		NR		2140 ug/L	B
Selenium	8.5 ug/L		32.7 ug/L		NR		2 ug/L	U	NR		NR		2 ug/L	U
Silver	10 ug/L	U	10 ug/L	U	NR		10 ug/L	U	NR		NR		10 ug/L	U
Sodium	68500 ug/L		156000 ug/L	E	NR		16000 ug/L	E	NR		NR		17300 ug/L	
Thallium	2 ug/L	U	2 ug/L	UN	NR		2 ug/L	UN	NR		NR		2 ug/L	U
Vanadium	10 ug/L	U	10 ug/L	U	NR		10 ug/L	U	NR		NR		10 ug/L	U
Zinc	22.1 ug/L		10.1 ug/L	B	NR		14.8 ug/L	B	NR		NR		5 ug/L	U

TABLE A.3-20
(Continued)

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Sample No.	108952		109032		109021		109026		109027		109189		109217	
Location	1892		1892		1894		1894		1896		1032		2032	
Parameters	**Result**	**LQ**	**Result**	**LQ**	**Result**	**LQ**	**Result**	**LQ**	**Result**	**LQ**	**Result**	**LQ**	**Result**	**LQ**
Aluminum	1010 ug/L		399 ug/L		NR		219 ug/L		NR		NR		102 ug/L	B
Molybdenum	20 ug/L	U	20 ug/L	U	NR		20 ug/L	U	NR		NR		10 ug/L	U
Silicon	7990 ug/L		9650 ug/L		NR		29900 ug/L		NR		NR		2260 ug/L	
Cyanide	3.6 ug/L	B	2 ug/L	U	2 ug/L	U	NR		2 ug/L	U	NR		2 ug/L	U

Note: These results have not been validated.
LQ-Laboratory Qualifier
NR-Not Requested

TABLE A.3-21

VOLATILE ORGANIC SAMPLE RESULTS FROM THE ADDITIONAL CHARACTERIZATION OF VADOSE AND PERCHED WATER IN THE K-65 AREA

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Sample No.	108952		109032		109021		109026		109027		109189		109217	
Location	1892		1892		1894		1894		1896		1032		2032	
Parameters	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ
Chloromethane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Bromomethane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Vinyl Chloride	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Chloroethane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Methylene Chloride	1 ug/L	BJ	2 ug/L	BJ	NR		NR		NR		2 ug/L	BJ	1 ug/L	BJ
Acetone	10 ug/L		4 ug/L	BJ	NR		NR		NR		10 ug/L	U	10 ug/L	U
Carbon Disulfide	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
1,1-Dichloride	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
1,1-Dichloride	10 ug/L	UU	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Chloroform	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
1,2-Dichloroethane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
2-Butanone	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
1,1,-1 Trichloroethane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Carbon Tetrachloride	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Bromodichlorome-thane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
1,2-Dichloropropane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
cis-1,3 Dichloropropane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Trichlorethene	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Dibromochloro-methane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
1,1,2-Trichloroethane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Benzene	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
trans-1,3-Dichloropropene	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Bromoform	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
4-Methyl-2-pentanone	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U

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TABLE A.3-21
(Continued)

Sample No.	108952		109032		109021		109026		109027		109189		109217	
Location	1892		1892		1894		1894		1896		1032		2032	
Parameters	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ	Result	LQ
2-Hexanone	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
1,1,2,2-Tetrachloroethane	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Toluene	10 ug/L	U	1 ug/L	J	NR		NR		NR		10 ug/L	U	10 ug/L	U
Chlorobenzene	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Ethylbenzene	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Styrene	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Tetrachloroethylene	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Xylenes, Total	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U
Vinyl acetate	10 ug/L	U	10 ug/L	U	NR		NR		NR		10 ug/L	U	10 ug/L	U

Note: These results have not been validated.
LQ-Laboratory Qualifier
NR-Not Requested

TABLE A.3-22

RADIOLOGICAL SAMPLE RESULTS FROM THE ADDITIONAL CHARACTERIZATION OF VADOSE AND PERCHED WATER IN THE K-65 AREA

Sample No. Location	109028 1891	109030 1891	109031 1891	108952 1892	109032 1892	120320 1892	109035 1893	109019 1894
Cs-137	NR	NR	NR	<20 pCi/L	<20 pCi/L	NR	NR	NR
Ru-106	NR	NR	NR	<130 pCi/L	<110 pCi/L	NR	NR	NR
Ra-226	<1 pCi/L	NR	NR	<1.0 pCi/L	35.8 pCi/L	NR	<1 pci/L	<1 pCi/L
Ra-228	NR	NR	NR	<3.0 pCi/L	23.7 pCi/L	NR	NR	NR
U-234	NR	NR	NR	118 pCi/L	427 pCi/L	NR	NR	NR
U-235/236	NR	NR	NR	6.33 pCi/L	21 pCi/L	NR	NR	NR
U-238	112 pCi/L	NR	NR	126 pCi/L	434 pCi/L	NR	55.1 pci/L	2.35 pCi/L
Pu-238	NR	NR	NR	<1.0 pCi/L	<1 pCi/L	NR	NR	NR
Pu-239/240	NR	NR	NR	<1.0 pCi/L	<1 pCi/L	NR	NR	NR
Th-228	NR	NR	NR	<1.0 pCi/L	<1 pCi/L	NR	NR	NR
Th-230	NR	NR	NR	<1.0 pCi/L	<1 pCi/L	NR	NR	NR
Th-232	NR	NR	NR	<1.0 pCi/L	<1 pCi/L	NR	NR	NR
Np-237	NR	NR	NR	<1.0 pCi/L	<1 pCi/L	NR	NR	NR
Sr-90	NR	NR	NR	<5.0 pCi/L	<5 pCi/L	NR	NR	NR
Tc-99	NR	NR	NR	<30 pCi/L	<30 pCi/L	NR	NR	NR
Th-Total	NR	NR	NR	<1.0 ug/L	.08 ug/L	NR	NR	NR
U-Total	NR	330 ug/L	318 ug/L	321 ug/L	1250 ug/L	NR	NR	NR
Gross Alpha	NR	NR	NR	350 pCi/L	546 pCi/L	NR	NR	NR
Gross Beta	NR	NR	NR	85.2 pCi/L	135 pCi/L	NR	NR	NR
Pb-210	NR	NR	NR	NR	NR	<3 pCi/L	NR	NR

TABLE A.3-22
(Continued)

Sample No. Location	109025 1895	109020 1896	109186 1032	109217 2032	109220 2032	120310 2032	120313 2032
Cs-137	NR	NR	NR	<20 pCi/l	NR	<20 pCi/L	NR
Ru-106	NR	NR	NR	<142 pCi/L	NR	<130 pCi/L	NR
Ra-226	<1 pCi/L	<1 pCi/L	<.5 pCi/L	<1 pCi/L	NR	<1 pCi/L	NR
Ra-228	NR	NR	NR	<3 pCi/L	NR	<3 pCi/L	NR
U-234	NR	NR	78.6 pCi/L	4.86 pCi/L	NR	5.32 pCi/L	NR
U-235/236	NR	NR	1.8 pCi/L	<1 pCi/L	NR	<1 pCi/L	NR
U-238	1.09 pCi/L	1.08 pCi/L	90.3 pCi/L	6.77 pCi/L	NR	7.29 pCi/L	NR
Pu-238	NR	NR	NR	<1 pCi/L	NR	<1 pCi/L	NR
Pu-239/240	NR	NR	NR	<1 pCi/L	NR	<1 pCi/L	NR
Th-228	NR	NR	NR	<1 pCi/L	NR	<1 pCi/L	NR
Th-230	NR	NR	NR	<1 pCi/L	NR	<1 pCi/L	NR
Th-232	NR	NR	NR	<1 pCi/L	NR	<1 pCi/L	NR
Np-237	NR	NR	NR	<1 pCi/L	NR	<1 pCi/L	NR
Sr-90	NR	NR	NR	<5 pCi/L	NR	<5 pCi/L	NR
Tc-99	NR	NR	NR	<30 pCi/L	NR	<30 pCi/L	NR
Th-Total	NR	NR	NR	.12 ug/L	NR	.28 ug/L	NR
U-Total	NR	NR	NR	4.86 ug/L	21 ug/L	20.1 ug/L	24 ug/L
Gross Alpha	NR	NR	NR	11.3 pCi/L	NR	29.2 pCi/L	NR
Gross Beta	NR	NR	NR	7.49 pCi/L	NR	8.46 pCi/L	NR
Pb-210	NR	NR	NR	NR	NR	<3 pCi/L	NR

NOTE: These results have not been validated
NR-Not Requested

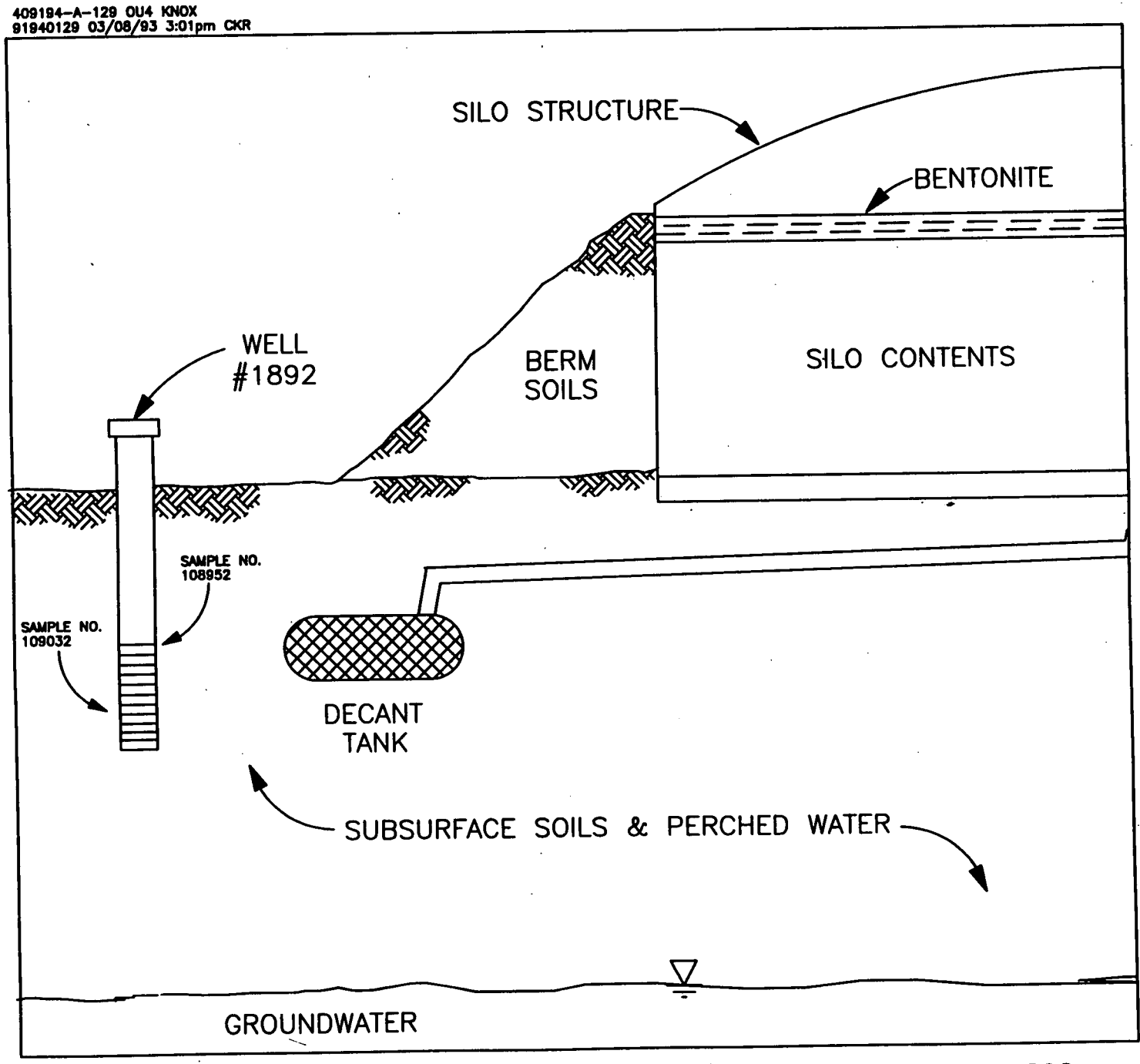

FIGURE A.3-1 CROSS SECTION OF DECANT SUMP TANK AND WELL 1892

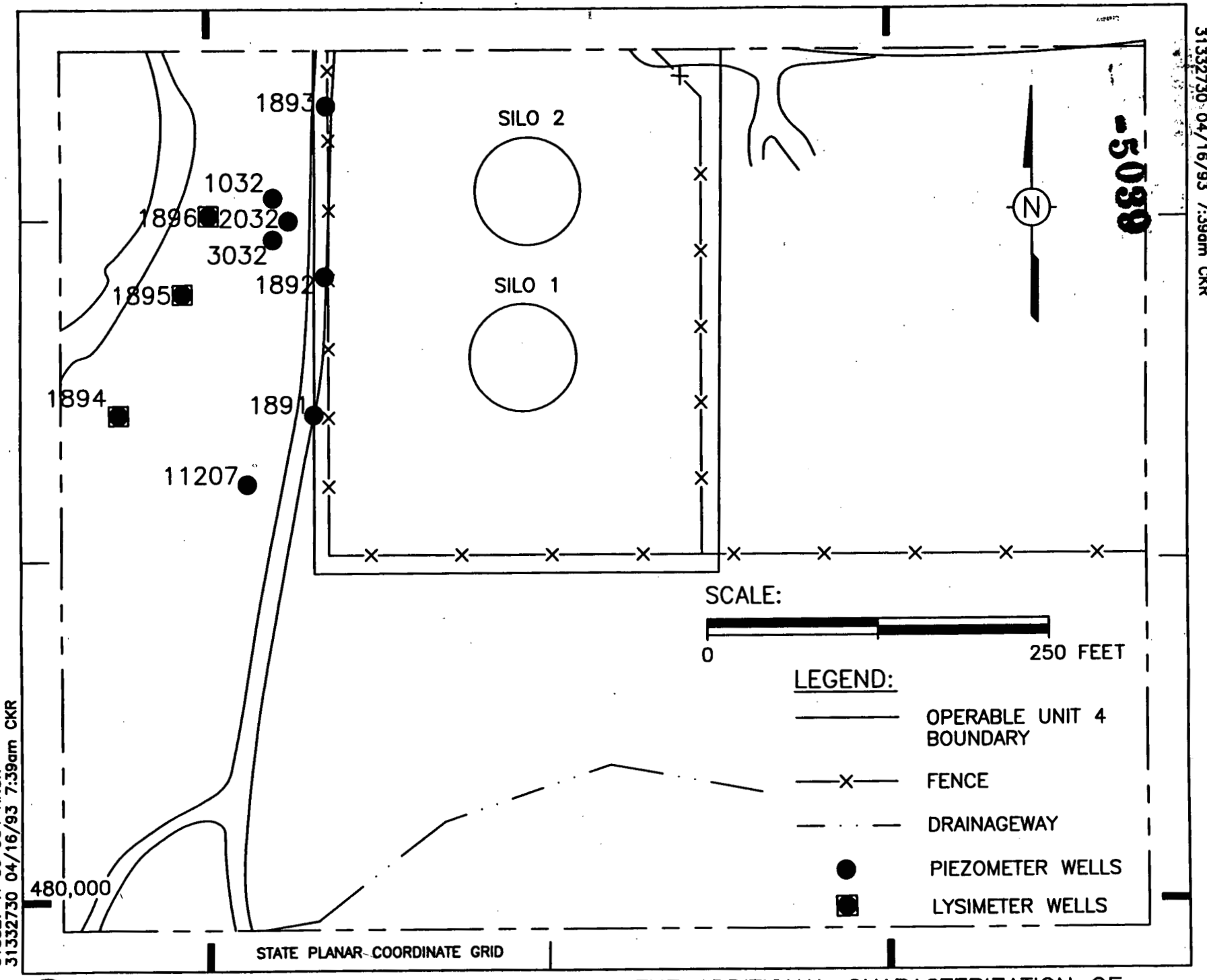

FIGURE A.3-2 SAMPLING LOCATIONS FOR THE ADDITIONAL CHARACTERIZATION OF VADOSE AND PERCHED WATER IN THE [illegible]-65 AREA

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APPENDIX B

DESCRIPTION OF TECHNOLOGIES AND PROCESS OPTIONS

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LIST OF ACRONYMS

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ADC	Analytical Development Corporation
AWWT	Advanced Wastewater Treatment
CDR	Conceptual Design Report
CFR	Code of Federal Regulations
cm/sec	centimeters per second
cm	centimeter
Cr	chromium
DDT	dichloro-diphenyl trichloroethane
DF	decontamination factor
DOE	United States Department of Energy
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
f^2	square feet
FEMP	Fernald Environmental Management Project
FS	Feasibility Study
ft/min	feet per minute
ft	feet
GRA	general response action
HEPA	high efficiency particulate air
HDPE	high density polyethylene
in	inch
km	kilometers
km/hr	kilometers per hour
LC/DS	leachate collection/detection system
LDR	land disposal restriction
m/min	meters per minute
m	meters
m^2	square meters
m^3/day	cubic meters per day
mi	mile
mi/hr	miles per hour

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LIST OF ACRONYMS
(Continued)

mm	millimeter
MSL	mean sea level
NAFB	Nellis Air Force Base
NEPA	National Environmental Policy Act
NORM	naturally occurring radioactive material
NTS	Nevada Test Site
PCB	polychlorinated biphenyl
Ra	radium
RAO	Remedial Action Objectives
RCRA	Resource Conservation Recovery Act
SO_2	sulfurdioxide
Th	thorium
U	uranium
UMTRCA	Uranium Mill Tailings Radiation Control Act
VOC	volatile organic compounds
yd^3/day	cubic yards per day

B.1.0 INTRODUCTION

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B.1.1 PURPOSE

Due to the diversity and complexity of the problems associated with Operable Unit 4, the operable unit was further divided into three subunits (A, B, and C) to effectively focus the development of remedial alternatives toward addressing the specific problems posed by the various wastes and contaminated media. Consistent with "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (OSWER Directive 9355.3-01), alternatives for the remediation of Operable Unit 4 have been developed by assembling combinations of technologies, and the media to which they would be applied, into alternatives that address contamination for a specific subunit. The process of developing and screening remedial alternatives consisted of the following six general steps:

- Development of remedial action objectives (RAOs) specifying the contaminants and media of interest, exposure pathways, and preliminary remediation goals that permit a range of treatment and containment alternatives to be developed.

- Development of general response actions (GRAs) for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the RAOs for the Fernald Environmental Management Project (FEMP) site.

- Identification of volumes or areas of media to which GRAs might be applied, taking into account the requirements for protectiveness as identified in the RAOs and the chemical and physical characterization of the FEMP site.

- Development and screening of the technologies applicable to each GRA to eliminate those that cannot be implemented technically at the FEMP site. The GRAs are further defined to specify remedial technology types (e.g., the GRA of treatment can be further defined to include chemical or biological technology types).

- Development and evaluation of technology process options in order to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.

- Assemblage of the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

As per the guidance document, the Feasibility Study (FS) Report for Operable Unit 4 uses the term "technology types" when referring to general categories of technologies, such as chemical treatment, physical treatment, waste stabilization, capping, or run-on/runoff control. Likewise, the use of the

term "technology process options" refers to specific processes within each technology type. For example, the waste stabilization technology type would include such process options as asphalt-based stabilization, cement-based stabilization, thermoplastic encapsulation, vitrification, and lime/flyash stabilization.

The intent of Appendix B is to provide a listing of the universe of potentially applicable technology process options that were considered in the development of remedial alternatives for Operable Unit 4. The listing offers the reader a more detailed explanation of the various process options considered in the Section 2.0 discussions of the FS Report for Operable Unit 4. Consistent with guidance, the universe of potentially applicable technology types and process options was reduced in Section 2.0 by evaluating the options with respect to their technical implementability for each subunit.

B.1.2 DESCRIPTION OF TECHNOLOGY PROCESS OPTIONS

The following FEMP process options are described in this appendix in alphabetical order, under the headings shown in Figure 2-2, Initial Screening of Technologies and Process Options in the FS Report for Operable Unit 4:

Above-Grade Disposal Vault
Abrasive Water Jet
Acid Washing with Oxidizing Agents
Administrative Controls
Air Stripping
Airlift Dredging
Asphalt-Based Cap
Asphalt-Based Stabilization
Backhoe
Biodenitrification
Biological Detoxification
Cement-Based Stabilization
Chemical Dechlorination
Chemical Extraction
Chemical Sealant Cap
Circular Diamond or Carbide Saws
Controlled Blasting
Conveyor System
Concrete-Based Cap
Core-Stitch Drilling
Crane with Clamshell System
Deep Geological Repository
Diamond Chain Saw
Diamond Rope Saw
Diversion/Collection
Dragline System
Drying/Calcination
Engineered Disposal Facility
Ex Situ Vitrification
FEMP Advanced Wastewater Treatment Facility
Flame Cutting/Gas Torch
Grading
Groundwater Monitoring
Grout Curtains
Hydraulic Splitter
Hydrolysis
Impact Hammer
Incineration
In Situ Vitrification
Interim Storage Facility
Land Farming
Leachate Collection/Detection
Lime/Flyash Stabilization
Lined/Unlined Pits/Trenches
Loader/Dozer
Multimedia Cap
Nevada Test Site
New Facility Adjacent to the FEMP Site
New Facility Within 483 km (300 mi) of the FEMP Site
Nonexplosive Demolition Compounds

Oil/Water Separation
Oxidation/Ozonation/Photolysis
Permitted Commercial Disposal Site
Physical Barriers
Pneuma/Oozer Dredging
Polymerization
Pressure Washing
Pumping Wells
Radon Monitoring
Rail Transport
Reduction
Revegetation
Sedimentation Basin/Sediment Trap
Shallow Soil Mixing
Sheet Pilings
Silo Rehabilitation
Slurry Pump with Jetting Ring
Slurry Walls
Soil Aeration
Soil-/Clay-Based Cap
Solid/Liquid Separation
Steam Stripping
Strippable Coatings
Subsurface Drains
Surcharging
Surface Water/Sediment Monitoring
Thermal Desorption
Thermite Reaction Lance
Thermoplastic Encapsulation
Truck Transport
Vacuum Grit-Blasting
Vacuum Scabbling
Vacuum with Cutterhead
Void Space Grout
Wrecking Ball

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Above-Grade Disposal Vault

This disposal concept will place a concrete disposal vault over a Leachate Collection/Detection System (LC/DS). The containerized waste will be placed in the concrete vault which will then be covered with a multimedia cap. Each concrete vault will have a service opening to allow access for the placement of disposal boxes (Figure B.1-1). The floor of the vault will have a minimum slope of 2 percent to facilitate any leachate collection and monitoring. The roof of the vault will also have a minimum slope of two percent to allow storm water runoff. As each vault is filled to capacity, all equipment and temporary utilities will be removed and the vault sealed prior to installation of the multimedia cap.

The vaults will be constructed on a reinforced concrete mat with a minimum thickness of 0.3 meter (m) [1 foot (ft)]. The perimeter of the mat will be bounded by a curb with embedded pipes that are connected to the manholes of the underlying multimedia LC/DS to facilitate the collection of any contaminated leachate after final closure. The LC/DS will be composed of alternating composite soil liners and drainage layers to minimize the potential release of contaminated leachate to the groundwater and the Great Miami Aquifer.

The soil of the composite liners will be constructed of a natural, compacted clay with a maximum permeability of 1×10^{-7} centimeter per second (cm/sec). The layers will be a minimum of 0.9 m (3 ft) thick. To improve the performance of the clay, a geomembrane of at least 40 mil in thickness will be placed over the surface of the clay, which has been smooth-rolled to ensure good hydraulic

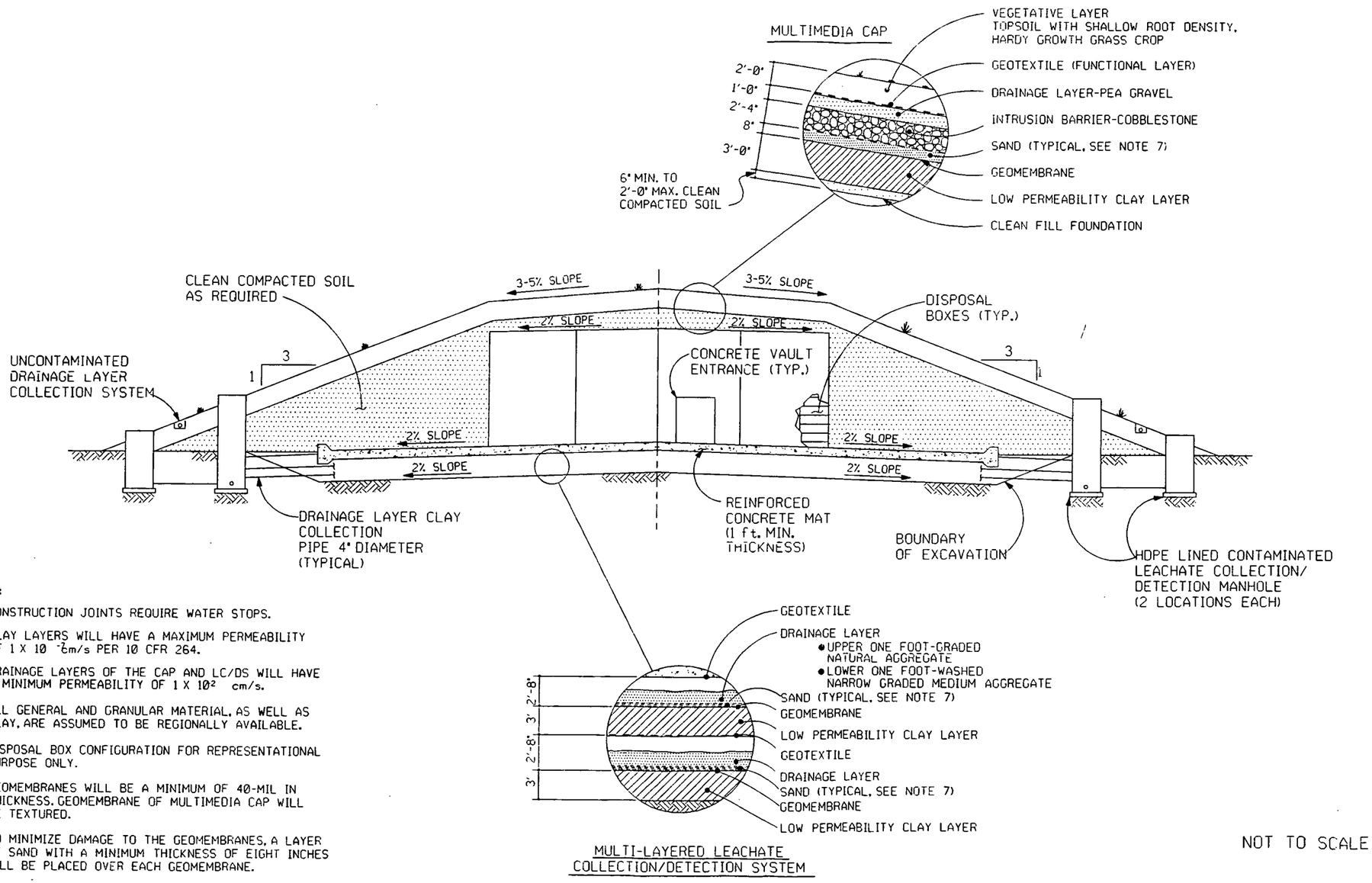

FIGURE B.1-1 ABOVE-GRADE DISPOSAL VAULTS

contact. To minimize damage to the geomembrane during construction, a sand layer with a minimum thickness of 20 centimeters (cm) [8 inches (in.)] will be placed over the geomembranes of the LC/DS.

Between the composite soil liners, drainage layers will be installed to intercept any leachate that may be generated. The drainage layers will be a minimum of 0.6 m (2 ft) each in thickness. The upper 0.3 m (1 ft) of each layer will be a graded natural aggregate, and the lower 0.3 m (1 ft) will be a narrow graded medium aggregate to provide a minimum permeability of 1×10^{-2} cm/sec. A geotextile membrane will be placed on the upper surface of each drainage layer to prevent the migration of granular fines from overlying material.

During placement of the aggregate, 10-cm (4-in.) diameter perforated piping will be installed within the aggregate to collect and direct any leachate to a series of manholes lined with high density polyethylene (HDPE). Likewise, any leachate not captured by the perforated piping that reaches the sand layer will travel along the slope of the cap to the manholes. The leachate will then be pumped from the manholes for treatment at the FEMP site advanced wastewater treatment facility (AWWT).

A multimedia cap constructed of five distinct layers of media will provide final closure of the vaults. The upper layer of the cap will be a vegetative layer consisting of topsoil with a hardy, shallow root grass cover. This layer will be noncompacted and have a minimum thickness of 0.6 m (2 ft) to support plant growth. The vegetative layer will inhibit erosion and allow runoff during storm events. A drainage layer will be beneath the vegetative layer to intercept infiltrating precipitation. The layer will consist of 0.30 m (1 ft) of compacted pea gravel, which will provide a minimum permeability of 1×10^{-2} cm/sec. A geotextile membrane will be placed between the vegetative layer and the top surface of the drainage layer to prevent the migration of fines from the vegetative layer to the drainage layer.

A layer of cobblestone with a minimum thickness of 0.7 m (2.3 ft) will be beneath the drainage layer to serve as an inadvertent intrusion barrier against both human and burrowing animals. Beneath the cobblestone will be a composite soil liner to impede downward moisture movement from the drainage layer. The soil of this layer will be natural, compacted clay with a maximum permeability of 1×10^{-7} cm/sec. The layer will be 0.9 m (3 ft) thick to ensure the isolation of the disposal containers. A geomembrane at least 40 mil in thickness will be placed over the surface of the clay, which is smooth-rolled to ensure good hydraulic contact and thus improving the performance of the clay. To minimize slippage of the overlying layers due to interfacial shearing characteristics, the geomembrane

will be textured. Similar to the composite soil liners of the LC/DS, a layer of sand will be placed over the geomembrane to minimize damage during construction.

The foundation of the multimedia cap will be clean, compacted soil. This layer will be a minimum of 0.15 m (6 in.) to a maximum of 0.6 m (2 ft) in thickness above the vaults. All general and granular material, as well as clay, are assumed to be regionally available. Upon completion of the multimedia cap, institutional actions will be provided to comply with the intent of 10 CFR 61, 40 CFR 191, and 40 CFR 264.

Abrasive Water Jet

An abrasive water jet cuts and dismantles nonreinforced radioactively contaminated concrete structures.

In the abrasive water jet process, a small diameter, high-velocity water jet and a stream of solid abrasives are introduced into a specially shaped abrasive jet nozzle from separate feed ports. The water jet's momentum is transferred to the abrasives, whose velocity rapidly increases. Garnet sand is the abrasive most commonly used for cutting. When steel grit is used, it can be separated magnetically and reused.

An abrasive water jet can be used to cut reinforced concrete.

The major advantage in using the abrasive water jet to cut contaminated concrete is its ability to cut thick reinforced concrete. A shroud and vacuum system can be used to contain the waste with more than 90 percent efficiency.

The major disadvantage with the abrasive water jet is the large volume of dirty and contaminated water it produces. Also, the system has its inherent dangers to personnel with the high pressure abrasives.

Acid Washing with Oxidizing Agents

Acid washing decontaminates concrete surfaces by removing surface contamination during generalized dissolution of the concrete surfaces.

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Acid washing can be used to decontaminate concrete floors and walls in lieu of mechanical techniques. The acid solution will react chemically with the concrete matrix, thereby removing the top layer of concrete along with the surface contamination. The acid solution can be applied manually or sprayed. The dissolved concrete and associated contamination must be rinsed from the surface and collected for treatment and disposal or reuse. A waste treatment system for spent acid solutions is required which could include all of the following unit operations: storage, neutralization, chemical oxidation, filtration, demineralization, evaporation, and stabilization. The objective of the liquid waste treatment process is to concentrate the decontamination waste, thereby minimizing the waste volume for disposal and allowing processed water to be recycled.

Acid washing to decontaminate concrete surfaces exhibits the following advantages: (1) acid type and other process parameters (i.e., concentration, temperature, time) can be optimized and selected for each application to give the maximum decontamination factor (DF); (2) it is a versatile process which can be substituted for mechanical decontamination techniques; (3) acid washing can be used to decontaminate external concrete; and (4) process equipment consists of simple off-the-shelf items which are readily available at minimal cost.

Disadvantages of acid washing are: (1) special precautions and training are required to protect workers handling potentially corrosive and reactive chemicals; (2) chemical cost for certain acids and oxidants can be high, given that these chemicals are consumed during the decontamination process and must be replaced; (3) the process results in a characteristic mixed waste stream that must be treated (i.e., neutralized, dewatered) prior to disposal; and (4) care must be taken in selecting decontamination chemical reagents to avoid generating a characteristic hazardous waste requiring additional processing.

Information required for evaluation includes:

- Type and physical/chemical form of radioactive contamination
- Material type containing the surface contamination
- Extent and degree of contamination present
- Degree of decontamination required
- Accessibility of contaminated surfaces

- List of operable equipment and process available to supplement decontamination operation

Administrative Controls

Administrative controls refer to restrictions placed on property egress by the supervising authority. These controls consist of legal deed restrictions, requirements for admission, posted warnings and hazards, and community relations to inform the public of the remediation activities and conditions. It should be noted that legal deed restrictions tend to extend beyond the purview of a current site owner or landlord and are, therefore, generally more lasting by nature.

Air Stripping

Air stripping is used to remove volatile compounds from aqueous waste streams. It is a mass transfer process in which volatile contaminants in water or soil are transferred to gas. The aqueous solution is typically introduced to a countercurrent air stream in a packed tower or a cross-flow tower where the liquid phase volatile compounds, which have an affinity for the gas phase, pass to the gas phase.

Generally, compounds with Henry's Law constants of greater than 0.003 can be effectively moved by stripping. This includes compounds such as 1,1,1-trichloroethane, trichloroethylene, chlorobenzene, vinyl chloride, and dichloroethylene. The feed system must be low in suspended solids and may require pH adjustments of hydrogen sulfide, phenol, ammonia, and other organic acids and bases to reduce solubility and improve transfer to the gas phase. This process option could be used to remove organics from water separated from the silos excavation slurry if the hydraulic removal option is chosen.

Airlift Dredging

Airlift dredges use compressed air to dislodge and transport sediment. Compressed air is introduced into the bottom of an open vertical pipe, usually controlled and supported by a barge-mounted crane. As the air is released, it expands and rises, creating upward currents that carry both water and sediment up the pipe. The applied air pressure must be sufficient to overcome the hydrostatic pressure at operating depths. Higher air pressures and flow rates result in higher transport capacity. Air can also be introduced through a special transport head that can be vibrated or rotated to further dislodge more cohesive sediment. Slurries of 1:3 solid/liquid ratio can typically be achieved with airlift dredges.

Airlift dredges are crane-supported and can be mounted on a work platform above the silos. Lateral control is achieved by swinging the boom of the crane in a manner similar to mechanical dredging. Vertical control is achieved by raising and lowering the open end of the vertical transport pipe and by varying the pressure of the air released at the end of the pipe.

The primary advantage of the airlift dredge is that it provides continuous transport of material, maximizing production rate. The primary limitation is that sufficient depth must be available to build up enough air pressure for operation. The minimum dredging depth for economical operation is approximately 6 to 9 m (20 to 30 ft). The vertical side walls of the silos are 8m (26 ft) tall [with residue material approximately 6m (20 ft) deep] and fall within the minimum range of economic operations. However, the silo domes would require removal to implement this technology. This is not easily implementable because the dome serves as primary containment for the radon in the headspace.

Asphalt-Based Cap

An effective method to control erosion and to minimize contact between infiltrating precipitation and emplaced waste is to construct a single-layered cap composed of low permeability material. Additionally, a single-layered cap may serve as an intrusion barrier to alleviate possible direct and indirect exposure to waste material. Bituminous asphalt is an effective material for the construction of a single-layered cap. Bituminous asphalt will not be as susceptible to freeze/thaw and shrink/swell cycles as single-layered caps constructed of natural soil/clay and additives.

A single-layered cap composed of bituminous asphalt would be acceptable under the following criteria:

- Applicable regulations are satisfied
- The cap is intended for temporary coverage
- Evapotranspiration substantially exceeds precipitation
- An acceptable distance exists between the emplaced waste being covered and the nearest source of groundwater
- Continual maintenance of the cap is ensured for integrity
- Appropriate construction guidance is strictly followed

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The thickness of an asphalt-based cap will be dependent on a specified allowable amount of settlement and on local weather conditions. A minimum slope of 2 percent must be maintained to provide runoff of precipitation to minimize generation of leachate from emplaced waste. To improve the life and effectiveness of an asphalt-based cap, periodic application of a special surface treatment may be required.

Asphalt-Based Stabilization

Asphalt-based stabilization is a microencapsulation process in which the waste materials do not react chemically with the encapsulating material. In this technology, a thermoplastic material, such as asphalt (bitumen), is used to bind the waste constituents into a stabilized mass. The asphalt binder may be heated before it is mixed with a dry waste material or the asphalt may be applied as a cold mix. In the latter case, compaction is used to remove additional water from the surrounding aggregate/waste particles.

Bitumen may have commercial application for stabilizing/solidifying oil- and gasoline-contaminated soils. In this application, the bitumen is used to dilute the hydrocarbon-contaminated soil which is then used as paving or patching material for roads. The resulting consistency will vary depending on the density of the hydrocarbon mixed into the bitumen and the amount of aggregate added to the mixture.

Thermoplastic encapsulation can also be applied to electroplating sludges, painting and refinery sludges containing metals and organics, dry incinerator ash, fabric filter dust, and radioactive wastes. However, the likelihood that many communities or regulatory agencies would accept such encapsulated material originating from Operable Unit 4 is very unlikely.

Backhoe

A backhoe is normally used for trenching and for other subsurface excavation where the excavator remains near the original working level. Backhoes are mechanically or hydraulically operated in a drag and hoist maneuver and are usually crawler-mounted. The lateral and vertical reach of a backhoe is limited by the length of the boom. Conventional backhoes are capable of digging to a depth of approximately 12.2 m (40 ft). Deeper digging depths [up to 24.3 m (80 ft)] are achieved by using modified backhoes with extended booms, modified engines, and counterweights.

Backhoes have limited lateral and vertical reaches that can be improved by using an extended reach and depth machine. Backhoes are capable of excavating almost any type of material. Material transport and support equipment are required for a successful operation.

Biodenitrification

Biological denitrification is a microbial process by which nitrates and nitrites are reduced to molecular nitrogen. Denitrification is a respiratory mechanism in which the nitrate/nitrite replaces molecular oxygen in bioassimilation. In the absence of molecular oxygen, facultative bacteria use the nitrates or nitrites as thermal electron acceptors while oxidizing the organic matter for energy. This requires the availability of an electron donor that is usually satisfied by the addition of methanol to the wastewater.

The addition of organic material is critical to effective nitrogen removal. The ratio of organic carbon to nitrogen is normally set at 1.3:1 for complete denitrification. High levels of dissolved solids are inhibitory to denitrification as are high nitrate/nitrite levels (greater than 0.1 percent). This process option can be used to denitrify the leaching waste stream from the K-65 media treatment if nitric acid is used.

Biological Detoxification

Biological processes can be used to detoxify a waste stream by destroying the organic components of the waste. Typical contaminants that are suitable for biological processes include petroleum wastes, such as sludges and polyaromatic hydrocarbons (PAH); chemical manufacturing products, such as acetone; and ethanol paint solvents. Some other possible contaminants for biological processes include: trichlorethylene (TCE), perchloroethylene (PCE), trichloroethane (TCA), polychlorinated biphenyl (PCB), complex PAHs (greater than 5 rings), trinitrotoluene (TNT), and dichloro-diphenyl trichloroethane (DDT). Biological processes will not destroy metals (but may alter them by oxidation/reduction), brine, or highly halogenated compounds.

Aerobic biological processes for the destruction of hazardous wastes are usually faster than anaerobic digestion and do not produce the methane and hydrogen sulfide gases that are common with anaerobic processes. On the other hand, aerobic processes are not as effective in breaking down halogenated chemicals as are anaerobic processes; therefore, it is important to know all the components of the waste before choosing a process.

Cement-Based Stabilization

This method involves mixing the wastes directly with portland cement, a very common construction material. The waste is incorporated into the rigid matrix of the hardened concrete. Most stabilization is done with Type I portland cement, but Types II and V can be used for sulfate or sulfite wastes. This method physically or chemically stabilizes the wastes, depending on waste characteristics. The end product may be a standing monolithic solid or may have a crumbly, soil-like consistency, depending on the amount of cement added.

Most hazardous wastes slurried in water can be mixed directly with cement, and the suspended solids will be incorporated into the rigid matrix. Although cement can physically incorporate a broad range of waste types, most wastes will not be chemically bound and are subject to leaching.

Cement stabilization is most suitable for immobilizing metals because at the pH of the cement mixture, most multivalent cations are converted into insoluble hydroxides or carbonates. However, metal hydroxides and carbonates are insoluble only over a narrow pH range and are subject to solubilization and leaching in the presence of even mildly acidic leaching solutions (e.g., rain). Portland cement alone is also not effective in immobilizing organics.

Chemical Dechlorination

Chemical dechlorination is accomplished by using reducing agents (e.g., sulfur dioxide or sodium sulfite), activated carbon, sunlight, prolonged storage, or aeration for certain volatile forms of chlorine.

Of the alternatives for dechlorination, sulfur dioxide (SO_2) has the most developed technology, has the most effective proven performance, and is least expensive. The process involves dissolving sulfur dioxide into water where it quickly forms sulfurous acid that reacts almost instantaneously with free and combined chlorine. The reaction yields small amounts or sulfuric and hydrochloric acids that are neutralized by the wastewater's buffering capacity.

An inherent by-product of this process is an off-gas of SO_2 and release of gaseous chlorine. An off-gas treatment system would be required and would involve condensation/disposal of the condensate and carbon filtration of the remaining effluent prior to discharge to the atmosphere.

Chemical Extraction

This option refers to the use of chemicals to extract contaminates from a waste stream. Chemical extraction is limited to the following process components:

- Leaching/Extraction. Leaching is the extraction of a solute from a solid mixture. It is similar to liquid-liquid extraction in that a liquid solvent is utilized to effect a transfer of the solute, then the solute is recovered from the solvent, usually by evaporation or distillation. The solid usually requires a pretreatment such as cutting, grinding, or crushing to increase the surface area. It is important to know the physical characteristics of the carrier solid and the manner the solute is held in the solid to determine the equipment needs and operating parameters.

- Metals Precipitation. Metals precipitation is carried out by adding acid or base to a waste solution to adjust the pH to a point where the metal(s) of concern have a low solubility. The metals then precipitate out of the solution. Coagulants are often added to the solution to aid in the precipitation process.

  One metals precipitation process that was developed for the precipitation of radionuclides is the TRU/Clear® process. This process was developed at the Los Alamos National Laboratory and is marketed by Analytical Development Corporation (ADC). The process uses potassium ferrate as an inorganic coagulant to remove radionuclides [i.e., uranium (U), thorium (Th), radium (Ra)] and other priority pollutants from wastewaters.

- Neutralization. Neutralization is the adjusting of the pH of a waste stream so that the waste is no longer acidic or basic. Neutralization is used as a treatment for waste acids and alkali solutions following metals precipitations to eliminate or reduce their reactivity and corrosiveness. Neutralization is an inexpensive treatment, especially if a waste acid stream can be used to neutralize a waste alkali stream and vice versa. The constituency of each waste stream must be known to prevent the formation of more hazardous compounds and to ensure that the reaction of mixing does not become violent.

Soil washing is an ex situ water-based chemical extraction process being developed by the FEMP's Operable Unit 5 to minimize generation of contaminated soils. It incorporates the separation of chemical contaminants from the soil matrix by a combination of physical and chemical treatments. The initial operation in the process is to reduce soil aggregates to single grain composition (i.e., clay, silt, sand, gravel, etc.,). This is accomplished by either mechanical means (e.g., high pressure water or mixers) and/or chemical dispersing agents (e.g., sodium salts). This is followed by various physical/chemical processes that aid in the extraction of inorganic, organic, and radiological chemical contaminants from the discrete soil particles. Spent washing (extracting) solution is then regenerated through precipitation and or ion exchange processes and recycled back through the soil washing process. The remaining residue is collected, containerized, and stored for either disposal or subsequent treatment (e.g., vitrification, solidification, stabilization, etc.,).

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Chemical Sealant Cap

Cement, quicklime, or other grouting materials can be applied to the surface of, or mixed with the bottom sediment to create a seal that minimizes leaching and erosive transport of contaminated sediments.

Grouts may be applied to the surface of bottom sediment using a number of approaches. These methods can generally be divided into two categories, those that involve stream diversion and those that do not.

There are essentially two approaches to sealing or stabilizing bottom sediment following stream diversion. The first is to pneumatically apply a layer of concrete (shotcrete) or grout to form a surface seal. The second method is to mix concrete, quicklime, or a grout with the contaminated sediment to stabilize the sediment.

In the second method, the stabilizing agent is applied to the surface and mixed with the contaminated sediment using rubber-tire or crawler-type rotor or trencher mixing equipment. The Japanese have developed a soft ground crawler vehicle that is designed to crawl freely on soft ground and stabilize the ground by continuously and uniformly mixing the soft soil with slaked lime or cement-based stabilization agents. The vehicle is equipped with a pair of caterpillar tracks that consist of a pair of pontoons wound with light-metal caterpillar bands by means of special rings. Contact pressure is light and the developer claims that it can float. The mixing unit is suspended between two pontoons. Both trencher and rotor types are available. The depth of mixing can be adjusted with a hydraulic cylinder; mixing to depths of 2.0 m (6.5 ft) is possible. The tracks can then be elevated, and the vehicle can be used for compaction.

Circular Diamond or Carbide Saws

Circular diamond or carbide saws are used when disturbance of the surrounding material must be kept to a minimum.

Large diamond or carbide-tipped saws are used to cut thick concrete walls and floors. These saws can cut through reinforcing bars, although the bars tend to break off diamonds from the blade. The blade is rotated by a pneumatic, hydraulic, or electric motor.

Thicknesses of up to 0.9 m (3 ft) have been cut with diamond and carbide-tipped saws. The maximum thickness is approximately 40 percent of the blade diameter. Cutting can be done either manually or remotely, depending on the size of the saw. Introduction of water at the kerf is necessary to cool the saw blade and minimize wear. In addition, the dust produced by the abrasive cutting is controlled with a water spray. A high efficiency recovery system is necessary to control contaminated runoff and treat the wastewater.

The demolition of contaminated concrete using diamond or carbide saws is recommended for removal of entire walls or floors. The abrasive blade produces no vibration, shock, smoke, sparks, or slag.

Controlled Blasting

The objective of using controlled blasting to demolish radioactively contaminated concrete is to fragment massive, reinforced concrete sections. The process consists of drilling holes in the concrete, loading the holes with explosives, and detonating the explosives using a delayed firing technique. Delayed firing increases the fragmentation and controls the direction of material movement. Each borehole fractures radially during detonation. The detonation wave separates the fractured surfaces and moves the material toward the structure's free face. The radial fractures in adjacent boreholes form a fracture plane.

Controlled blasting is the concrete demolition method recommended for all concrete greater than 0.6 m (2 ft) in thickness, provided noise and shock in adjacent occupied areas are not of concern. The process is well suited to heavily reinforced concrete demolition because, with proper selection of blast parameters, a high degree of fragmentation may be achieved.

The major advantage of controlled blasting is the relatively large amount of concrete that can be demolished in a short time period. With adequate access for heavy duty equipment, state-of-the-art drills, and hauling equipment, high removal rates are possible. Heavily reinforced, radioactively contaminated concrete can be removed at a rate of 76.5 cubic meters per day (m^3/day) [100 cubic yards per day (yd^3/day)]. Higher removal rates, up to 765 m^3/day (1000 yd^3/day), can be expected for light reinforced, noncontaminated concrete. These rates include drilling, loading, shooting, rebar cutting, and loading the waste pile into hauling equipment.

The major disadvantage of using controlled blasting is the limitations presented by the workplace. If access for blast hole drilling is limited, high-speed track-mounted drills cannot be used, necessitating

the use of slower hand-held drills. Fog sprayers must be used to hold down contaminated dust, creating a secondary liquid waste. There is also an inherent danger in controlled blasting in regard to personnel safety and nearby building damage. These special considerations can limit the effectiveness and the rate of contaminated concrete removal.

Conveyor System

A conveyor system is useful in transporting large amounts of material through continuous feed processes; however, the system is difficult to implement as a removal technology and is primarily used to support other options. The system consists of a steel or synthetic surface that is carried along a circuit of rollers. The termination point of the system is generally a loading point for another transporting mechanism or a feed input shelter for a treatment plant. The system can be modified to assist in waste removal by the addition of a bucket line or series of steel shelves along the conveyor surface.

Concrete-Based Cap

Similar to the asphalt-based cap, a single-layered cap composed of concrete is effective to control erosion and to minimize generation of leachate produced by precipitation infiltration through emplaced waste. A single-layered cap constructed of concrete must meet the same six criteria designated for the asphalt-based cap. A minimum slope of two percent is required to ensure precipitation runoff to minimize the generation of leachate. Like the asphalt-based cap, periodic application of special surface treatment may be required to maintain integrity.

Core-Stitch Drilling

Core stitch drilling is recommended for nonreinforced concrete, especially when surroundings are not to be disturbed. The technique consists of drilling holes in the concrete using a diamond or carbide-tipped drill bit in an electric- or fluid-driven rotary drill. The center lines of the holes are located to correspond to the desired breaking plane in the concrete. The hole pitch is such that there is very little concrete left between the adjoining holes (less than half the radius of the holes). When a line of holes has been drilled along the breaking plane, bars are inserted into the holes and force is applied to the free end of the bars in a line perpendicular to the breaking plane to shear the remaining concrete. Alternatively, a wrecking ball may be dropped onto the piece to be removed to shear the remaining concrete, or a diamond rope saw could be threaded into the hole and a relatively fast cut through minimum concrete could be made with minimum dust generation and surrounding disturbance. This is a fairly slow process but could be improved by the use of multiple drilling heads.

Crane with Clamshell System

A clamshell (or grab bucket) is a crane-operated mechanical removal device that could be crawler-mounted for this application. A clamshell is normally used for a reach/depth of up to 30.4 m (100 ft). Production rates for clamshells are relatively low, typically in the range of 20 to 30 cycles per hour, and vary with depth, working media, and swing angle. Clamshell buckets range in capacity from 0.8 to 9.2 m^3 (1 to 12 yd^3). A large-capacity, specially designed bucket could be used for this application. The bucket could be designed so that the probability of losing material during hoisting would be reduced to a minimum.

Clamshell dredging can excavate any type of material (except highly consolidated sediments and solid rock). The excavation is done at nearly in situ densities. Clamshell dredges can be operated in confined areas, and by using a long boom, operator exposure can be minimized. Major problems are low production, potential of losing material during hoisting operation, and high energy/operational costs. Material transport and support equipment are required for a successful operation.

Deep Geological Repository

A deep geological repository is a disposal facility that offers isolation and protection for the waste due to its deep earthen location, which gives it natural soil and rock barriers. Deep geological repositories can be permitted to store waste regulated by 40 Code of Federal Regulations (CFR) 191. Presently, there is not a licensed mine or deep geologic repository in the United States.

Diamond Chain Saw

A diamond chain saw is a device that is powered by hydraulics and is capable of cutting concrete and steel reinforcement. Some saws use a stream of water for cooling and dust control. A diamond chain saw is used when the creation of airborne contaminants is controlled by other means and the thickness of the concrete is no more than 0.6 m (2 ft) thick. The advantages of a diamond chain saw are its light weight and the fact that it can be easily managed by a single person. Its disadvantage is the creation of airborne contaminants and the limited thickness of material it can saw.

Diamond Rope Saw

Diamond rope saws are used when the creation of airborne contaminants and vibration to surrounding structures need to be kept to a minimum. The diamond rope saw is a smooth cutting technology capable of much deeper cuts than the diamond or carbide-tipped saws.

Diamond rope saws are used to cut concrete up to 6 m (20 ft) thick at various orientations to the horizontal plane. Resulting cuts are accomplished more quickly than those made with the diamond-tipped circular saw or the abrasive water jet, and with less noise and virtually no dust or vibration.

The diamond rope saw consists of a length of wire rope with diamond embedded steel beads strung onto the rope and separated by short sections of either steel or resilient plastic. Diamond cutting wires are supplied in diameters of 0.64, 0.95, 1.59, or 1.91 cm (1/4, 3/8, 5/8, or 3/4 in.).

The rope saw is fed through previously drilled holes. The ends are then securely joined and wrapped around a hydraulically driven flywheel. A predetermined strain is applied to the rope saw. The diamond rope saw travels at a rate of 912 and 1520 meters per minute (m/min) [3000 and 5000 feet per minute (ft/min)], cutting concrete at a rate of 0.93 to 3.72 square meters (m^2) [10 to 40 square feet (ft^2)] (cut surface area) per hour. A small amount of water is added to the cut line for lubrication and cooling of the diamond rope saw and then collected for filtration and recycling at the exit point or downgradient from the plane of the cut. The diamond rope saw mechanism, including saw stand and hydraulics, can be placed as far from the actual work as necessary for personnel and equipment protection.

The main advantage to the diamond rope saw is that it can cut at any elevation and in any direction. The major disadvantage is the setup time required between cuts. The specific configuration of the rope saw is dependent on the project requirements, thickness of the cut, type of aggregate contained in the concrete, and the amount of reinforcement in the concrete.

Diversion/Collection

Surface water diversion and collection forms an essential part of surface water management and includes dams, dikes/berms, channels (earthen/pipe), waterways, terraces/benches, chutes, downpipes, seepage ditches/basins, levees, and floodwalls. These techniques can be used as temporary or permanent measures for effective surface water control to prevent flooding, to control erosion, and to direct surface runoff.

Surface water diversion and collection techniques are useful support category techniques that may be either used in combination with each other or with other selected technologies. Some of these techniques are commonly used during site work and can be effective in preventing the contact of surface runoff with contaminated water and waste material.

Dragline System

A dragline is similar to a clamshell and is also a crane-operated device that would be crawler-mounted for this application. The primary difference is that a dragline bucket is loaded by being pulled across the material, whereas the clamshell is dropped into the material and hoisted vertically. A dragline can be used to excavate many types of materials. It has a longer reach than a clamshell and better horizontal control. A dragline has a greater potential of hoisting material and may require a specially designed bucket.

Drying/Calcination

Drying and calcination are weight/volume reduction techniques that use heat to remove bound water from sludges or solids. Water of dehydration can be removed by calcination because of the higher temperatures involved. Bound water is best removed by drying. Both of these techniques are ineffective on the hazards associated with any organics, metals, or radioactive materials in the sludge.

Drying is a commercial technology in the nuclear power industry for volume reduction of radioactive waste. Drying will reduce the weight and volume of the sludge and will reduce the cost of packaging and off-site transportation and disposal. Any drying system would require ventilation and dust control equipment. Drying can be accomplished in indirect heat transfer equipment, through direct contact with hot gas, or in equipment that combines both methods of heat input. The water produced by the drying or calcination process may have to be condensed and may require treatment for entrained particulate or volatilized organics.

Calcination may offer some additional weight/volume reduction over drying, but this advantage will probably be outweighed by the increase in air emission and cost.

Engineered Disposal Facility

The proposed engineered disposal facility concept basically consists of mounding over waste that has been placed on a stable structural pad. The facility will accept only dry waste placed in corrosion resistant containers and/or highly stabilized waste forms (Figure B.1-2). The following designs are typical:

- Closure cap with LC/DS and roller-compacted concrete intrusion barrier
- Cap thickness, including fill cover over the waste to form a 5-m (16.5-ft) criterion per 10 CFR 61

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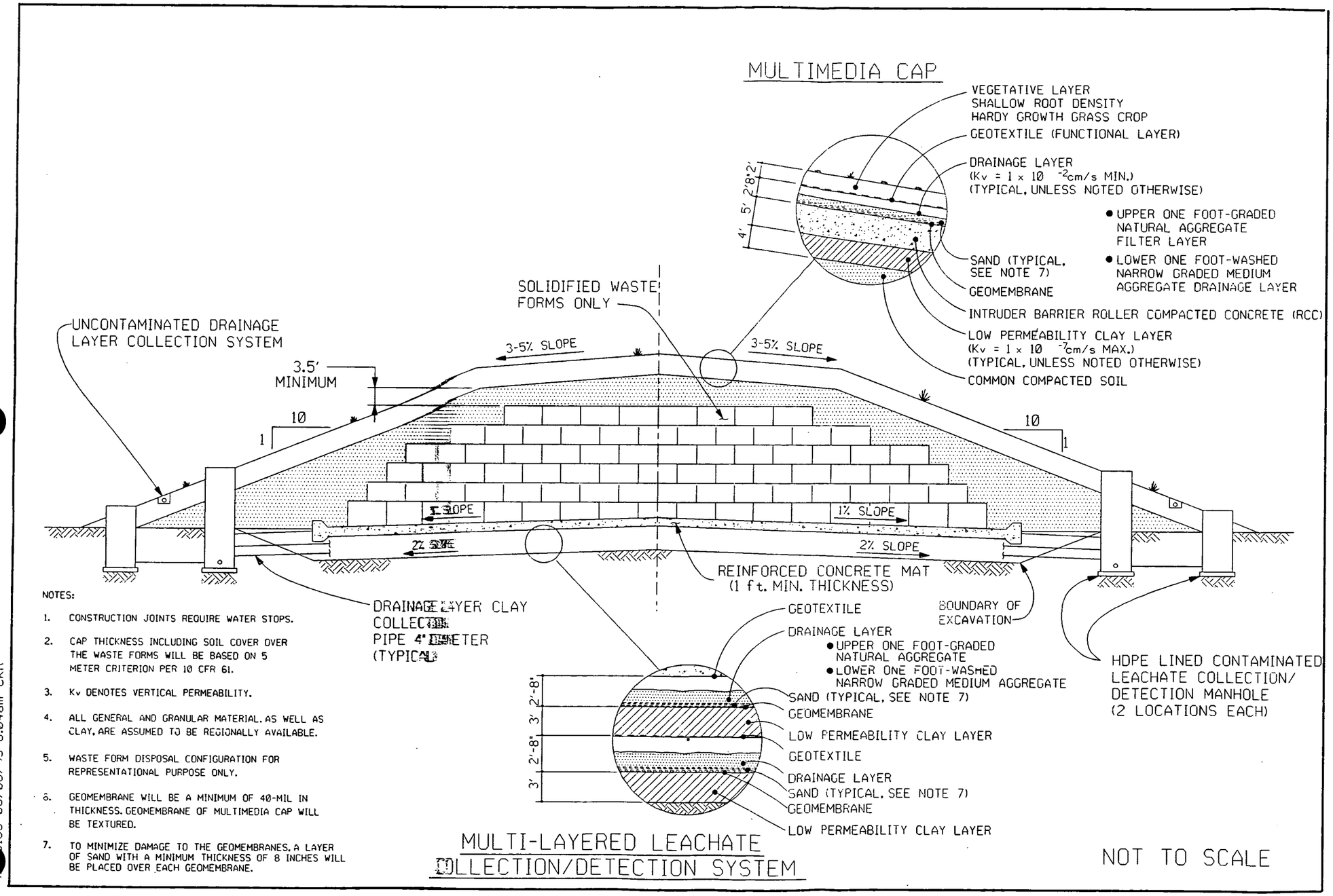

NOTES:

1. CONSTRUCTION JOINTS REQUIRE WATER STOPS.
2. CAP THICKNESS INCLUDING SOIL COVER OVER THE WASTE FORMS WILL BE BASED ON 5 METER CRITERION PER 10 CFR 61.
3. Kv DENOTES VERTICAL PERMEABILITY.
4. ALL GENERAL AND GRANULAR MATERIAL, AS WELL AS CLAY, ARE ASSUMED TO BE REGIONALLY AVAILABLE.
5. WASTE FORM DISPOSAL CONFIGURATION FOR REPRESENTATIONAL PURPOSE ONLY.
6. GEOMEMBRANE WILL BE A MINIMUM OF 40-MIL IN THICKNESS. GEOMEMBRANE OF MULTIMEDIA CAP WILL BE TEXTURED.
7. TO MINIMIZE DAMAGE TO THE GEOMEMBRANES, A LAYER OF SAND WITH A MINIMUM THICKNESS OF 8 INCHES WILL BE PLACED OVER EACH GEOMEMBRANE.

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FIGURE B.1-2 ENGINEERED DISPOSAL FACILITY

- Low permeability (1 x 10^{-7} cm/sec, maximum) multiple clay liner underlayment with a LC/DS

The advantages and disadvantages of an engineered disposal design are outlined as follows:

- Advantages

  - Ease and low cost of construction
  - Features covers and underliners complete with a LC/DS
  - Isolates waste forms from the groundwater regime
  - Isolates the waste from the surface environment and human contact
  - Soil provides shielding from radionuclide emissions
  - Waste may be retrieved after closure (except for in-place pumped waste/concrete)

- Disadvantages

  - Long-term cap maintenance and monitoring costs (e.g., primary and secondary LC/DS sumps) are required.

  - Integrity of engineered disposal may be compromised by the effects of weather, deep-rooted vegetation, and burrowing insects or animals.

  - During lulls in waste from placement activities, the open tumuli will be exposed directly to rainfall; this will generate leachate requiring additional testing and treatment.

Ex Situ Vitrification

Vitrification converts contaminated solids into a glass (amorphous) and crystalline mineral matrix that has extremely durable mechanical and chemical properties. Vitrification at melting temperatures between 1100 and 1600°C (2000 and 2900°F) will destroy organics and fix metals into the nonleachable stabilized melt. In vitrification, the waste mixture must have sufficient mineral content to form the glassy/crystalline matrix. If the waste is low in silica or alumina compounds, they may be added in the form of sand or soil.

Glass melting equipment (both continuous and batch) can be used to vitrify wastes. Conventional equipment, including "cold cap" and "drop tube electro" melters, have been studied for vitrifying radioactive waste. Batch (in can) melting of radioactive waste has been studied. A stirred tank melter also has been proposed but not extensively studied. Gas-fired melters are not appropriate because of air pollution control requirements.

The cold cap, drop tube, and stirred tank melters would be fed a mix of waste, sand, and fluxing agents and would produce a glass melt to be "pulled" off. This melt could be cast as blocks or frit and would resemble bottle glass. This product could be entombed or buried as required for final disposal.

Any vitrification process will produce off-gas containing steam, products from combustion of any organics, and some particulates. Some metals may be volatilized but these emissions should be lower than with other thermal techniques. The off-gas from any vitrification process must be collected and treated.

FEMP Advanced Wastewater Treatment Facility

This option refers to the use of the FEMP AWWT facility as "a discharge point" for untreated remediation water. This system would assume responsibility for the treatment and disposal of any wastewaters that develop as a result of the remediation. The FEMP AWWT facility utilizes ion exchange and metals precipitation.

Ion Exchange. Ion exchange is the process whereby toxic ions are removed from the aqueous phase by being exchanged with relatively harmless ions held by the ion exchange material. The ion exchange resins are primarily synthetic organic materials containing ionic functional groups to which exchangeable ions are attached. The resins can be tailored to be selective of specific ions. Ion exchange can be used to remove all metallic elements when present as soluble species, inorganic anions such as halides, nitrates, and cyanides, and organic acids such as carboxylics, sulfonics, and phenols. The ion exchange resins are sensitive to suspended solids and oxidants. This process option could be used to scavenge metals and other selective ions from the wastewater.

Metals Precipitation. Metals precipitation is carried out by adding acid or base to a waste solution to adjust the pH to a point where the metal(s) of concern have a low solubility. The metals then precipitate out of the solution. Coagulants are often added to the solution to aid in the precipitation process.

One metals precipitation process that was developed for the precipitation of radionuclides is the TRU/Clear® process. This process was developed at the Los Alamos National Laboratory and is marketed by ADC. The process uses potassium ferrate as an inorganic coagulant to remove radionuclides (i.e., U, Th, Ra) and other priority pollutants from wastewaters.

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Flame Cutting/Gas Torch

The objective of the flame cutting technique is to demolish radioactively contaminated concrete by cutting heavily reinforced, thick [up to 152 cm (60 in.)] concrete into manageable sections.

Flame cutting of concrete consists of a thermite reaction process whereby a powdered mixture of iron and aluminum oxides in a pure oxygen jet is ignited. The temperature in the jet is typically in the range of 1982 to 2482°C (3600 to 4500°F), causing rapid decomposition of the concrete in contact with the jet. Reinforcing rods in the concrete add iron, which sustains the flame and assists the reaction.

The torch is moved along the workface by the operator, who uses a variable speed electric motor mounted on a metal frame that covers the area to be cut. The rate of cutting depends on the depth of concrete being cut.

Flame cutting can be used when vibration is not allowed and the concrete to be cut is thicker than can be cut using other methods, such as a diamond saw.

The major advantage in using flame cutting to demolish concrete surfaces is the ability to cut extremely thick structures.

The major disadvantage is that during flame cutting, large amounts of dust, smoke, and heat are produced. These can be removed by using an exhaust system that includes flexible duct, prefilters, and if the material is radioactive, high efficiency particulate air (HEPA) filters. However, the effluent gas must be cooled to prevent damage to the HEPA filters.

Grading

Grading is the general term for techniques used to shape or reshape the surface of covered landfills to manage surface water infiltration and runoff while controlling erosion. The spreading and compaction steps used in grading are techniques practiced routinely at sanitary landfills. The equipment and methods used in grading are essentially the same for all landfill surfaces, but applications of grading technology will vary by site. Grading is often performed in conjunction with surface sealing practices and revegetation as part of an integrated landfill closure plan.

Grading is a relatively inexpensive remedial action component when suitable cover materials are available on property or close to the disposal site. The techniques and equipment used in grading operations are well established and are widely used in all forms of land development. It is usually possible to find contractors and equipment locally, thus expediting the work and avoiding extra expenses.

Surface grading serves several functions:

- Reduces ponding, which minimizes infiltration and reduces subsequent differential settling
- Reduces runoff velocities to reduce soil erosion
- Roughens and loosens soils in preparation for revegetation
- Can be a factor in reducing or eliminating leaching of wastes

Groundwater Monitoring

Groundwater monitoring is used as an inventory control method through record keeping by several common inventory monitoring techniques. The monitoring method is effective in that it may be the first indicator of leakage, product migration, and effects of abatement efforts. Groundwater monitoring is the most prevalent form of environmental monitoring for underground storage tanks. Methods used in groundwater monitoring include: collection upgradient, dye method, groundwater and soil sampling, observation wells, remote infrared sensing, surface geophysical methods, U-tubes, and vapor wells.

Groundwater monitoring can be used as an active part of an environmental cleanup action or as gauge/inventory monitoring should institutional actions be the method chosen as part of remediation. Groundwater monitoring wells would be placed both WP and downgradient of the remediated area. Groundwater data would be collected from the wells to verify effectiveness of remedial actions taken. Real time data can be used to compare against modeled groundwater quality predictions to monitor long-term effectiveness.

Grout Curtains

Grout curtains are narrow, vertical walls installed in the ground to divert laterally flowing groundwater. A grout curtain may be used upgradient of a contaminated area to prevent clean water from migrating through wastes or downgradient to limit migration of contaminants.

This technology is commercially available for use in shallow applications [9-12 m (30-40 ft) maximum depth]. The effectiveness of this technology largely depends on the presence of a confining layer of clay or rock into which the grout curtain is keyed. Without a confining layer, the grout curtain will not form an effective barrier (groundwater will find pathways under the grout curtain).

The local geology of the Operable Unit 4 area does not have this confining layer; thus, the technology would not be effective.

Hydraulic Splitter

This method is effective in cutting steel-reinforced concrete up to 0.9 m (3 ft) thick in one pass. The technology is also referred to as an abrasive water jet cutting system. The process generates no airborne contaminants or hazardous fumes. Water and abrasives can be fully contained. To minimize waste, the water may be recycled. Upon completion, any contaminated water would require treatment. The operation can be controlled and remotely operated to prevent the possibility of injury to workers.

Hydrolysis

Hydrolysis is the process of breaking a bond in a molecule (which is ordinarily not water soluble) so that it will go into ionic solution with water. Hydrolysis can be achieved by the addition of chemicals (e.g., acid hydrolysis), by irradiation (e.g., photolysis), or biologically (e.g., enzymatic bond cleavage). The cloven molecule can then be further treated by other means to reduce toxicity.

Chemical hydrolysis is applicable to a wide range of otherwise refractory organics. Acid hydrolysis, as in situ treatment, must be carefully performed because of the potential to mobilize any heavy metals that are present.

Impact Hammer

The objective of using an impact hammer (jackhammer) to demolish radioactively contaminated concrete is to remove concrete by mechanically fracturing localized sections of concrete.

Impact hammers are recommended for use on floors to remove small areas that are inaccessible for heavy equipment. They may also be used to expose reinforcing rods after controlled blasting to permit cutting of the rods.

The major advantage of using impact hammers is their ability to operate in relatively small work areas. Hand-held units can remove localized contaminated concrete without any disruptions to surrounding equipment or structures.

The major disadvantage of using impact hammers to demolish concrete structures is the slow removal rate. Removal rates of 20 m^3/day (26 yd^3/day) per impact hammer can be expected using the impact hammer technique. The inordinate amount of noise and dust generated by this method is also considered.

Incineration

The technology under consideration for incineration involves the use of a rotary kiln incinerator. A rotary kiln incinerator is a long, inclined tube that is rotated slowly. Wastes and auxiliary fuels are introduced to the high end of the kiln, and the rotation constantly agitates (tumbles) the solid materials being burned. This tumbling causes great turbulence and allows for improved combustion. Rotary kilns are intended primarily for solids combustion, but liquids and gases may be co-incinerated with solids. Exhaust gases from the kiln pass to a secondary chamber or afterburner for further oxidation. Ash residue is discharged and collected at the low end of the kiln. Exhaust gases require acid gas and particulate removal through the use of a gas scrubber, and the ashes may require stabilization before landfilling.

Most types of solid, liquid, and gaseous organic wastes or a mixture of these wastes can be treated with this technology. Explosive wastes and wastes with high inorganic salt content and/or heavy metals require special evaluation. This operation can create high particulate emissions that require postcombustion control.

In Situ Vitrification

The in situ vitrification process option converts contaminated solids into a glass and crystalline matrix without removal of the contaminated material. The crystalline matrix formed has durable mechanical and chemical properties. The contaminated material is "locked" in the glass matrix. Leaching of contaminants will occur but is only subject to the surface area of the vitrified product. The energy required to heat and melt the waste in place is supplied by applying electric current to electrodes buried in the waste. Because the moltened waste is conductive, it is heated by its own resistance (joule heating). For this process to be cost effective, the depth of the contaminated solids must be at

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least 1.8 m (6 ft). Large sites can be treated by successive in situ vitrification of adjacent blocks or zones.

In situ vitrification does not allow the optimization of the vitrified product formula to minimize leachable contaminants. Nonhomogenous solids would cause the glass matrix to be a different crystalline structure and promotes fracturing of the waste product. This in turn would promote higher leaching rates of contaminants.

In situ vitrification would destroy all organic contaminants in the soil. Inorganic contaminants would volatilize, including Mercury (Hg), Cadmium (Cd), and lead (Pb); however, these would be removed by an off-gas scrubber system, thus, generating a secondary waste stream.

Interim Storage Facility

Interim storage will be available until a suitable permanent disposal facility is available to accept waste; however, the interim storage facility will have a design life of 30 years. The interim storage facility will be designed to store waste up to 10 years until final disposal. This facility will be constructed on FEMP property and will be designed to conform to all applicable design criteria governing the storage of wastes of this nature.

Land Farming

Land farming is an option for untreated soil with low radioactivity levels. This material could be transported to an appropriately selected and sufficiently large expanse of remote, open land and spread to a degree that the soil radioactivity level approaches the natural background radiation level of these materials. The material can also be blended with clean fill for dilution and then spread over the land or disposed under road beds. This technology has not been demonstrated for radioactive waste. Land farming appears to be more appropriate for dry, granular, soil-like materials or tailings that are not mixed with other contaminants.

The technology appears simple and relatively inexpensive. It could result in a permanent remedy for the contaminated sites involved; however, selecting a site to receive the materials would likely be a politically and socially sensitive issue. The types of materials that could be accepted would probably fall within a very narrow range of physical and chemical characteristics. The technology has not been demonstrated. Utilizing land farming techniques on Operable Unit 4 wastes would create a high potential for airborne inhalation hazards to the public. A potential problem may be emitting

respirable particles into the air. Land spreading could contribute to a nonpoint source pollution problem generated by native soil.

Leachate Collection/Detection

Resource Conservation Recovery Act (RCRA) requirements mandate that leachate collection and removal systems be placed immediately above the primary liner in all new hazardous waste landfills. Such systems must be capable of maintaining a leachate depth of 0.3 m (1 ft) or less above the liner and withstanding clogging, chemical attack, and forces exerted by wastes, equipment, or soil cover.

U.S. Environmental Protection Agency (EPA) guidance documents recommend that the leachate collection system consists of a drainage layer at least 0.3 m (1 ft) thick, with a hydraulic conductivity greater than or equal to 1×10^{-3} cm/sec and a minimum slope of 2 percent. When installed over a secondary clay liner with hydraulic conductivity of 1×10^{-7} cm/sec, such a system provides the four-order-of-magnitude difference in permeability known to significantly increase drainage efficiency. The drainage layer should be covered by a filter (graded sand layer or geotextiles) to prevent infiltration of fines from the waste and subsequent clogging of the drainage layer.

Leachate collection pipe networks should consist of slotted or perforated drain pipe bedded and backfilled with a gravel envelope. Layouts should include base liner slopes greater than or equal to 2 percent and pipe grades greater than or equal to 0.005. Pipe spacing should be determined for the unit. All pipes should be joined and, where appropriate, bonded. Sumps or basins should be installed at low points on the base of the fill to collect leachate discharging from the collection network. A riser pipe extending from the sump to the ground surface enables leachate removal.

Lime/Flyash Stabilization

Some waste streams and contaminated soils can be dewatered and stabilized by the addition of large amounts of siliceous materials combined with a setting agent such as lime, flyash, or cement. It is important to know the chemical constituency of the waste since materials such as borates, sulfates, salts, and metallic anions interfere with the process. While this process is used for a variety of wastes, treatability studies should be performed for each new waste stream to ensure that the stabilization objectives are achieved.

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Lined/Unlined Pits/Trenches

Lined and unlined pits and trenches are open, uncontrolled waste dumping areas. These trenches and pits are generally not acceptable as a disposal option because of current regulatory requirements. Notwithstanding, such disposal practices for the wastes encountered in Operable Unit 4 would be viewed as being irresponsible and subject to both civil and criminal prosecution. The option is listed as a basis for comparison between modern disposal facilities and disposal facilities of the past that have resulted in remediation activities.

Loader/Dozer

A front-end loader is a tractor with a bucket for digging, lifting, hauling, and dumping materials. Front-end loaders are generally equipped with a hydraulically controlled bucket lift and can be either crawler- or rubber-tire-mounted. The front-end loader's buckets vary in capacity and design.

Crawler-mounted loaders are excellent excavators for rough, unstable surfaces. They can carry materials as far as 91 m (300 ft) beyond which the production rate becomes economically unfavorable. Medium-sized crawler-loaders typically have maximum bucket capacities of 3.8 to 4.6 m^3 (5 to 6 yd^3). Rubber-tire-mounted loaders for high production operations on stable surfaces have bucket capacities up to 20 m^3 (26 yd^3). Usually, front-end loaders are used in combination with excavation equipment such as backhoes.

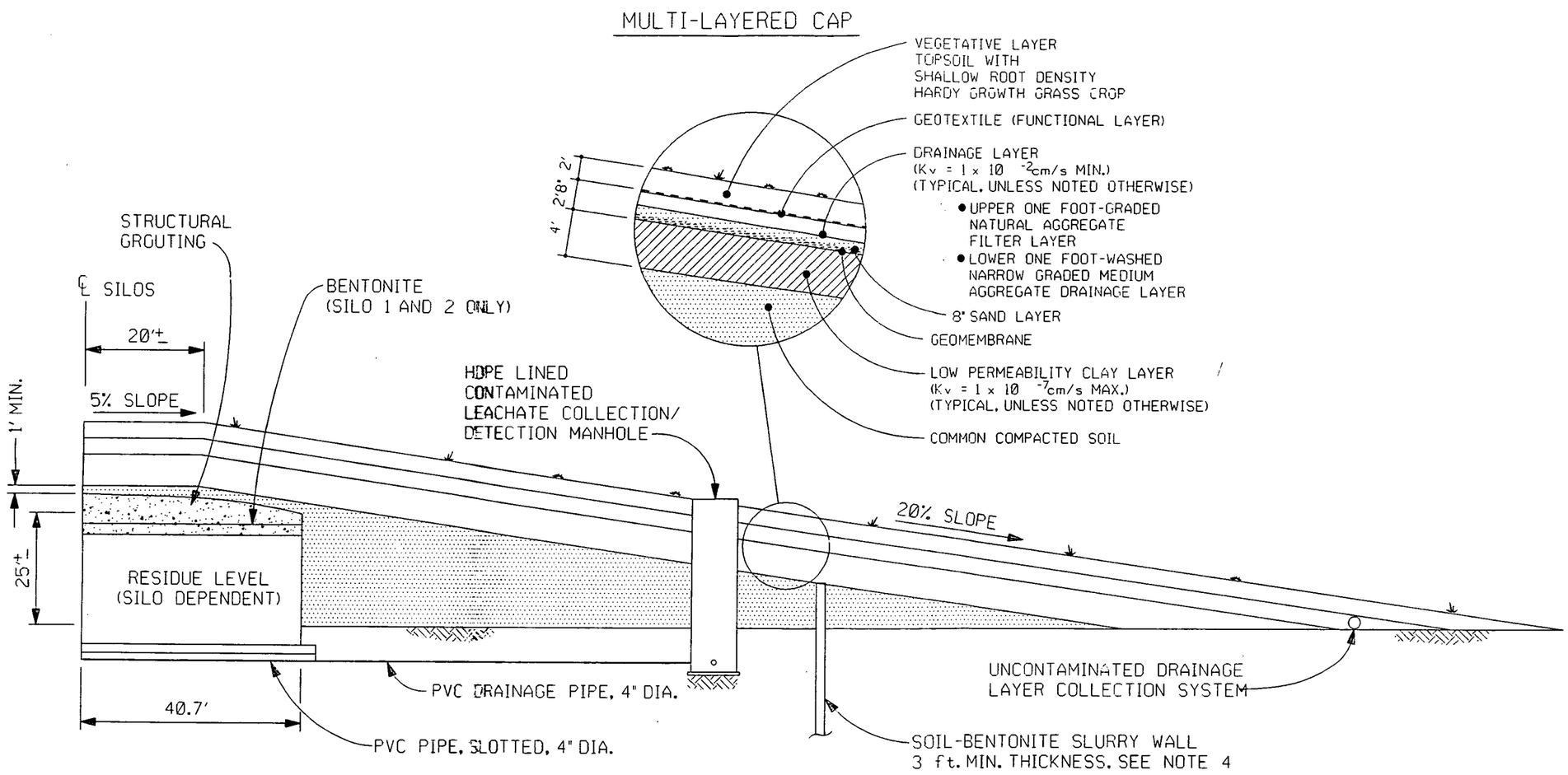
Crawler dozers equipped with blades of various sizes and shapes (straight to U-shaped) have tremendous earth-moving power and are excellent graders. In drum excavation work, these dozers can remove miscellaneous fill or soil overburden, or they can push earth and undamaged or empty drums from unstable surface areas to more accessible areas for lifting and loading operations. The dozers are generally used in combination with other excavation equipment such as backhoes.

Multimedia Cap

The multimedia cap is the preferred cap design because it incorporates the most effective attributes of all the other designs. The components of the multimedia cap (Figure B.1-3) are described as follows:

- Clay layer

  A 1.2-m (4-ft) minimum thickness, compacted clay layer with a verified 1×10^{-7} cm/sec permeability will be placed over the fill soils. This additional thickness will provide greater long-term resistance to stress-induced cracking and potential vegetative root attack, minimizing the possibility of water migration through the clay layer. Caps must also meet the requirements set forth in 40 CFR 261 Subpart Q and 40 CFR 192



NOTES:

1. SURFACE RUN-OFF (UNCONTAMINATED) FROM CAP WILL BE DIRECTED TO SEDIMENTATION BASIN OR PADDYS RUN.
2. CAP AND DOME CAVITY GROUT THICKNESS WILL CONFORM TO THE 5 METER CRITERION PER 10 CFR 61.
3. Kv DENOTES VERTICAL PERMEABILITY.
4. SLURRY WALL WILL EXTEND INTO THE GREAT MIAMI AQUIFER A MINIMUM OF TWO FEET.
5. ALL GENERAL AND GRANULAR MATERIAL, AS WELL AS CLAY, ARE ASSUMED TO BE REGIONALLY AVAILABLE.
6. THE GEOMEMBRANE WILL BE A MINIMUM THICKNESS OF 40-MILL AND TEXTURED.

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FIGURE B.1-3 MULTIMEDIA CAP

for control of radon through the clay layer. The cap must be constructed with enough erosion resistance to provide reasonable insurance of containment of radioactive waste and radon for 1000 years.

- Drainage layer

A drainage layer with a minimum thickness of 0.6 m (2 ft) will be placed over the clay layer. The upper 0.3 m (1 ft) of the drainage layer will be a natural graded natural aggregate, and the lower 0.3 m (1 ft) will be a narrow graded medium aggregate to provide a minimum permeability of 1 x 10^{-2} cm/sec.

The drainage layer will intercept infiltrating precipitation and will rapidly transport the water to an uncontaminated collection system located at the toe of the multimedia cap. A geotextile liner will be placed between the top surface of the drainage layer and the overlying vegetative layer to prevent the migration of fines from the vegetative to the drainage layer.

- Vegetative layer

The 0.6-m (2-ft) thick vegetative layer placed over the drainage layer shall be composed of common clean soils with the upper 8-cm (3-in.) thickness capable of supporting a hardy, persistent growth, shallow-rooted [zero root density at 30.5 cm (12 in)] deep grass crop.

The vegetative layer protects the clay layer against environmental abrasion including desiccation, freeze/thaw damage, erosion, and hydraulic-induced stresses caused by standing or ponding water. The vegetation on the surface should be maintained to preclude both old field succession and erosion in order to provide reasonable insurance of containment of radioactive waste and radon for 1000 years. Such maintenance would include but not be limited to mowing, reseeding, fertilization, burrow fill material, etc.,.

Nevada Test Site

This process option calls for the disposal of the wastes at an existing government facility located in an arid western environment. This facility is currently operating and accepting many types of U.S. Department of Energy (DOE) waste. An Environmental Impact Statement (EIS) for waste disposal activities at the Nevada Test Site (NTS) is currently in process to satisfy the requirements of the National Environmental Policy Act (NEPA). Several disposal technologies are currently utilized at NTS (e.g., shallow land burial, burial in trenches, and disposal in large-diameter augered shafts). However, only shallow land burial is utilized for low level waste since mixed waste is not currently accepted at the facility. Because the facility is located in an area with an arid climate far from any population centers and significant water sources, it offers many advantages from a long-term risk standpoint. An interim on-site storage facility can be a part of this process option if the administrative and regulatory issues for off-site waste disposal have not been resolved at the start of

remediation. The wastes could be transported to the facility by truck or rail as discussed elsewhere in this appendix.

Human habitation of the NTS area ranges from as early as 10,000 B.C. to the present. Various aboriginal cultures occupied the NTS area over this extended period as evidenced by the presence of artifacts at many surface sites and more substantial deposits of cultural material in several rock shelters. This period of aboriginal occupation was sustained primarily by a hunting and gathering economy based on using temporary campsites and shelters. The area was occupied by Pauite Indians at the time of the first known outside contact in 1849.

The NTS has been the primary location for testing the nation's nuclear explosive devices since January 1951. The NTS is operated by the DOE as the on-continent test site for nuclear weapons testing. It is located in Nye County, Nevada, with the southeast corner lying about 105 kilometers (km) [65 miles (mi)] northwest of the city of Las Vegas, Nevada. The NTS encompasses about 3500 km^2 (1350 mi^2), an area larger than the state of Rhode Island. The dimensions of the NTS vary from 46 to 56 km (28 to 35 mi) in width (eastern to western border) and from 64 to 88 km (40 to 55 mi) in length (northern to southern border). The NTS is surrounded on the east, north, and west sides by public access exclusion areas consisting of the Nellis Air Force Base (NAFB) Bombing and Gunnery Range and the Tonopah Test Range. These two areas comprise the NAFB Range Complex, which provides a buffer zone between the test areas and public lands. The combination of the NAFB Range Complex and the NTS is one of the larger unpopulated land areas in the United States, comprising some 14,200 km^2 (5470 mi^2). Mercury, Nevada, located at the southern end of the NTS, is the main Base Camp for worker housing and administrative operations for the site. Area 12 Base Camp, located at the northern end of the site, is the other major worker housing and operations support facility.

The topography of the NTS is typical of much of the Basin and Range physiographic province of Nevada, Arizona, and Utah. North-south-trending mountain ranges are separated by broad, flat-floored, and gently-sloped valleys. Elevations range from about 910 m (3000 ft) above mean sea level (MSL) in the south and east, rising to 2100 m (6900 ft) in the mesa areas toward the northern and western boundaries. The slopes on the upland surfaces are steep and dissected, whereas the slopes on the lower surfaces are gentle and alluviated with rock debris from the adjacent highlands. The principal effect upon the terrain from nuclear testing has been the creation of numerous dish-shaped surface subsidence craters, particularly in Yucca Flat. There are not continuously flowing

streams on the NTS. Surface drainages for the Yucca Flat and Frenchman Flat are in closed-basin systems, which drain onto the dry lake beds (playas) in each valley. The remaining area of the NTS drains via arroyos and dry streambeds that carry water only during unusually intense or persistent storms. Rainfall or snow melt typically infiltrates quickly into the moisture deficient soil or runs off in normally dry channels, where it evaporates or seeps into permeable sands and gravels. During extreme conditions, flash floods may occur. The northwest portion (Pahute Mesa) of the NTS has integrated channel systems which carry runoff beyond NTS boundaries into the closed basins and playas in Kawich Valley and Gold Flat on the NAFB Range Complex. The western half and southernmost part of the NTS have channel systems which carry runoff from intense storms towards the southern boundary of the NTS and off site towards the Amargosa Desert.

In general, the geology consists of three major rock units. These are (1) completely folded and faulted sedimentary rocks of Paleozoic age overlain at many places by (2) volcanic tuffs and lavas of Tertiary age, which (in the valleys) are covered by (3) alluvium of late Tertiary and Quaternary age. The sedimentary rocks of Paleozoic age are many thousands feet thick and are comprised mainly of carbonate rocks (dolomite and limestone) in the upper and lower parts, separated by a middle section of clastic rocks (shale and Quartzite). The volcanic rocks are relatively undeformed, and dips are generally gentle. The alluvium is derived from erosion of the nearby hills of Tertiary and Paleozoic rocks. The volcanic rocks of Tertiary age are predominantly tuffs, which erupted from various volcanic centers, and lavas, mostly rhyolitic in composition. The aggregate thickness of the volcanic rocks is many thousands of feet, but in most places, the total thickness of the section is far less because of erosion or nondeposition. These materials erupted before the collapse of large volcanic centers known as calderas. Alluvial materials fill the intermountain valleys and cover the adjacent slopes. These sediments attain thickness of 600 to 900 m (2000 to 3000 ft) in the central portions of the valleys. The alluvium in Yucca Flat is vertically offset along the prominent north-south-trending Yucca fault.

Depths to groundwater beneath the NTS vary from about 157 m (515 ft) beneath the Frenchman Flat playa (Winograd and Thordarson 1975) in the southern part of the NTS to more than 610 m (2000 ft) beneath part of Pahute Mesa. In the eastern portions of the NTS, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer. The flow in the shallower parts of the groundwater body is generally toward the major valleys (Yucca and Frenchman) where it deflects downward to join the regional drainage to the southwest in the carbonate aquifer. The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley

groundwater basin. Groundwater beneath the eastern part of the NTS is in the Ash Meadows subbasin defined by discharge through evapotranspiration along a spring line in Ash Meadows (south of the NTS). Most of the western NTS is in the Alkali Flat/Furnace Creek Ranch subbasin, which discharges by evapotranspiration at Alkali Flat and by spring discharge near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley subbasin, discharging by evapotranspiration in the Oasis Valley.

A long-term hydraulic monitoring program was instituted in 1972 to be operated by the EPA under an interagency agreement. Groundwater was monitored on and around the NTS, at eight sites in other states, and at two locations off property in Nevada in 1991 to detect the presence of any radioactivity in the groundwater. No radioactivity was detected in the groundwater sampling network around NTS. The NTS groundwater monitoring network currently utilizes wells that were drilled for water supply or exploratory purposes. Therefore, an extensive program to install groundwater monitoring wells has been implemented. The program will involve the installation of approximately 90 wells on or near NTS.

Precipitation levels on the NTS are low, runoff is intermittent, and the majority of the active testing areas on the NTS drain into closed basins on the site. The NTS mesas receive an average annual precipitation of 23 cm (9 in.), which includes winter snow accumulations. The lower elevations receive approximately 15 cm (6 in.) of precipitation annually, with occasional snow accumulations lasting only a matter of days. Predominating winds are southerly during summer and northerly during winter. The prevailing wind direction during winter months is from north-northeast, and during summer months, winds prevail from the south. In Yucca Flat, the average annual wind speed is 11 kilometers per hour (km/hr) [7 miles per hour (mi/hr)]. The prevailing wind direction during the winter months is north-northwest and during summer months is south-southwest. At Mercury, the average annual wind speed is 13 km/hr (8mi/hr), with a prevailing wind direction of northwest during the winter months and southwest during the summer months.

The greater part of the NTS is vegetated by various associations of desert shrubs typical of the Mojave or Great Basin Deserts or the zone of transition desert between these two. There are areas of desert woodland (pinon and juniper) at higher elevations. Even there, typical Great Basin shrubs, principally sagebrushes, are a conspicuous component of the vegetation. Although shrubs (or shrubs and small trees) are the dominant forms, herbaceous plants are well represented in the flora and play an important role in supporting animal life.

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Extensive floral collection has yielded 711 taxa of vascular plants within or near the boundaries of the NTS. Associations of creosote brush, *Larrea tridentata*, which are characteristic of the Mojave Desert, dominate the vegetation mosaic on the bajadas of the southern NTS. Between 1220 and 1520 m (4000 and 5000 ft) elevations in Yucca Flat, transitional associations are dominated by *Grayia spinosa-Lycium andersonii* (hopsage/desert thorn) associations, while the upper bajadas support *Coleogyne* types. Above 1520 m (5000 ft), the vegetation mosaic is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* ssp. *nova*. Above 1830 m (6000 ft), pinon pine and juniper mix with the sagebrush associations where there is suitable moisture for these trees. No plant species located on the NTS is currently on the federal endangered species list; however, the state of Nevada has placed *Astragalus beatleyae milk-vetch* on its critically endangered species list. Most mammals on the NTS are small and secretive (often nocturnal in habitat), hence not often seen by casual observers; larger mammals include horses, burros, deer, mountain lions, bobcats, coyote, kit foxes, and rabbits. Reptiles include four species of venomous snakes; bird species are mostly migrants or seasonal residents. In terms of distribution and relative abundance, rodents are the most important group of mammals on the NTS. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada. In 1989, the desert tortoise, *Gopherus agassizii*, was placed on the endangered species list by the U.S. Department of Interior and was relisted as threatened in 1991. Tortoise habitats on the NTS are found in the southern third of NTS outside the current areas of nuclear test activities in Yucca Flat, Rainier Mesa, and Pahute Mesa.

There are many archaeological sites on the Pauite and Rainier Mesas testing areas. Surveys of some of these NTS areas are documented in. In addition to the archeological sites, there are also some sites of historical interest on the NTS. The principal sites include the remains of primitive stone cabins with nearby corrals at three springs, a natural cave containing prospector's paraphernalia in Area 30, and crude remains of early mining and smelting activities.

In 1991, 17 pre-activity surveys were conducted for archeological sites on the NTS, and reports on the findings were prepared. These pre-activity surveys identified 56 sites containing previously unknown archeological information. These sites were added to the cultural resources inventory files, site records, and all artifacts collected from the NTS were processed for storage. Due to avoidance of all potentially significant sites by activities at the NTS, no test excavations, data recovery plans, or data-recovery projects were undertaken in 1991.

Excluding Clark County, the major population center (approximately 741,000 in 1990), the population density within a 150-kilometer radius of the NTS is about 0.5 persons per square kilometer. In comparison, the 48 contiguous states (1990 census) had a population density of approximately 29 persons per square kilometer. The estimated average population density for Nevada in 1990 (including Clark County) was 2.8 persons per square kilometer. The off-site area within 80 kilometers of the NTS Control Point is predominantly rural. CP-1 (a building at the Control Point) historically has been the point from which distances from the NTS were determined.

Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of 15,000, is located 80 kilometers south of CP-1. The Amargosa Farm area, which has a population of about 950, is located about 50 kilometers southwest of CP-1. The largest town in the near off-site area is Beatty, which has a population of about 1500 and is located approximately 65 kilometers to the west of CP-1. The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The estimated that the population within the Monument boundaries ranges from a minimum of 200 permanent residents during the summer months to as many as 5000 tourists and campers on any particular day during "Death Valley Days" in the month of November. The largest nearby population in this desert is the Ridgecrest-China Lake area about 190 km (118 mi) southwest of the NTS containing about 28,000 people. The next largest is in the Barstow area (104 km^2 or 40 mi^2) located 265 km (165 mi) southsouthwest of the NTS with a 1991 population of 21,000. The Owens Valley, where numerous small towns are located, lies 50 km (31 mi) west of Death Valley. The largest town in the Owens Valley is Bishop, located 225 km (140 mi) northwest of the NTS, with a population of 3500.

Recreational areas lie in all directions around the NTS and are used for such activities as hunting, fishing, and camping. In general, the camping and fishing sites to the northwest, north, and northeast of the NTS are utilized throughout the year except for the winter months. Camping and fishing locations to the southeast, south and southwest are utilized throughout the entire year. The peak hunting season is from September through January.

New Facility Adjacent to the FEMP Site

This process option calls for the disposal of the wastes at a facility to be constructed adjacent to the site. This facility would be constructed adjacent to the site in a location with more desirable geological characteristics than those found on FEMP property. The facility would have waste

acceptance criteria consistent with those established for the FEMP property disposal facility described in the Conceptual Design Report (CDR). Because a site has not been selected nor has a facility been constructed and will not likely be before Operable Unit 4 is remediated, a FEMP property disposal facility could be used in the interim. The wastes could be transported by truck or rail.

New Facility Within 483 Kilometers (300 Miles) of the FEMP Site

This process option calls for the disposal of the wastes at a facility to be constructed within a 483-km (300-mi) radius of the site. This facility, a federally-owned regional disposal site, would be constructed in an area with desirable demographic and geologic conditions and would be shared by a number of DOE facilities in the region. This facility is assumed to have waste acceptance criteria consistent with the FEMP property disposal facility described in the CDR. Because a site has not been selected nor has a facility been constructed and will not likely be before Operable Unit 4 is remediated, a FEMP property disposal facility could be used in the interim. The wastes could be transported by truck or rail.

Nonexplosive Demolition Compounds

This process option utilizes a chemical agent for the demolition of heavily reinforced concrete structures through the introduction of intrinsic physical forces within the structure. By eliminating the use of explosive powders, flyrock, fugitive dust, gas vapor, vibration, and noise are not produced. The demolition agent is mixed with water to produce a chemical reaction and is then poured into drilled, cylindrical holes of a designed pattern. The fracturing process occurs as the mixture hardens and expands within the holes. Cracks are generated within three hours after placement of the mixture.

This nonexplosive demolition agent minimizes the potential safety hazard to workers. Because the agent consists of safe organic and inorganic compounds, no special regulation or license is required.

Oil/Water Separation

Oil/water separators are commonly found in wastewater treatment facilities because of their effectiveness in removing the free oil from waste streams. The separator is usually placed at the beginning of the treatment process before chemicals are added. A separator is constructed of chambered cells that allows the waste stream to slow down without turbulence so the materials can separate due to the differential in their specific gravities. The oil will combine in a layer that floats

on top of the water. The water is carried off through an opening in the bottom of the separator and oil is collected off the top for additional treatment or disposal.

Oxidation/Ozonation/Photolysis

Chemical oxidation is used primarily for detoxification of cyanide and for treatment of dilute waste streams containing oxidizable organics. Among the organics for which oxidative treatment has been reported are: aldehyde, mercaptans, phenols, benzidine, unsaturated acids, and certain pesticides.

Chemical oxidation can be an effective way of pretreating wastes before biological treatment; compounds that are refractory to biological treatment can be partially oxidized, making them more amenable to biological oxidation.

One of the major limitations with chemical oxidation is that the oxidation reactions frequently are not complete (reactions do not proceed to CO_2 and H_2O). Incomplete oxidation may be due to oxidant concentration, pH, oxidation potential of the oxidant, or formation of a stable intermediate. The danger of incomplete oxidation is that oxidation products with a greater toxicity could be formed. Chemical oxidation is not well suited to high-strength, complex waste streams. The most powerful oxidants are relatively nonselective and any oxidizable organics in the waste stream will be treated. For highly concentrated waste streams, this will result in the need to add large concentrations of oxidizing agents to treat target compounds. Some oxidants such as potassium permanganate can be decomposed in the presence of high concentrations of alcohols and organic solvents.

Permitted Commercial Disposal Site

This process option calls for the disposal of the wastes at an existing permitted commercial disposal site located in an arid western environment. Envirocare is representative of a typical permitted commercial disposal site. Envirocare is currently permitted to accept mixed waste which meet RCRA land disposal restrictions (LDRs). This facility is operating and accepting low-level radioactive waste. Because the facility shares many of the same geographic and climatological characteristics as the government facility (Nevada Test Site), it offers many of the same long-term risk advantages.

The Envirocare site near Clive, Utah, is licensed by the state of Utah for naturally occurring radioactive material (NORM), as well as mixed NORM and chemically hazardous waste. The site is located on the eastern edge of the Great Salt Lake Desert in Tooele County, Utah, approximately 129 km (81 mi) west of Salt Lake City (See Figure I.7 located in Appendix I of this report). The

Envirocare site occupies approximately 220 hectares (540 acres) in a county set-aside area zoned for radioactive waste disposal and is located approximately 0.62 km (1 mi) south of a rail switch point identified as Clive. Approximately 40 hectares (100 acres) adjacent to the site is the disposal location for uranium mill tailings removed from Salt Lake City as part of the Uranium Mill Tailings Radiation Control Act (UMTRCA) program. Much of the land surrounding the Envirocare site is public domain administered by the U.S. Bureau of Land Management.

The Envirocare site is situated in an arid desert area rated by the Bureau of Land Management as being poor for grazing or forage production. Vegetation at the site is a homogeneous, semidesert low shrubland, composed primarily of shadscale. This shrubland is part of the northern desert shrub biome of the cold desert formation and has been described as a saltbrush (shadscale)-greasewood shrub complex. Plant communities identified in the area are shadscale-gray molly, black greasewood-Gardner saltbrush, and a shadscale-gray molly/black greasewood transitional community (Figure I.8); all three communities are low in species diversity. The vegetation forms an important ground cover that provides habitat for wildlife.

Animal species reported from the area, all of which may breed or nest there, include black-tailed jackrabbit, deer mouse, grasshopper mouse, horned lark, and desert horned lizard. No wetlands or other aquatic habitats are present at or in the vicinity of the Envirocare facility. The nearest stream channel ends approximately 3 km (1.9 mi) east of the site, and the nearest body of permanent surface water is Big Spring, about 45 km (28 mi) east of the facility.

Physical Barriers

Physical barriers represent any structures placed to inhibit/control public contact. Physical barriers could consist of fences, roadblocks, and/or security posts. Site access will be limited to authorized personnel only. Physical barriers are used along with administrative controls to form an effective barrier between areas accessible to the public and unauthorized for access by the public.

Pneuma/Oozer Dredging

The pneuma dredge consists of a pump that is lowered by a crane into the sediment being dredged. The pump is driven by compressed air and operates by positive displacement. The body of the pump contains three cylindrical vessels, each with an intake opening on the bottom and an air port and a discharge outlet on top. The air ports can be opened to the atmosphere through air hoses and valves.

The three cylinders operate in parallel, each one-third cycle ahead and behind the other two cylinders, and controlled by an air distributor located on the control vessel.

Pneuma dredges are normally suspended from a crane cable and pulled ahead into the sediment being dredged by a second cable. The dredge head is essentially fixed relative to the vessel so that lateral manipulation of the dredge is limited to the positioning and movement of the vessel.

The oozer dredge, developed in Japan, consists of a pump similar in concept to the pneuma dredge. It uses negative (vacuum) pressure in the filling chambers and atmospheric pressure when dredging in the shallow depths. The pump is usually mounted at the end of a ladder. The pump body consists of two cylinders to which a vacuum is applied to increase the differential pressure and flow between the sediment and the cylinders. Sediment thickness detectors, underwater television cameras, and a turbidimeter are attached near the suction mouth for monitoring. Suspended oil can be collected by an attached hood, and cutters can be attached for dislodging hard soils.

Oozer dredges are normally pulled along a straight line fixed by a cable-and-winch arrangement anchored on land or on the bottom of the dredge area. The dredge vessel moves along the line of the cable, and the cable is repositioned to establish a new line as dredging progresses.

Polymerization

Polymerization systems can be formulated to work with both organic solvent, oil, or water-base waste systems; most of the processes developed to date are designed to work with water-base wastes. The systems consist of monomers that are polymerized or cross-linked by the use of catalysts or accelerators after being mixed with the liquid waste. This kind of system is almost infinite in potential variety, but for practical purposes has been limited so far to urea-formaldehyde, polybutadiene, polyester-epoxy, acrylamid gel, urea-formaldehyde with plaster of paris, polyolefin encapsulation, and polyurethane.

A disadvantage of polymerization is that the presence of water and other ingredients in the wastes often interferes with the polymerization reaction. For use with water-base wastes, the systems are formulated as emulsions. The urea-formaldehyde process is especially prone to this problem, which has reduced its once extensive use in the nuclear waste area.

In most cases, the action of the organic polymer is primarily permeation limiting. Usually, there is no direct reaction between the waste constituents and the polymer, nor does the system actually insolubilize, detoxify, or destroy the hazardous constituents. However, since these polymers generally have a very low order of permeability, they are more reflective in this respect than many inorganic systems. The mechanism of most organic systems is microencapsulation of the waste material, which separates the waste from its environment. One of the technical advantages of many of the organic processes is that a given polymer can be applied to a wide variety of waste types because there is usually no direct chemical interaction between the polymer and the waste. This is advantageous when dealing with a complex mixture of wastes or a wide variety of individual wastes in a given disposal situation. A primary disadvantage of the organic processes to date has been cost.

Pressure Washing

This technique is most often used in areas where the contaminated surface is hard to reach and/or at high elevations. Pressure washing consists of high pressure water (usually hot water) sprayed against the surface to be decontaminated, thus removing the contamination by impaction and washing. This high-pressure wash is usually generated by a small self-contained unit including the pump, burner, and tank necessary to perform operations. Accessories supplied to certain systems allow the injection of abrasive additives into the stream to improve the cleaning process. These abrasives are usually recycled by means of a cyclone within the system, then reused. These pressure-washing techniques are best suited for decontaminating surfaces that can be dusty and do not allow for building service and/or ventilation. The main advantages of pressure washing are the remote operation capabilities of the individual units and the absence of dust generation in the cleaning process. The main disadvantage to this system is that some quantities of process water may be required, which results in generation of a secondary waste stream. This liquid waste stream must be contained to prevent contamination of surrounding areas. Other disadvantages include the safety risks associated with high pressure/temperature operations and the need for worker training in the operation and maintenance of these machines.

Pumping Wells

Groundwater extraction techniques involve the active manipulation and management of groundwater to contain or remove a plume or to adjust groundwater levels to prevent formation of a plume. Types of wells used in management of contaminated groundwater include wellpoints, suction wells, ejector wells, and deep wells. The selection of the appropriate well type depends on the depth of contamination and the hydrological and geological characteristics of the aquifer.

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Where plume containment or removal is the objective, either extraction wells or a combination of extraction and injection wells can be used. Use of extraction wells alone is best suited to situations where contaminants are miscible and move readily with water; where the hydraulic gradient is steep and hydraulic conductivity high; and where quick removal is not necessary. Extraction wells are frequently used in combination with slurry walls to prevent groundwater from overtopping the wall and to minimize contact of the leachate with the wall to prevent wall degradation. Slurry walls also reduce the amount of contaminated water that requires removal so that costs and pumping time are reduced.

Extraction or injection wells can also be used to adjust groundwater levels; however, this application is not widely used. In this approach, plume development can be controlled at sites where the water table intercepts disposed wastes by lowering the water table with extracting wells. For this pumping technique to be effective, infiltration into the waste pile must be eliminated and liquid wastes must be completely removed. If these conditions are not met, the potential for development of a plume of contaminants exists. The major drawback to using well systems for lowering water tables is the continued costs associated with maintenance of the system.

Radon Monitoring

Radon monitoring consists of active and passive radon monitoring equipment that is used to ascertain conditions of the Operable Unit 4 area during and after remediation activities are complete. Radon monitoring equipment included are full flow air sampling devices and carbon adsorption units.

Rail Transport

The FEMP site can readily accommodate rail transport by use of existing on-property track spurs. Rail transport offers many advantages over trucking, including:

- Low cost per waste ton/mile transported
- Lower accident rate
- Ability to haul large tonnages at one time, which could possibly lessen the potential public exposure

A possibility exists that the approved waste site may not have an available rail spur. However, a spur could be built.

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A major consideration for any transport mechanism may be the resistance from local groups. -5039 Although considerable local opposition should be expected, the mass transportation required to implement off-site disposal could be challenged in numerous local political jurisdictions along the transport route, creating unacceptable site cleanup delays.

Reduction

Chemical reduction involves adding a reducing agent that lowers the oxidation of a substance to reduce toxicity or solubility or to transform it to a form that can be more easily handled. For example, in the reduction of hexavalent chromium [Cr (VI)] to trivalent chromium [Cr (III)] using sulfur dioxide, the oxidation state of Cr changes from 6+ to 3+ (Cr is reduced) and the oxidization state of sulfur increases from 2+ to 3+ (sulfur is oxidized). The decrease in the positive valence or increase in the negative valence with reduction takes place simultaneously with oxidation in chemically equivalent ratios.

Chemical reduction is well demonstrated for the treatment of lead, mercury, and chromium. However, for complex waste streams containing other potentially reducible compounds, laboratory and pilot-scale tests will be required to determine appropriate chemical feed rates and reactor retention times.

Chemical reduction can be carried out using simple, readily available equipment and reagents. Capital and operating costs are low and the process is easy to implement.

Revegetation

The establishment of a vegetative cover is a cost-effective method to stabilize the surface of hazardous waste disposal sites, especially when preceded by capping and grading. Revegetation decreases erosion by wind and water and contributes to the development of a naturally fertile and stable surface environment. Also, the technique can be used to upgrade the appearance of disposal sites that are being considered for various reuse options. Short-term vegetative stabilization (i.e., on a semiannual or seasonal basis) can also be used as a remedial technique for disposal sites.

A systematic revegetation plan will include: (1) selection of suitable plant species, (2) seedbed preparation, (3) seeding/planting, (4) mulching and/or chemical stabilization, and (5) fertilization and maintenance.

Sedimentation Basin/Sediment Trap

Sedimentation basins and sediment traps are used to control suspended solids entrained in surface flows. Sedimentation basins and sediment traps are constructed by placing an earthen dam across a waterway or natural depression, or by excavation, or by a combination of both. The purpose of installing a sedimentation basin or sediment trap is to impede surface runoff carrying solids, thus allowing sufficient time for the particulate matter to settle.

Sedimentation basins and sediment traps are usually the final step in control of diverted, uncontaminated, surface runoff before discharge. They are especially useful in areas where there is a high silt or sand content in the surface runoff. They are an essential part of any good surface flow control system.

The removal of suspended solids from waterways is based on the concept of gravitational settling of the suspended material. The major components of a sedimentation basin include a principal and emergency spillway, an antivortex device, and a basin.

Shallow Soil Mixing

Shallow soil mixing is a method of mixing soils or sludges with dry or fluid treatment chemicals to produce a solidified or stabilized end product. Shallow soil mixing is designed to provide in situ mixing of ponds, pits, and lagoons to a depth of 9 m (30 ft) or more using a crane-mounted mixing system. The mixing head is enclosed in a bottom-opened cylinder that allows a closed system for the mixing of waste and treatment chemicals. As the mixing head blades pass in an up-and-down motion through the waste, a negative pressure is maintained on the cylinder headspace to pull any vapors or dust to an air treatment system.

Shallow soil mixing has the advantages of a negative head pressure, treatment of any off-gases and/or dust, and waste treatment by stabilization chemicals that can be correctly proportioned during mixing operations. It also is operable to mixing depths of 9 m (30 ft) or more.

Sheet Pilings

In addition to slurry walls, sheet piling can be used to form a groundwater barrier. Sheet piles could be used to isolate surface contamination by diverting groundwater from the contamination source. Sheet piles can be made of wood, precast concrete, or steel. However, wood is an ineffective water

barrier, and concrete is used primarily where great strength is required. Steel is the most effective in terms of groundwater cutoff and cost, and is discussed in the following paragraphs.

For construction of a sheet piling cutoff, the pilings are assembled at their edge interlocks before they are driven into the ground. This is to ensure that earth materials and added pressures will not prevent a good lock between piles. The piles are then driven a few feet at a time over the entire length of the wall. This process is repeated until all piles are driven to the desired depth.

Steel sheet piling can be employed as a groundwater barrier much like the other options discussed in this appendix. However, sheet pile walls do not provide a complete barrier against groundwater flow because water may move through the sheet pile joints. Therefore, because of costs and unpredictable wall integrity, it is seldom used except for temporary dewatering for other construction, or as erosion protection where some other barrier, such as a slurry wall, intersects flowing surface water.

One of the largest drawbacks of sheet piling, or any other barrier technology requiring pile driving, is the problem caused by rocky soils. Damage to or deflection of the piles is likely to render any such wall ineffective as a groundwater barrier. There are limitations to the depth to which sheet pilings can be driven. Sheet pilings made of wood, precast concrete, or steel can generally be used to maximum depths of 30, 40 to 50, or 80 to 100 feet, respectively.

Silo Rehabilitation

Silo rehabilitation refers to construction techniques that will restore the structural integrity and minimize the release of contaminates from the silo's structure. Long-term rehabilitation of the structure could include the application of paint, foam, concrete, or emulsions. Such applications could be designed to effectively control releases from the silo. However, the construction program will require an operations and maintenance protocol to restore the protective coatings as the effective life of the product ends.

Slurry Pump With Jetting Ring

The silos' contents and Decant Sump Tank sludge could be removed with a slurry pump with jetting ring supported by a work platform placed over the silos. It would consist of a flotation device with a dredging or sludge pump mounted on a swinging arm. The jetting ring and cutterheads are options that may or may not be required depending on the nature and consistency of the waste. If the waste is too thick or too high in solids to pump, the jetting ring would blast the waste with high pressure

water. This would loosen the material and increase the water content. The cutterhead can be used when there is enough water (e.g., standing water). The cutterhead chops up the waste and mixes it with the water to form a pumpable slurry. The dredge can be powered by electric, diesel, or gasoline motors. The slurry pump would pump the slurried materials from the silos to the material processing facility.

Slurry Walls

Slurry walls are the most commonly used subsurface barriers. Slurry walls are constructed in a vertical trench that is excavated under a slurry. The slurry (which is usually a mixture of bentonite and water) assists in shoring the trench to prevent collapse and forms a filter cake on the trench walls that prevents fluid loss to the surrounding ground.

Backfilling, performed by mixing soil materials with a bentonite and water slurry, results in this type of slurry wall. For on-property slurry preparation to be effective, the work area should be located adjacent to the slurry wall installation site.

The use for slurry walls may not be appropriate in areas subject to seismic activity or where heavy equipment operation is to be routine. Vibrations from both sources could result in thixotropy, the liquefaction of the settled slurry mix.

For slurry walls to be effective, it is necessary to use them in conjunction with a suitable cap. The slurry wall should extend to the least permeable underlying layer and go to a predetermined design depth below the bottom of the waste. A detailed predesign investigation characterizing the subsurface conditions and materials is required. Permeabilities of the subsurface layer (to which the slurry wall extends) and the soil-bentonite wall itself are critical elements in the design. The issue of waste/wall compatibility should be addressed early in the design by permeability testing of the proposed backfill mixture with actual site leachate or groundwater. Based on the investigation results, suitable design and support activities can be recommended.

Slurry walls can also be placed eterring from the waste and can divert groundwater away from waste, minimizing leachate production.

Soil Aeration

Soil aeration involves the injection of a continuous air stream into contaminated soils. The air injection is used to drive away volatile organics and to assist in drying the soil. This technique is not effective in removing metals or any radioactive contaminants, although the air injection may temporarily flush out radon concentrations. The technology is most effective in removing hydrocarbons from contaminated soil.

Soil-/Clay-Based Cap

A natural soil or clay cover possessing a lower permeability characteristic than the waste over which it is placed may be used to construct a single-layered cap. As a cap material, the soil/clay layer must control erosion and minimize generation of leachate produced by the infiltration of surface precipitation through the emplaced waste.

As compared to single-layered caps constructed of asphalt or concrete, a natural soil/clay is not recommended because of greater susceptibility to freeze/thaw and shrink/swell cycles. These cycles will result in significant cracking and weathering of the cap and will require greater maintenance than asphalt or concrete. Additionally, a natural soil/clay single-layered cap will serve as a poor intrusion barrier as compared to a similar cap constructed with asphalt or concrete.

Solid/Liquid Separation

Solid/liquid separation technology consists of three primary technology subgroups: filtration, sedimentation, and centrifugation. Filtration is primarily used for streams with concentrated slurries of large particles. Filtration is accomplished by introducing a liquid-solid stream onto a filtration medium or screen. The liquid that passes through the screen is called the "filtrate" and the solid deposited on the screen is called the "cake." There are many types of filters; common filter types include filter presses, horizontal belt filters, and vacuum filtration, each having its own advantages and disadvantages.

Filter presses achieve solid/liquid separation by forcing the water from the sludge under high pressure. Two common types of filter presses are recessed plate filter and plate and frame filter. Advantages of using filter presses include high concentrations of cake solids, good filtrate clarity, high solids capture, and low chemical use. Disadvantages include high labor costs and limitations on filter cloth life.

Horizontal belt filters convey sludge on horizontally-mounted continuous belts and use gravity and/or pressure to dewater sludge. Types of horizontal belt filters include moving-screen concentrator, capillary dewatering system, rotating-gravity concentrator, and belt pressure filter. Horizontal belt filters are typically used to dewater sludge with solids in the range of 5 to 10 percent to solids in the 20 to 30 percent range.

Vacuum filtration uses cylindrical drums that have filter medium, which can be a cloth of natural or synthetic fibers, coil springs, or a wire-mesh fabric. The drum is suspended above and dips into a container of sludge. As the drum slowly rotates, sludge is drawn into a circumference of the filter medium by an internal vacuum. Water is drawn through the porous filter cake for that sector of the circumference. The performance of vacuum filters is affected by the type of sludge, filter medium, and sludge feed temperature. One disadvantage of vacuum filters is that the performance can be highly variable, and chemical condition prior to dewater is necessary.

When the slurry contains low concentrations of fine particles, sedimentation may be a better method of solid/liquid separation than filtration. Sedimentation is the process by which suspended particles are allowed to settle out of solution by gravity. Sedimentation requires large amounts of space but can handle large flow rates and requires low maintenance. The size of the sedimentation tank or pond depends on the flow rate of the slurry along with the concentration and density of the solids to be removed.

Centrifugation uses an open basket centrifuge to force particles contained in the liquid stream to the wall of the centrifuge where they collect as a cake. The clear liquid leaves the centrifuge via a hollow shaft in the center of the centrifuge. Centrifugal separation is good for low flow rate streams with low concentration of solids. The space requirement for centrifugation is small, but the energy consumption is high.

Steam Stripping

Steam stripping is used to evaporate volatile organics from aqueous waste streams. The process is carried out in a packed or tray tower and is essentially a continuous fractional distillation process. Steam enters at the bottom of the column and provides direct heat to the system. The liquid stream containing the volatile organic contaminants is introduced at the top of the column and flows cross current to the steam. The steam exits the column at the top contaminated with the volatile organics that were stripped from the liquid stream. This stream is then condensed and goes on to further

processing such as carbon adsorption or further distillation. The bottom contains the stripped effluent and is further condensed and processed.

Steam stripping is used to treat aqueous wastes contaminated with chlorinated hydrocarbons, aromatics, alcohols, and high boiling point chlorinated aromatics such as pentachlorophenol.

Strippable Coatings

Using strippable coatings removes wipeable contaminants from large surface areas by trapping these contaminants in a polymer matrix that is "strippable." These coatings may also be used to protect large areas from becoming contaminated or recontaminated during decommissioning operations.

Strippable coatings are available as liquids that may be applied to surfaces by brushing or rolling. After application, these coatings are allowed to cure to a thin, solid coating that may be stripped from the surface. During the coating process, the liquid occupies small voids to contact contaminants. These contaminants are trapped and bonded to the polymer matrix during the curing process. When dried, the coating, along with trapped contaminants, may be stripped from the substrate and disposed of as a waste.

Equipment used in decontamination operations consists of rollers, brushes, or spray compressors to apply the liquid polymer and waste containers for stripped coatings. Assuming a layer of 1 millimeter (mm) (.04 in.) is applied to a surface, it is estimated that approximately 0.008 m^3 (0.01 ft^3) of waste in the form of "stripped" coating would be generated per square foot of surface area.

The strippable coating technique is applicable for decontaminating both smooth and porous surfaces including painted surfaces, concrete, and metals. This technique may also be used to protect clean surfaces from becoming contaminated during decommissioning operations. When used for protecting clean surfaces, these contaminants will be trapped and retained on the top of the surface coating, rather than the underside. Both loose and absorbed radioactive contaminants are amenable to decontamination by the strippable coating process. Examples of particulate contaminants present in the silos are uranium oxide, concrete rubble, and miscellaneous debris.

The advantages of this technique are that large, accessible surfaces such as walls and floors can be treated. Equipment requirements are simple and inexpensive. Personnel can be easily trained to

apply coatings. If compaction can be implemented, a relatively low volume of contaminated polymer is generated as waste.

The disadvantages are that the application, curing, and removal times can be long for irregular shapes. This process will not remove contamination that is retained below the treatment surface.

The information requirements for process evaluation include:

- Type and form of contamination
- Surface and substrate material upon which contamination is present
- Accessibility of contaminated area
- Desired degree of decontamination
- Equipment and materials available for use in decontamination, including those present at the site and available from other sources
- Material Safety Data Sheets for coatings

Subsurface Drains

Subsurface drains include any type of buried conduit used to convey and collect aqueous discharges by gravity flow. Subsurface drains function like an infinite line of extraction wells. They create a continuous zone of influence in which groundwater within this zone flows toward the drain.

The major components of a subsurface drainage system are:

- Gravel bed - for conveying flow to a storage tank or wet well. Gravel bed (or french drains) are narrow, vertical trenches lined with slotted, plastic pipe and filled with porous backfill.
- Envelope - for conveying flow from the aquifer to the drain pipe or bed
- Filter - for preventing fine particles from clogging the system, if necessary
- Backfill - to bring the drain to grade and prevent ponding
- Manholes or wet wells - to collect flow and pump the discharge to a treatment plant

Because drains essentially function like an infinite line of extraction wells, they can perform many of the same functions as wells. They can be used to contain or remove a plume or to lower the

groundwater table to prevent contact of water with the waste material. The decision to use drains or pumping is generally based on a cost-effectiveness analysis.

For shallow contamination problems, drains can be more cost-effective than pumping, particularly in strata with low or variable hydraulic conductivity. Under these conditions, it would be difficult to design and it would be cost-prohibitive to operate a pumping system to maintain a continuous hydraulic boundary. Subsurface drains may also be preferred over pumping where groundwater removal is required for several years, because the operation and maintenance costs of pumping are substantially higher.

One of the biggest drawbacks of using subsurface drains is that they are generally limited to shallow depths. Although it is technically feasible to excavate a trench to almost any depth, the costs of shoring, dewatering, and hard rock excavation can make drains cost-prohibitive at depths of more than 12 m (40 ft). However, in stable low permeability soils where little or no rock excavation is required, drains may be cost-effective to depths of 30.4 m (100 ft).

Surcharging

This technology typically induces densification and subsidence in incompetent soils by mounding or overburdening the area of treatment with large fill soil quantities for a long time. After the compaction goal is achieved, the soil overburden may be removed and discarded or used for surcharging another area (termed "rotating surcharge technique").

This technology is one of the simplest and least expensive methods for large area treatment. This method can be used most effectively in free-draining soils but can be readily applied to fine-grained and cohesive soils by installation of sand drains, collection trenches and sumps, or wick drains to decrease the waste consolidation time.

If drains are installed, they will provide a pathway for contaminated pore water to the fill surface. Pore water would then be collected and treated, which could potentially expose workers to contamination. If the drains are not used, the surcharge would force the contaminated pore water into the surrounding soil and confining basin surface, potentially leading to a rise in monitored contaminants for a short time. In either ease, the surcharge would produce an adequately compacted waste/soil matrix for closure cap-bearing purposes.

Before the start of any full-scale stabilization efforts, the following support activities would be required:

- Field and/or laboratory studies to confirm the chosen technology's abilities
- Removal of any free-standing water from the treatment area
- Evaluation and implementation of temporary and permanent groundwater control measures.
  - Temporary wellpoints or withdrawal wells outside the treatment areas during construction
  - Slurry wall technology
  - Upgradient groundwater interceptor ditches and drains
  - Combinations of the above

After treatment, the surcharge would be removed to design-specified elevations, and a cap would be constructed in conjunction with required groundwater control measures to provide an environmentally secure permanent waste disposal unit.

Surface Water/Sediment Control

One of the primary technologies used in remedial action is surface water/sediment control. Surface water/sediment control technologies are categorized by one of the following functions:

- Prevention of run-on and/or interception of runoff
- Prevention of infiltration
- Control of erosion
- Collection and transfer of water
- Storage and discharge of water
- Protection from flooding

A summary of surface water/sediment control technologies is: capping, lagoon covers, grading, revegetation, dikes and berms, channels and waterways, terraces and benches, chutes and downpipes, seepage basins and ditches, sedimentation basins and ponds, and levees and floodwalls.

Thermal Desorption

Thermal desorption is a new technology for treating soils or sludges that are contaminated by inorganics. In this process, the contaminated solid is heated to a temperature [typically 149 (300) to 538°C (1000°F)] sufficient to volatilize the hazardous organics adsorbed on the material. These temperatures are not high

enough to destroy most organic compounds; they must be destroyed by further treatment of the vapor driven off the solids. These vapors can be treated by fume incineration or by condensation followed by off-site disposal, incineration, or chemical treatment. It is frequently cost-effective to dry the solids before thermal desorption.

Thermal desorption has been demonstrated on soils contaminated with volatile organic compounds (VOCs) and on sediment that contains polychlorinated biphenyls (PCBs). Some highly volatile inorganics, such as mercury, might be partially volatilized, but thermal desorption is not a practical metals removal technology.

Thermal desorption can remove organics from soils and sludges but has no effect on uranium, thorium, and other radioactive compounds. Thermal desorption produces a dry, dusty product that could be a greater hazard than the initial solids. Processing, handling, and transportation of the dried product increases the potential for inadvertent release to the environment of dusts that contain uranium, thorium, and other metals present in the various wastes. Thermal desorption has been demonstrated on a pilot scale and is nearing commercialization.

Thermite Reaction Lance

The objective of using a thermite reaction lance to demolish radioactively contaminated concrete is to cut the concrete into manageable sections ready for disposal.

The thermite reaction lance is a high temperature flame-cutting device for cutting irregularly shaped materials. This equipment consists of a combination of steel, aluminum, and magnesium wires packed inside an iron pipe through which a flow of oxygen gas is maintained. Typical thermite reaction lances are 3 m (10 ft) in length and 0.64 to 0.95 cm (0.25 to 0.38 in.) in diameter. The thermite reaction lance is ignited by a high temperature source such as an electric arc or an oxygenburning torch. During operation, the thermal reaction at the tip completely consumes the constituents of the lance and causes the temperatures to reach 2204 to 4982°C (4000 to 9000°F) depending on the environment. A 3-m (10-ft) lance will burn for 6 minutes.

During cutting, the thermite reaction lance must be hand-held and the operator must be equipped with fireproof protective clothing and a mask. The smoke and dust problems with this equipment are similar to those experienced with flame cutting.

The thermite reaction lance can cut almost any material at the silos and is suitable for irregular surfaces.

The major advantage of the thermite reaction lance is its ability to cut a wide variety of the materials likely to be found at the silos. In addition, the thermite reaction lance can cut material rapidly. It can burn a hole 5.1 cm (2 in.) in diameter through reinforced concrete 107 cm (42 in.) thick in less than 6 minutes. Material further than 2.5 cm (1 in.) from the hole is not affected.

The major disadvantage of using the thermite reaction lance is the large amount of dust, smoke, and heat that are produced. Because the process generates considerable smoke, a control envelope and ventilation must be provided, particularly if the component being cut is contaminated.

Thermoplastic Encapsulation

Thermoplastic encapsulation involves sealing wastes in a matrix such as asphalt bitumen, paraffin, or polyethylene. The waste is dried, heated, and dispersed through a heated plastic matrix. The mixture is then cooled to form a solid-like but deformable material. Bitumen encapsulation is the most widely used of the thermoplastic techniques.

Thermoplastic encapsulation involving the use of an asphalt binder is most suitable for heavy metal or electroplating wastes. Relative to the cement stabilization, the increase in volume is significantly less and the rate of leaching is significantly lower. Also, thermoplastics are not affected much by either water or microbial attack.

There are a number of waste types that are incompatible with thermoplastic stabilization. Oxidizers such as perchlorates or nitrates can react with many of the stabilization materials to cause an explosion. Some solvents and decreasing agents can cause asphalt materials to soften and never become rigid. Xylene and toluene diffuse quite rapidly through asphalt. Salts that partially dehydrate at elevated temperatures can be a problem. Sodium sulfate hydrate, for example, will lose some water during asphalt incorporation, and if the waste asphalt mix containing the partially dehydrated salt is soaked in water, the mass will swell and crack due to rehydration. This can be avoided by easily eliminating dehydrated salts or coating the outside of the waste/asphalt mass with pure asphalt. Since this process option is useful in stabilizing very soluble materials, chelating and complexing agents (cyanides and ammonium) can cause problems with contamination of heavy metals by altering the solubility of metals.

Truck Transport

Truck transport can provide portal-to-portal service with the road system available between the FEMP site and the approved waste site. The main disadvantage of truck transport is the size of public roadways near the FEMP site. These two-lane rural roads are heavily traveled with considerable uncontrolled cross traffic and regional access/egress commuter traffic.

A major consideration for any transport mechanism may be the resistance from local groups. Although considerable local opposition should be expected, the mass transportation required to implement off-site disposal could be challenged by various agencies along the transport route, creating unacceptable site cleanup delays.

Vacuum Grit-Blasting

Vacuum grit-blasting is one of the most widely used decontamination techniques. Vacuum grit-blasting can be used with wet or dry applications and in conjunction with other cleaning techniques such as scabbling. The technique begins with a stream of abrasive substance that is pressurized and propelled against the surface to be cleaned, much like a sand blasting technique. The resulting dust/particle accumulation is then vacuumed away in a vacuum collar surrounding the abrasive cleaning head. This process enables all the abrasive/dust/particulate resulting from the cleaning process to be captured and removed from the area, minimizing the spread of contamination. Some systems have added features so that the abrasive can be recycled into the cleaning system. There is also a type of vacuum blasting technique using CO_2 pellets/particles as the cleaning agent. In this technique, the abrasive substance sublimes upon contact, eliminating the spent abrasive waste stream.

The main advantages to vacuum grit-blasting are the high cleaning efficiency and absence of dust generation. The main disadvantage is the slow rate of removal compared to pressure washing/scabbling techniques and the high cost of certain systems. To assess the merits of a vacuum system for this application, the amount of surface area to be decontaminated should be considered, as well as any time constraints and manpower availability.

Vacuum Scabbling

One method for physical decontamination of the interior walls involves the removal of concrete from the interior walls by vacuum scabbling. This technique chips away small amounts of the top layer of material (usually concrete), and vacuums it away for collection, thus removing the contamination

affixed to the surface. The chipping process is performed by a pneumatically-driven piston equipped with spikes to strike the surface and cause the concrete to break away. This process is best suited for flat surfaces. The main advantage to scabbling is the ease of operation and applicability to remote operation. No special worker training is required for vacuum scabbling operations. The disadvantages are the inability to decontaminate surfaces not having a smooth and flat profile.

In order to make a decision regarding vacuum scabbling techniques as a means of decontamination, consideration should be given to the amount of flat concrete surface to be cleaned.

Several vacuum systems are available for use to capture dust and particles associated with vacuum scabbling. These are self-contained systems for collecting dust and particles, which use a vacuum shroud in conjunction with the scabbling tool. Most systems have a self-cleaning, dual-stage HEPA filter, which drops collected material into a waste container, thus minimizing filter changes. The unit can also be equipped with an automatic full-drum level detector to prevent overfilling of containers.

Vacuum with Cutterhead

Vacuum with cutterhead is a pneumatic removal technology that could be used to remove the waste material from the silos. The cutterhead could be used to loosen waste residue, and the vacuum would displace it with negative pressure.

Void Space Grout

Structural grouting is widely considered for sealing and covering. The success of this method is largely dependent on the type of problem, selection of grout, and techniques of application. The basic types of grout that would be used in the void space of the silo are those that do not mix with soil to decrease permeability or those that actually solidify over the waste material. Grouting applications include grouting with or without mechanical mixing, or using various inspection piping configurations for in situ grouting. Grouting is primarily used with good results for correcting infiltration problems in small areas. When the area to be grouted becomes very large, temperature cracks will develop due to expansion and contraction of the grout and the material it is covering.

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Wrecking Ball

A proven and effective demolition technique, this method utilizes a large steel sphere attached to a crane to demolish concrete structures. Any steel wire and rebar would require cutting with a gas torch once the structure is demolished. The major disadvantage of this method is substantial dust generation.

REFERENCE LIST

U.S. Environmental Protection Agency, 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA," OSWER Directive 9355.3-01, EPA 540/G89/004, EPA, Washington, DC.

APPENDIX C

SUMMARY OF CEMENT STABILIZATION, CHEMICAL EXTRACTION, AND VITRIFICATION TREATABILITY STUDIES

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LIST OF ACRONYMS

COC	Constituent of Concern
DOE	United States Department of Energy
EA	Environmental Assessment
EDTA	ethylenediaminetetraacetic acid
EPA	United States Environmental Protection Agency
$FeCl_2$	ferrous chloride
Fe_3^t	iron
FEMP	Fernald Environmental Management Project
FS	Feasibility Study
HCl	hydrochloric acid
HNO_3	nitric acid
ICP	Inductively Coupled Plasma
KCl	potassium chloride
MAC	Maximum Allowable Concentrations
MTCLP	Modified Toxicity Characteristic Leachate Procedure
NA	not applicable
NaOCl	chlorine bleach
ND	not detected
OEPA	Ohio Environmental Protection Agency
OU4	Operable Unit 4
Pb	lead
PCT	Product Consistency Test
PNL	Pacific Northwest Laboratories
Po	polunium
psi	pounds per square inch
Ra	radium
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
TC	Toxicity Characteristic
TCLP	Toxicity Characteristic Leaching Procedure
Th	thorium

LIST OF ACRONYMS
(Continued)

TPD	tons per day
UCI	Upper Confidence Interval
UCS	Unconfined Compressive Strength
U	uranium
w/w	wet weight of waste

LIST OF MEASUREMENTS

cm/s	centimeter per second
dpm	disintegrations per minute
g/cm^3	grams per cubic centimeter
g	grams
in/min	inches per minute
in.	inch
m^2	square meter
µCi	microcuries
µg/g	micrograms per gram
µg/L	micrograms per liter
mg/L	milligram per Liter
mg/kg	milligram per kilogram
ml	milliliter
mrem/hr	millirem per hour
nCi/g	nanocuries per gram
ohm•cm	ohm centimeter
Pa•s	Pascal Second
pCi	picocurie
pCi/hr	picocuries per hour
pCi/L	picocuries per liter
pCi/g/hr	picocuries per gram per hour
$pCi/m^2/s$	picocuries per square meter per second
ton/ft^2	ton per square foot

C.1.0 CEMENT STABILIZATION TREATABILITY STUDY

C.1.1 INTRODUCTION

Cement stabilization treatability tests were carried out in support of the Operable Unit 4 Remedial Investigation/Feasibility Study (RI/FS) process currently underway at the Fernald Environmental Management Project (FEMP). The tests were performed in accordance with the approved Treatability Study Work Plan for Operable Unit 4 for cement stabilization and chemical extraction, (DOEa 1992).

The cement stabilization technology considered involves the use of portland cement, flyash, and reagents such as attapulgite, sodium silocote, clinoptilolite, ferrous chloride ($FeCl_2$), and blast furnace slag to make a concrete-like material out of the silo residue. Criteria used to evaluate the performance of the various mixtures includes leachability, low permeability, sufficient unconfined compressive strength (UCS), and final waste form volume.

Remedy Screening (preliminary phase) and Remedy Selection (advanced phase) were performed for this study.

C.1.2 TREATABILITY TEST METHODOLOGY

There are many unknown variables affecting the activity levels of the Operable Unit 4 material as well as the performance of the proposed reagents in conjunction with this material. A matrix of interactive treatability experiments was created to decrease the number of formulas for subsequent treatability tests based on their effectiveness in treating the silo material. The most effective formulas resulting from these tests were used in the Feasibility Study (FS) detailed analysis of alternatives. This treatability study also provided a range of formulas for the cement stabilization technology which will be evaluated during the remedial design phase.

C.1.2.1 Description of the Phased Approach

The treatability study was conducted in three phases to address stabilization of the untreated material contained within Silos 1, 2, and 3. The effects of various inorganic stabilization reagents, in conjunction with cement, were investigated to identify adequate stabilization formulas for use in completing the FS. This treatability study summary addresses the results from the first two phases of this study. The first phase consisted of Remedy Screening (preliminary phase), which tested stabilization formulas using composited material from Silos 1 and 2 in three stages, and also addresses a Silo 3 composite sample in two stages. This phase yielded formulas meeting certain preselected

criteria, which were then further evaluated in a second phase entitled Remedy Selection (advanced phase). This second phase identified formulas which proved acceptable on the heterogenous Silos 1 and 2 material from specific locations within those silos (zones) as well as formulas on composite samples from the relatively homogenous Silo 3 material. The third phase, which is optional, was completed later in the RI/FS process. It is presented in Appendix H of this FS. Figure C.1-1 illustrates the phases and stages of testing that were performed.

C.1.2.2 Reagent Selection

The reagents tested included portland cement Type II, FEMP Operable Unit 2 and commercially available Type F flyash, blast furnace slag, sodium silicate, attapulgite, clinoptilolite, $FeCl_2$) and water. Blast furnace slag and portland cement were added to solidify the waste, to add silicates to react with the material, and to maintain the treated waste in an alkaline form in order to decrease the leachability of the Resource Conservation Recovery Act (RCRA) metals and radionuclides of concern. Type II portland cement was chosen because of the expected high levels of sulfate in the waste (it is moderately sulfate resistant as compared to Type I). The materials that were originally processed at the FEMP site to produce the silo contents included pitchblende, ore concentrates, and raffinate. Pitchblendes contain varying amounts of sulfate. Ore concentrates resulted from processing the ore with acid, which frequently was sulfuric acid. Raffinate was typically treated with barium sulfate to precipitate the radium.

Flyash was used in conjunction with cement, since it acts to economically increase the strength of the treated waste. The flyash also may decrease the effect of certain inhibitors, e.g., sulfates and oil, on the cement setting and strength formation reactions. Sodium silicate was added to react with the metals and lower their solubilities. Silicate additives may also increase the treated waste bearing strength, reduce the volume increase of the treated waste, and lower the effect of inhibitors, e.g., sulfate, for a given cement-flyash additive loading. Attapulgite and clinoptilolite were added to adsorb metals (in particular cesium) and to decrease the leaching of contaminants from the treated waste. $FeCl_2$ was added as a reducing agent for the hexavalent chromium in Silo 3.

C.1.3 TEST OBJECTIVES AND DESIRED DATA

The specific objectives of Remedy Screening (preliminary phase) and Remedy Selection (advanced phase) treatability tests were as follows:

- To develop a database of leachate concentrations of hazardous and radioactive materials for various combinations of cement stabilized waste forms

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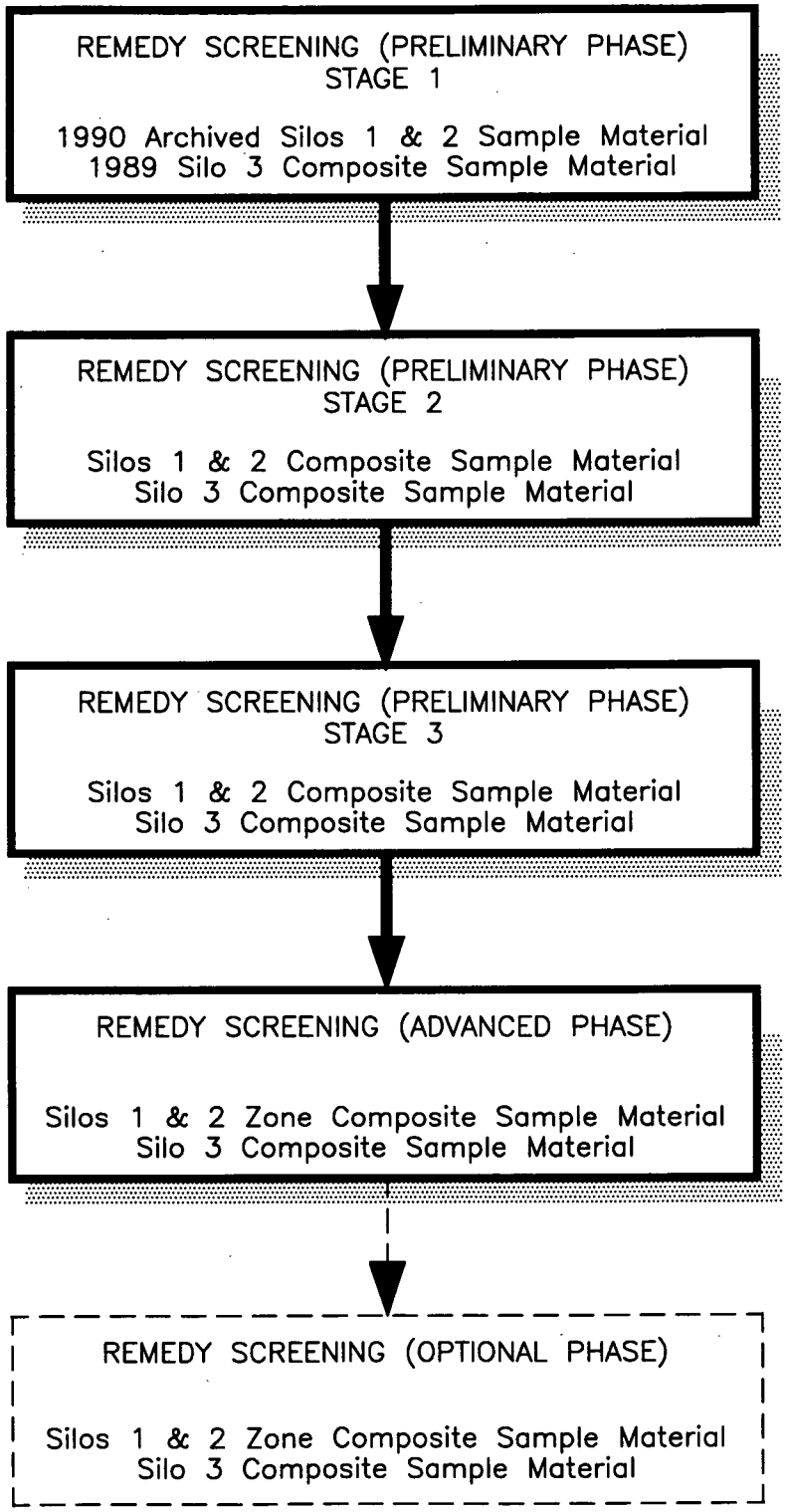

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FIGURE C.1-1 CEMENT STABILIZATION TREATABILITY PROGRAM FOR UNTREATED WASTE (SILOS 1, 2, AND 3)

- To develop a database of stabilization reagents and relative quantities required to minimize leachable concentrations of radionuclides and constituents of concern (COCs) from the final waste form
- To establish the proof of process and applicability of the selected stabilization technology
- To determine a range of cement stabilization reagents and relative quantities required so that the final waste form achieves a UCS of approximately 500 pounds per square inch (psi)
- To minimize the final volume of treated waste
- To develop preliminary reagent mixtures for use in future cement stabilization treatability studies
- To provide information for the development of preliminary cost and design data for the FS
- To provide leaching characteristics of stabilized and unstabilized waste obtained from the Toxicity Characteristic Leaching Procedure (TCLP)
- To develop the following preliminary process parameters design treatability studies: (1) shear strength, (2) waste form temperature rise, (3) general description of waste before and after reagent addition, (4) permeability of stabilized waste, (5) percentage of water in the waste, (6) hydrogen ion concentration (pH) of the leachate solution, and (7) observations if there was evolution of gas during mixing or curing processes
- To provide chemical and radiological analytical data

C.1.4 RESULTS AND DISCUSSION

C.1.4.1 Remedy Screening (Preliminary Phase)

In order to determine trends of the response variables (e.g., UCS values) as a function of the reagent loadings and to determine the envelope of reagents that would meet the performance criteria, Remedy Screening (preliminary phase) experiments were statistically designed to yield widely varying values of the response variables. This was accomplished by using a wide range of reagent loadings. The range of cement and flyash loadings varied from 26 to 68 percent [weight reagent divided by wet weight of waste (w/w)]. The adsorbents (attapulgite and clinoptilolite) and set/strength accelerator (sodium silicate) percentages ranged from 0 to 12 and 0 to 7 w/w percent respectively. Blast furnace slag and $FeCl_2$ were used in Remedy Screening (preliminary phase) Stage 3 experiments.

The performance of Remedy Screening (preliminary phase) Stage 3 samples is summarized in Table C.1-1 based on the Modified Toxicity Characteristic Leaching Procedure (MTCLP) as defined in the Treatability Study Work Plan for Operable Unit 4. Analysis of the results indicates that cement stabilization of the material in Silos 1 and 2 can readily achieve the desired UCS. Silo 3 requires higher loadings of reagents since 43 percent of the formulas do not achieve a 500 psi UCS. For Silo 2, all formulas passed the Toxicity Characteristics (TC) regulatory requirements. Stabilized samples from Silos 1 and 3, however, had a significant number of failures for lead (Silo 1) or arsenic and chromium (Silo 3). The leachability of chromium in Silo 3 was controlled in Stage 3 by the addition of a reducing agent, $FeCl_2$, or the addition of blast furnace slag to the formulation. Table C.1-1 also lists the maximum and minimum values for uranium and gross alpha and beta. Uranium was more leachable from Silo 2 material than either Silos 1 or 3 material. The values for gross alpha and beta decreased in order of Silo 1, Silo 2, and Silo 3, respectively. The two most promising formulas derived from the Remedy Screening (preliminary phase) Stage 3 testing program were used in Remedy Selection (advanced phase) of the program. The most promising formulation had a UCS greater than 500 psi, met the TC regulatory criteria, had relatively low gross alpha and beta values in the MTCLP extraction fluid, and had a relatively low volume increase.

C.1.4.2 Remedy Selection (Advanced Phase)

During the 1990/91 sampling of Silos 1 and 2, each silo was divided into three equal zones. The top third of the material was Zone A, the middle third was Zone B, and the bottom third was Zone C. Zone composite samples were created by combining sample material that was collected from the same zone. Both zone and composite samples from Silos 1 and 2 were tested, while Silo 3 testing involved composite samples only. Silo 3 samples were from 1989 sampling of Silo 3.

The formulas used for Remedy Selection (advanced phase) are presented in Tables C.1-2 and C.1-3. The units are grams (g) of reagent added to each 100 g of combined w/w and added bentonite. Tables C.1-2 and C.1-3 must be considered together to completely understand the formulas utilized in this phase. Table C.1-2 is a summary table related to each silo which supplies a formulation identification number but does not specifically list the waste material or the bentonite quantities. Table C.1-3 shows the formulas for each zone of each silo.

As indicated in Table C.1-3, 20, 10, and zero (0) percent bentonite loadings were added to Zones A, B, and C, respectively for Silos 1 and 2. Bentonite was added to the formulation to account for the effect of the completed Silos 1 and 2 Removal Action in which bentonite was added to Silos 1 and 2

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TABLE C.1-1

REMEDY SCREENING (PRELIMINARY PHASE)
STAGE 3 - CEMENT STABILIZATION
MTCLP SUMMARY

Parameter	Pass/Fail Value *	Units	Percentage of Failures		
			Silo 1	Silo 2	Silo 3
As	2.15	ppm	3	0	43
Ba	43	ppm	0	0	0
Cd	0.43	ppm	0	0	0
Cr	2.15	ppm	0	0	24
Pb	2.15	ppm	22	0	0
Se	0.43	ppm	6	0	0
Ag	2.15	ppm	0	0	0
UCS	500	psi	3	3	43

* Pass/fail value is TC regulatory criteria adjusted for maximum dilution from the addition of reagents to waste.

Contaminant	Units	Minimum - Maximum Values		
		Silo 1	Silo 2	Silo 3
Uranium	ppm	0.0-0.53	0.0-1.9	0.0-0.85
Alpha	dpm/4 cc	151-1365	71-724	0-24
Beta	dpm/4 cc	56-783	0-364	2-12

TABLE C.1-2

SUMMARY OF CEMENT STABILIZATION REMEDY SELECTION (ADVANCED PHASE) FORMULATIONS[a]

	Formula	Cement (g)	Flyash (g)	Attapulgite (g)	Clinoptilolite (g)	$FeCl_2$ (g)	BFS (g)
Silo 1	1	51	31	6	6	0	0
	2	50	15	0	0	0	25
Silo 2	1	51	31	6	6	0	0
	2	50	15	0	0	0	25
Silo 3	1	51	31	0	4	1	0
	2	40	0	0	0	0	40

[a]Reagent loadings per 100 g of combined w/w and added bentonite.

TABLE C.1-3

CEMENT STABILIZATION
REMEDY SELECTION (ADVANCED PHASE) FORMULATIONS[a]

Silo	Strata	Waste[b] (wt%)	Bentonite[b] (wt%)	Cement (g)	Flyash (g)	Attapulgite (g)	Clinoptilolite (g)	Water (g)	Ferrous Chloride (g)	BFS (g)
1	A	80	20	50	15	0	0	64	0	25
1	A	80	20	51	31	6	6	77	0	0
1	B	90	10	50	15	0	0	58	0	25
1	B	90	10	51	31	6	6	68	0	0
1	C	100	0	50	15	0	0	42	0	25
1	C	100	0	51	31	6	6	54	0	0
2	A	80	20	50	15	0	0	57	0	25
2	A	80	20	51	31	6	6	70	0	0
2	B	90	10	50	15	0	0	47	0	25
2	B	90	10	51	31	6	6	64	0	0
2	C	100	0	50	15	0	0	36	0	25
2	C	100	0	51	31	6	6	48	0	0
3	Composite	100	0	40	0	0	0	87	0	40
3	Composite	100	0	40	0	0	0	91	0	40
3	Composite	100	0	51	31	0	4	94	1	0

[a]Reagent loadings per 100 g of combined w/w and added bentonite.
[b]There were 20%, 10%, and 0% bentonite loadings added to Zones A, B, and C, respectively for Silos 1 and 2.

to attenuate radon emissions. Portland cement and blast furnace slag were added to stabilize the waste and to add silicates to react with the metals. Cement and flyash additions maintained the treated waste in an alkaline form which should decrease the leachability of RCRA metals and radionuclides of concern. When the cement and flyash were used together, they functioned to increase the strength and decrease the permeability of the treated waste. The flyash and blast furnace slag may have also decreased the effect of inhibitors (e.g., sulfates and oil) on the cement setting and strength formation reactions. Attapulgite and clinoptilolite were added to absorb metals and to decrease their leachability from the treated waste. $FeCl_2$ was added as a reducing agent for the hexavalent chromium in Silo 3.

Table C.1-4 lists the results obtained from Remedy Selection (advanced phase) testing related to each formulation against the following criteria: UCS, volume increase, and permeability values. All of the formulas achieved the UCS goal of 500 psi. Permeability results were acceptable based on the EPA's Handbook for Cement Stabilization/Solidification of Hazardous Waste, which states that "Permeabilities measured in stabilized waste typically range from around 10^{-4} to 10^{-8} centimeter per second (cm/s). Such low permeabilities indicate decreased mobility in the treated waste and a slower transfer of contaminants from the solid mass to leaching waters" (EPA 1990b). All of the treated Operable Unit 4 samples had permeabilities between 10^{-7} to 10^{-9} (cm/s). Consistently, the cement/blast furnace slag/flyash formulas (Formula 2) did not increase the volume of treated waste as much as the cement-flyash formulas (Formula 1). In addition, the more bentonite added to the waste, the greater increase in the volume of treated waste.

C.1.4.3 TCLP Data

The TCLP was performed on untreated samples of K-65 material from each zone of Silos 1 and 2 and on untreated samples of Silo 3 material. The TCLP leachate was also analyzed for radionuclides. Tables C.1-5 through C.1-11 presents the leachate concentrations for untreated K-65 and Silo 3 material.

The TCLP results from Remedy Selection (advanced phase) are presented in two different formats in the Treatability Study Report for Operable Unit 4 for the cement stabilization and chemical extraction treatability tests: results of actual analysis of the extract and results adjusted for dilution by cement stabilization reagents. The adjustment for dilution is made because addition of the stabilizing reagents reduces the concentrations of the various COCs in the treated waste. In order to determine if leachate concentration reductions are due to treatment or dilution, the results are adjusted for dilution. For

TABLE C.1-4

REMEDY SELECTION (ADVANCED PHASE) RESULTS OF UCS, VOLUME INCREASE, AVERAGE VOLUME INCREASE, AND PERMEABILITY

Silo No.	Zone	Formulation	UCS (psi)	Volume Increase (%)	Average Volume Increase[a] (%)	Permeability
1	A	1	1399	246	216	4E-08
1	A	1-Dup	1087	253	NA	4E-08
1	B	1	1612	196	NA	3E-08
1	C	1	>1487	150	NA	2E-08
1	A	2	>1399	209	167	4E-08
1	B	2	>1437	170	NA	4E-08
1	C	2	>1506	122	NA	2E-08
2	A	1	852	208	168	6E-08
2	A	1-Dup	1164	207	NA	6E-08
2	B	1	>1425	174	NA	5E-08
2	C	1	>1454	122	NA	5E-08
2	A	2	>1404	173	136	4E-08
2	B	2	>1461	141	NA	6E-09
2	C	2	>1528	94	NA	1E-08
3	Composite	1	>1414	63	63	3E-07
3	Composite	2	>1387	50	52.5	2E-07
3	Composite	2-Dup	>1447	55	NA	5E-08

[a]Average for the specific silo formulation combination.
NA - Not applicable.

TABLE C.1-5

SUMMARY OF TCLP METALS ANALYSES FOR SILO 1 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Concentration of Contaminants[f]
Aluminum	12/12	0	0.314	0.067	0.228-0.441	g
Antimony	12/12	0	0.093	0.019	0.067-0.129	g
Arsenic	1/11	1	0.002	e	e	5.0
Barium	12/12	0	0.868	0.402	0.348-1.83	100.0
Beryllium	6/12	0	0.002	0.0004	0.002-0.003	g
Boron	11/12	0	0.255	0.070	0.168-0.384	g
Cadmium	12/12	0	0.003	0.001	0.002-0.005	1.0
Calcium	12/12	0	55.4	33.6	17.6-108	g
Chromium	12/12	0	0.059	0.012	0.045-0.081	5.0
Cobalt	12/12	0	1.82	0.89	0.72-3.06	g
Copper	12/12	0	0.208	0.097	0.068-0.404	g
Iron	10/12	0	0.046	0.022	0.018-0.1	g
Lead	8/9	3	614	221	229-841	5.0
Magnesium	12/12	0	8.96	2.00	6.12-13.8	g
Manganese	12/12	0	0.163	0.070	0.067-0.308	g
Mercury	1/12	0	0.0002	e	e	0.2
Molybdenum	12/12	0	0.072	0.026	0.036-0.108	g
Nickel	12/12	0	3.18	1.39	1.32-5.57	g
Potassium	12/12	0	10.3	5.32	2.95-18.3	g
Selenium	11/11	1	0.135	0.088	0.015-0.306	1.0
Silicon	12/12	0	31.9	8.2	13.5-42.1	g
Silver	12/12	0	0.034	0.008	0.023-0.048	5.0
Thallium	9/12	0	0.005	0.003	0.002-0.009	g
Vanadium	12/12	0	0.023	0.005	0.017-0.032	g
Zinc	12/12	0	0.128	0.079	0.02-0.323	g

[a] The sample numbers used in this data set include: 99727, 99742, 99869, 99884, 99908, 99929, 99938, 99967, 99985, 100003, 100024, and 100038.
[b] Rejected data not included in total number of samples.
[c] Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures.
[d] Values expressed in milligram per liter (mg/L).
[e] Analyte was detected in a single sample.
[f] Data obtained from 40 CFR 261.24.
[g] No standard Maximum Allowable Concentrations (MAC) specified in 40 CFR 261.24.

R = re-sample; data are unuseable
U = analyzed for but not detected
UJ = estimated as not detected

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TABLE C.1-6

SUMMARY OF TCLP ORGANICS ANALYSES FOR SILO 1 RESIDUES - 1990/1991

Analyte	Frequency of Detection	Rejected	Mean[c] (mg/L)[d]	Standard Deviation[c] (mg/L)[d]	Range[c] (mg/L)[d]	Maximum Concentration of Contaminants[f]
PCBs and Pesticides						
None detected						
Semivolatile Organics						
4-Chloro-3-methylphenol	1/10	1	0.004	e	e	g
4-Nitrophenol	1/11	0	0.008	e	e	g
Benzoic acid	4/10	1	0.049	0.048	0.006-0.1	g
Bis(2-Ethylhexyl)phthalate	2/10	1	0.052	0.065	0.006-0.098	g
Di-n-octylphthalate	4/10	1	0.021	0.002	0.005-0.05	g
N-Nitroso-di-n-propylamine	4/10	1	0.127	0.116	0.018-0.28	g
Volatile Organics						
2-Butanone	7/9	2	0.005	0.003	0.001-0.01	200.0
4-Methyl-2-pentanone	8/11	0	0.002	0.003	0.001-0.01	g
Acetone	9/10	1	0.223	0.153	0.069-0.49	g
Methylene chloride	9/11	0	0.018	0.010	0.009-0.038	g
Tetrachloroethene	1/5	6	0.001	e	e	0.7
Toluene	5/11	0	0.002	0.002	0.001-0.005	g

[a] The sample numbers used in this data set include: 99726, 99734, 99741, 99749, 99868, 99876, 99883, 99891, 99907, 99915, 99928, 99932, 99937, 99945, 99960, 99962, 99976, 100010, 100023, 100031, 100037, and 100041.
[b] Rejected data not included in total number of samples.
[c] Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d] Values expressed in milligrams per liter (mg/L).
[e] Analyte detected in a single sample.
[f] Data obtained from 40 CFR 261.24.
[g] No standard MAC specified in 40 CFR 261.24.

R = re-sample; data are unuseable
U = analyzed for but not detected
UJ = estimated as not detected

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TABLE C.1-7

SUMMARY OF TCLP METALS ANALYSES FOR SILO 2 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)	Standard Deviation[c] (mg/L)	Range[c] (mg/L)	Maximum Concentration of Contaminants[d]
Aluminum	7/7	0	1.29	0.763	0.462-2.75	e
Antimony	6/6	1	0.096	0.018	0.079-0.123	e
Arsenic	8/8	0	0.064	0.110	0.003-0.32	5.0
Barium	8/8	0	2.96	3.30	0.157-8.47	100.0
Beryllium	7/7	0	0.005	0.0007	0.003-0.006	e
Boron	4/4	0	0.69	0.58	0.24-1.5	e
Cadmium	7/7	1	0.047	0.028	0.010-0.077	1.0
Calcium	7/7	0	483	276	163-975	e
Chromium	8/8	0	0.129	0.036	0.086-0.207	5.0
Cobalt	7/7	0	3.02	2.11	1.18-6.16	e
Copper	7/7	0	1.41	1.41	0.274-3.86	e
Iron	7/7	0	0.076	0.012	0.053-0.090	e
Lead	7/7	1	516	348	117-1072	5.0
Magnesium	7/7	0	15.4	8.84	7.39-29.6	e
Manganese	7/7	0	0.776	0.466	0.409-1.62	e
Molybdenum	7/7	0	0.058	0.027	0.034-0.099	e
Nickel	7/7	0	3.48	1.45	2.04-5.77	e
Potassium	5/7	0	4.032	1.18236	2.64-5.31	e
Selenium	8/8	0	0.114	0.184	0.026-0.568	1.0
Silicon	5/5	1	16.3	5.2	12.1-24.3	e
Silver	8/8	0	0.093	0.032	0.053-0.164	5.0
Thallium	6/7	0	0.009	0.011	0.0022-0.0288	e
Vanadium	5/5	1	0.053	0.006	0.046-0.060	e
Zinc	6/6	1	0.339	0.184	0.141-0.563	e

[a] The sample numbers used in this data set include: 99355, 99709, 99773, 99801, 99810, 99830, 99845, and 99860.
[b] Rejected data not included in total number of samples.
[c] Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d] Data obtained from 40 CFR 261.24.
[e] No standard MAC specified in 40 CFR 261.24.

R = re-sample; data are unuseable
U = analyzed for but not detected
UJ = estimated as not detected

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TABLE C.1-8

SUMMARY OF TCLP ORGANICS ANALYSES FOR SILO 2 RESIDUES - 1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (mg/L)	Standard Deviation[c] (mg/L)	Range[c] (mg/L)	Maximum Concentration of Contaminants (mg/L)[d]
PCBs and Pesticides						
alpha-BHC	1/6	1	0.0002	e	e	f
beta-BHC	3/6	1	0.0004	0.0002	0.0002-0.0006	f
Semivolatile Organics						
N-Nitroso-di-n-propylamine	1/7	0	0.005	e	e	f
Pentachlorophenol	1/7	0	0.018	e	e	100.0
Volatile Organics						
2-Butanone	3/7	1	0.002	0.002	0.002-0.002	200.0
4-Methyl-2-pentanone	1/8	0	0.001	e	e	f
Acetone	2/8	0	0.0535	0.054	0.015-0.092	f
Carbon disulfide	1/8	0	0.004	e	e	f
Methylene chloride	2/8	0	0.03	0.023	0.014-0.046	f

[a]The sample numbers used in this data set include: 99707, 99708, 99772, 99780, 99800, 99804, 99809, 99817, 99829, 99836, 99844, 99852, 99859, and 99863.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R, U, or UJ are excluded. The mean and standard deviation have been rounded to show no more than three significant figures. The range has been rounded to the nearest thousandth, unless a fourth decimal place is required to show a value.
[d]Data obtained from 40 CFR 261.24.
[e]Analyte was detected in a single sample.
[f]No standard MAC specified in 40 CFR 261.24.

R = re-sample; data are unuseable
U = analyzed for but not detected
UJ = estimated as not detected

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TABLE C.1-9

SUMMARY OF TCLP RADIOLOGICAL ANALYSES FOR SILO 1 AND 2 RESIDUES
1990/1991

Analyte[a]	Frequency of Detection[b]	Rejected	Mean[c] (pCi/L)[d]	Standard Deviation[c] (pCi/L)	Range of Detects[c] (pCi/L)
SILO 1					
Actinium-227	3/3	0	6550	1090	7302-5014
Lead-210	3/3	0	1,059,000	476,000	509,000-1,670,000
Polonium-210	3/3	0	138,000	55,900	71,200-208,000
Radium-226	3/3	0	50,200	11,500	40,150-66,370
Thorium-228	3/3	0	34.9	14.7	14.9-49.8
Thorium-230	3/3	0	385	61	307-455
Thorium-232	3/3	0	7.0	1.1	5.65-8.42
Uranium-234	3/3	0	1010	1040	238-2480
Uranium-235/236	3/3	0	52.3	57.1	9.74-133
Uranium-238	3/3	0	976	972	246-2350
SILO 2					
Actinium-227	3/3	0	3430	669	2620-4258
Lead-210	3/3	0	148,000	51,500	104,000-220,000
Polonium-210	3/3	0	24,700	8140	18,100-36,200
Radium-226	3/3	0	61,900	26,500	24,410-81,840
Radium-228	2/2	1	15.4	4.4	11-19.7
Thorium-228	3/3	0	114	73	24.7-204
Thorium-230	3/3	0	159	96	72.8-293
Thorium-232	1/3	0	1.87	e	e
Uranium-234	3/3	0	2200	1410	417-3860
Uranium-235/236	3/3	0	90.9	56.8	19.2-158
Uranium-238	3/3	0	2270	1460	421-4000

[a]Sample numbers used in this data set include: (Silo 1) 10050 through 10052, and (Silo 2) 10065 through 10067.
[b]Rejected data not included in total number of samples.
[c]Values qualified with an R or < are excluded. The mean and standard deviation have been rounded to show three significant figures.
[d]Values expressed in picoCuries per liter (pCi/L)
[e]Analyte was detected in a single sample.
[f]Analytical data taken from RI Table 4-12

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TABLE C.1-10

EP TOXICITY RESULTS FOR SILO 3 RESIDUES - 1989[a]

	Frequency of Detection	Mean (mg/L)	Standard Deviation (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Maximum Concentration of Contaminants[b] (mg/L)
Silo 3						
Arsenic	9/11	9.481	12.393	ND[c]	41.5	5.0
Barium	11/11	0.080	0.046	0.02	0.156	100.0
Cadmium	11/11	0.847	1.740	0.108	6.32	1.0
Chromium	11/11	5.05	3.22	0.336	11.9	5.0
Lead	7/11	0.239	0.327	ND[c]	1.01	5.0
Mercury	2/11	0.0005	0.0009	ND[c]	0.003	0.2
Selenium	11/11	2.65	3.00	0.92	11.7	1.0
Silver	1/11	0.007	0.008	ND[c]	0.032	5.0

[a]The data presented in table have not been validated. The sample numbers used in this data set include: MM3325 through MM3335.
[b]Data obtained from 40 CFR 261.24.
[c]ND - Not Detected.

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TABLE C.1-11

TCLP RADIOLOGICAL ANALYSES FOR SILO 3 RESIDUES

Radiological Parameters[a]	Concentration (pCi/L)[b, c]
Actinium-227	5.54 ± 1.94
Gross alpha	3150 ± 830
Gross beta	670 ± 340
Lead-210	87.1 ± 9.2
Polonium-210	245 ± 110
Protactinium-231	< 647
Radium-226	2455 ± 558
Radium-228	< 110
Thorium-228	3.17 ± 1.42
Thorium-230	10.4 ± 2.8
Thorium-232	< 1
Uranium-234	92.2 ± 13.8
Uranium-235/236	5.09 ± 1.59
Uranium-238	86 ± 13

[a]Data from sample 100074 (11/12/92).
[b]Values for concentration taken from Table 4-19 of the Remedial Investigation (RI) Report for Operable Unit 4.
[c]Values expressed in picocuries per liter (pCi/L).

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purposes of this summary report, only dilution adjustment TCLP results are presented in Tables C.1-11a through C.1-22.

C.1.4.4 Comparison of Treated and Untreated TCLP Results

TCLP results from the untreated K-65 and Silo 3 material and the dilution adjusted TCLP data from Remedy Selection (advanced phase) were compared. The percent reductions of radionuclide activity and chemical concentration are separately presented by silo and formulation (see Tables C.1-23 through C.1-34). Comparisons are made for all zone samples from Silos 1, 2, and 3 on a site basis. The results from the complete silo samples are indicative of what may be expected from treatment of each complete silo. Zone to zone comparisons for Silos 1 and 2 are not presented in this summary report but are included in the Treatability Study Report for Operable Unit 4. These zone to zone comparisons show the effect of the heterogeneity of the waste. That is, for a heterogeneous feed, if the zone to zone percent reduction values are similar, the treatment process is likely to be consistently effective or ineffective for the constituent in question.

TCLP chemical and radiological data comparisons for Silo 1 zone composite samples indicated that antimony, lead, and zinc levels were reduced. Lead consistently had greater than 99 percent reductions. Barium, boron, selenium, vanadium, and particularly molybdenum had increased concentrations in the TCLP leachate using Formulas 1 (cement/flyash) and 2 (blast furnace slag/cement/flyash). Chromium concentrations also increased for Formula 1. Lead-210 (Pb-210), polonium-210 (Po-210), and uranium (U)-total consistently had high percent reductions (greater than 97 percent). Mean radium percent reductions ranged from approximately 72 to 94 percent. Chemical and radiological data comparisons for Silo 2 zone composite samples indicated that antimony, barium, boron, cadmium, chromium, copper, lead, selenium, thallium, and zinc had reductions. Consistent with the Silo 1 results, the percent reduction of lead was greater than 99 percent. Molybdenum concentrations increased for both Formulas 1 and 2, although not as much as for Silo 1. Increases were also observed for 2-butanone, barium, and chromium for Formula 1 (cement/flyash). Finally, acetone and vanadium had increases for Formula 2 (blast furnace slag/cement/flyash). As with Silo 1, Pb-210, Po-210, and U-total had high percent reductions. Radium-228 (Ra-228) had mean reductions ranging from 48 to 57 percent. The mean reduction of Ra-226 ranged from 53 to 84 percent.

For Silo 3 composite samples, all of the chemical COCs had positive reductions except for barium. Formula 2 (blast furnace slag/cement/flyash) had all positive percent reductions for radionuclides.

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TABLE C.1-11a

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP DATA, ALL ZONES OF SILO 1, FORMULA 1

Chemical	Frequency of Detection	Range of Detection (mg/L)
2-Butanone	2/4	0.004-0.006
Acetone	2/4	0.027-0.033
Antimony	3/4	0.076-0.090
Barium	4/4	0.854-1.715
Benzoic Acid	2/4	0.008-0.008
Boron	4/4	0.330-0.417
Chromium	4/4	0.119-0.124
Lead	4/4	0.047-0.355
Molybdenum	4/4	20.000-27.767
Selenium	4/4	0.194-0.439
Tributyl phosphate	4/4	0.035-0.505
Vanadium	4/4	0.022-0.044
Zinc	4/4	0.023-0.040

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TABLE C.1-12

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP DATA, ALL ZONES OF SILO 1, FORMULA 2

Chemical	Frequency of Detection	Range of Detection (mg/L)
Acetone	3/3	0.023-0.046
Antimony	3/3	0.066-0.100
Barium	3/3	1.188-1.342
Boron	3/3	0.272-0.413
Lead	3/3	0.009-0.202
Molybdenum	3/3	11.844-21.863
Selenium	3/3	0.188-0.388
Tributyl phosphate	3/3	0.029-0.361
Vanadium	3/3	0.024-0.067
Zinc	3/3	0.027-0.029

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TABLE C.1-13

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP DATA, ALL ZONES OF SILO 2, FORMULA 1

Chemical	Frequency of Detection	Range of Detection (mg/L)
2-Butanone	1/4	0.008-0.008
Acetone	4/4	0.050-0.097
Antimony	3/4	0.064-0.091
Arsenic	4/4	0.009-0.019
Barium	4/4	2.233-2.796
Benzoic Acid	1/4	0.005-0.005
Boron	4/4	0.225-0.260
Cadmium	1/4	0.012-0.012
Chromium	4/4	0.115-0.167
Copper	1/4	0.058-0.058
Lead	4/4	0.066-0.784
Molybdenum	4/4	0.833-3.417
Selenium	4/4	0.000-0.117
Tributyl phosphate	4/4	0.388-1.223
Vanadium	3/4	0.022-0.051
Zinc	4/4	0.027-0.048

TABLE C.1-14

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP DATA, ALL ZONES OF SILO 2, FORMULA 2

Chemical	Frequency of Detection	Range of Detection (mg/L)
Acetone	3/3	0.019-0.078
Aluminum	3/3	0.821-1.281
Antimony	3/3	0.060-0.083
Arsenic	3/3	0.010-0.020
Barium	3/3	1.920-2.395
Boron	3/3	0.259-0.337
Calcium	3/3	1323.2-1336.5
Chlorobenzene	1/3	0.002-0.002
Chromium	3/3	0.021-0.045
Lead	3/3	0.031-0.075
Lithium	3/3	0.414-0.555
Magnesium	3/3	0.842-0.996
Molybdenum	3/3	0.570-2.624
Potassium	3/3	49.810-54.182
Selenium	3/3	0.020-0.131
Silicon	3/3	8.764-18.897
Tetrachloroethene	1/3	0.002-0.002
Thallium	1/3	0.006-0.006
Tributyl phosphate	3/3	0.190-0.970
Vanadium	2/3	0.066-0.080
Zinc	3/3	0.035-0.047

TABLE C.1-15

REMEDY SELECTION (ADVANCED PHASE)
DILUTION ADJUSTED TCLP DATA,
SILO 3, FORMULA 1

Chemical	Frequency of Detection	Range of Detection (mg/L)
Arsenic	1/1	0.089-0.089
Barium	1/1	0.387-0.387
Beryllium	1/1	0.005-0.005
Boron	1/1	2.542-2.542
Chromium	1/1	0.992-0.992
Molybdenum	1/1	1.084-11.084
Selenium	1/1	0.335-0.335
Thallium	1/1	0.024-0.024
Vanadium	1/1	0.686-0.686
Zinc	1/1	0.020-0.020

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TABLE C.1-16

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP DATA, SILO 3, FORMULA 2

Chemical	Frequency of Detection	Range of Detection (mg/L)
Acetone	2/2	0.013-0.040
Antimony	1/2	0.074-0.074
Arsenic	2/2	0.089-0.100
Barium	2/2	0.428-0.439
Beryllium	2/2	0.004-0.004
Boron	2/2	2.320-2.338
Chromium	2/2	0.051-0.059
Molybdenum	2/2	11.079-12.122
Selenium	2/2	0.248-0.261
Thallium	2/2	0.032-0.039
Vanadium	2/2	0.707-0.716
Zinc	2/2	0.020-0.025

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TABLE C.1-17

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP RADIOLOGICAL DATA, ALL ZONES OF SILO 1, FORMULA 1

Radionuclide	Frequency of Detection	Range of Detection (pCi/L)
Pb-210	4/4	156.12-732.04
Po-210	4/4	74.175-150.10
Ra-226	3/3	9417.5-24660
Ra-228	1/3	6.447-6.447
U-Total	2/4	0.003-0.003 (mg/L)

TABLE C.1-18

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP RADIOLOGICAL DATA, ALL ZONES OF SILO 1, FORMULA 2

Radionuclide	Frequency of Detection	Range of Detection (pCi/L)
Pb-210	3/3	56.844-268.06
Po-210	3/3	44.106-173.38
Ra-226	3/3	6996.2-11882
Ra-228	1/3	7.814-7.814
U-Total	2/3	0.003-0.003 (mg/L)

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TABLE C.1-19

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP RADIOLOGICAL DATA, ALL ZONES OF SILO 2, FORMULA 1

Radionuclide	Frequency of Detection	Range of Detection (pCi/L)
Pb-210	4/4	359.22-961.16
Po-210	4/4	21.553-131.65
Ra-226	4/4	14194-94369
Ra-228	3/4	7.476-16.194
U-Total	1/4	0.004-0.004 (mg/L)

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TABLE C.1-20

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP RADIOLOGICAL DATA, ALL ZONES OF SILO 2, FORMULA 2

Radionuclide	Frequency of Detection	Range of Detection (pCi/L)
Pb-210	3/3	96.388-158.37
Po-210	3/3	15.760-59.886
Ra-226	3/3	10456-21863
Ra-228	3/3	5.875-9.734
U-Total	1/3	0.003-0.003 (mg/L)

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TABLE C.1-21

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP RADIOLOGICAL DATA, SILO 3, FORMULA 1

Radionuclide	Frequency of Detection	Range of Detection (pCi/L)
Pb-210	1/1	360.75-360.75
Ra-226	1/1	1712.2-1712.2
Ra-228	1/1	111.21-111.21
U-Total	1/1	0.006-0.006 (mg/L)

TABLE C.1-22

REMEDY SELECTION (ADVANCED PHASE) DILUTION ADJUSTED TCLP RADIOLOGICAL DATA, SILO 3, FORMULA 2

Radionuclide	Frequency of Detection	Range of Detection (pCi/L)
Pb-210	1/2	6.830-6.830
Po-210	1/2	11.280-11.280
Ra-226	2/2	194.24-1320.1
Ra-228	2/2	82.730-92.990

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TABLE C.1-23

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP DATA
ALL ZONES OF SILO 1, FORMULA 1

Chemical	Mean Percent Reduction	95% Upper Confidence Interval (UCI) on Mean Percent Reduction
2-Butanone	0	0
Antimony	40.9	12.6
Barium	-55.4	-49.3
Benzoic acid	NA	NA
Boron	-46.6	-41.6
Chromium	-105.1	-87.9
Lead	>99.9	>99.9
Molybdenum	-34022.2	-32187.2
Selenium	-103.7	-139.9
Tributyl phosphate	NA	NA
Vanadium	-30.4	-65.4
Zinc	75.0	82.0

NA - Not applicable.

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TABLE C.1-24

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP DATA
ALL ZONES OF SILO 1, FORMULA 2

Chemical	Mean Percent Reduction	95% UCI on Mean Percent Reduction
Antimony	15.1	2.9
Barium	-46.8	-16.8
Boron	-35.3	-41.0
Lead	>99.9	>99.9
Molybdenum	-24581.9	-25322.1
Selenium	-102.2	-112.0
Tributyl phosphate	NA	NA
Vanadium	-91.3	-157.7
Zinc	78.1	86.9

NA - Not Applicable.

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TABLE C.1-25

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP RADIOLOGICAL DATA
ALL ZONES OF SILO 1, FORMULA 1

Radionuclide	Mean Percent Reduction	95% UCI on Mean Percent Reduction
Pb-210	>99.9	>99.9
Po-210	>99.9	>99.9
Ra-226	72.6	62.8
Ra-228	94.8	93.0
U-Total	>99.9	97.3

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TABLE C.1-26

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP RADIOLOGICAL DATA
ALL ZONES OF SILO 1, FORMULA 2

Radionuclide	Mean Percent Reduction	95% UCI on Mean Percent Reduction
Pb-210	>99.9	>99.9
Po-210	>99.9	99.9
Ra-226	80.9	82.1
Ra-228	94.5	91.5
U-Total	>99.9	97.3

TABLE C.1-27

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP DATA
ALL ZONES OF SILO 2, FORMULA 1

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Chemical	Mean Percent Reduction	95% UCI on Mean Percent Reduction
2-Butanone	-50.0	-250.0
Antimony	45.6	12.5
Arsenic	73.1	94.1
Barium	-4.9	67.0
Benzoic acid	NA	NA
Boron	54.3	81.7
Cadmium	90.5	88.3
Chromium	-9.4	-12.1
Copper	99.2	98.9
Lead	>99.9	>99.9
Molybdenum	-2918.2	-4580.8
Selenium	90.1	40.6
Tributyl phosphate	NA	NA
Vanadium	55.8	8.9
Zinc	87.5	90.5

NA - Not Applicable.

TABLE C.1-28

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP DATA
ALL ZONES OF SILO 2, FORMULA 2

Chemical	Mean Percent Reduction	95% UCI on Mean Percent Reduction
Acetone	-44.8	-14.7
Antimony	23.9	20.2
Arsenic	71.2	93.8
Barium	8.0	71.7
Boron	41.9	76.2
Chromium	77.3	69.8
Lead	>99.9	>99.9
Molybdenum	-2518.2	-3494.5
Selenium	31.7	33.5
Tetrachloroethene	NA	NA
Thallium	71.4	78.6
Tributyl phosphate	NA	NA
Vanadium	43.3	-42.9
Zinc	86.0	90.3

NA - Not Applicable.

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TABLE C.1-29

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP RADIOLOGICAL DATA
ALL ZONES OF SILO 2, FORMULA 1

Radionuclide	Mean Percent Reduction	95% UCI on Mean Percent Reduction
Pb-210	99.6	99.6
Po-210	99.7	99.6
Ra-226	53.3	12.6
Ra-228	57.9	17.8
U-Total	>99.9	>99.9

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TABLE C.1-30

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP DATA
ALL ZONES OF SILO 2, FORMULA 2

Radionuclide	Mean Percent Reduction	95% UCI on Mean Percent Reduction
Pb-210	99.9	99.9
Po-210	99.9	99.8
Ra-226	74.4	73.3
Ra-228	48.7	50.6
U-Total	>99.9	>99.9

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TABLE C.1-31

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CHEMICAL CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP DATA
SILO 3, FORMULA 1

Chemical	Percent Reduction
Arsenic	98.3
Barium	-556
Beryllium	57.5
Chromium	78.2
Selenium	63.7
Thallium	42.2
Vanadium	71.5
Zinc	89.2

TABLE C.1-32

REMEDY SELECTION (ADVANCED PHASE)
PERCENT REDUCTION OF CHEMICAL CONSTITUENTS OF CONCERN
DILUTION ADJUSTED TCLP DATA
SILO 3, FORMULA 2

Chemical	Percent Reduction
Antimony	NA
Arsenic	98.2
Barium	-635
Beryllium	61.6
Chromium	98.8
Selenium	72.4
Thallium	15.0
Vanadium	70.5
Zinc	87.5

NA - Not Applicable.

Note: Characterization data consists of one sample. Formula 2 data consists of two samples which were averaged. No 95% UCI was calculated.

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TABLE C.1-33

REMEDY SELECTION (ADVANCED PHASE) PERCENT REDUCTION FOR RADIONUCLIDES DILUTION ADJUSTED TCLP RADIOLOGICAL DATA SILO 3, FORMULA 1

Radionuclide	Percent Mean Reduction
Pb-210	-121.6
Ra-226	62.7
Ra-228	NA
U-Total	98.2

NA - Not Applicable

TABLE C.1-34

REMEDY SELECTON (ADVANCED PHASE)
PERCENT REDUCTION FOR RADIONUCLIDES
DILUTION ADJUSTED TCLP RADIOLOGICAL DATA
SILO 3, FORMULA 2

Radionuclide	Percent Mean Reduction
Pb-210	97.0
Po-210	98.0
Ra-226	82.8
Ra-228	NA

NA - Not Applicable.

Note: Characterization data consists of one sample. Formula 2 data consists of two samples which were averaged. No 95% UCI was calculated.

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The cement/flyash/$FeCl_2$ formulation had a concentration increase for Pb-210. This increase was likely attributable to the PH of the TCLP extraction solution. In general, increases between the untreated and treated waste leachate results are likely the result of the following: 1) the heterogeneity of the silo residue,and 2) the pH and ionic strength of the extraction fluid during the TCLP test, and/or the type of extraction fluid (TCLP types 1 and 2) used.

Molybdenum was one of the analyses which resulted in an increased concentration in the treated waste. This increase can likely be attributed to the solubility of molybdenum being strongly dependent on the pH of the extraction solution. Its solubility increases dramatically at the higher pH (greater than 10.5) measured in the TCLP extraction fluids for the treated material. Barium also had higher concentrations in the treated waste versus the untreated residues. Barium is a constituent of the silo material, and it is present as a low solubility sulfate complex. The cement stabilization process results in the calcium within the cement partially reacting with sulfate in the barium sulfate complex causing the solubility of barium to increase. Therefore, higher levels of barium in the treated waste versus the untreated residues are to be expected as a result of this process option.

2-butanone is another silo constituent which leached more in the treated material versus the untreated residues. For Silo 1, the range of 2-butanone in the untreated and treated materials ranged from nondetectable levels to 6 ppb, respectively. For Silo 2, the corresponding ranges were nondetectable levels to 2 ppb and nondetectable to 8 ppb, respectively. These low levels of 2-butanone in the samples with values above nondetectable levels are likely the result of laboratory contamination. Particularly, since it is an impurity commonly found in methanol, which is a solvent often used in preparation of samples for volatile compound analysis.

In general, the constituents that were present in the TCLP leachate at higher levels in the treated waste than in the untreated residues are present at low concentrations. These concentrations are low enough such that additional processing is not required for the following reasons: 1) The leachate concentrations are below the RCRA regulatory levels. 2) All these constituents were at concentrations sufficiently low that they would contribute little to the overall risk.

Based on the preceding discussed of TCLP results, the following observation is clear: As a general trend for the cement stabilization of waste from all three silos, the blast furnace slag/cement/flyash formulas were more effective in controlling the Leaching of Constituents based on TCLP than the cement/flyash formulas. This trend is most apparent with the Ra-226 results.

C.1.4.5 Five-Day Static Leach Test Results

The five-day static leach test is a procedure that is significantly different than the TCLP. The TCLP mixes crushed samples in a water/acetic acid/acetate solution for 18 hours, while the five-day static leach test is performed with 1.4 inch by 2.9 inch cylinders in stagnant deionized water for five days. The results, however, were generally the same order of magnitude as for the TCLP leachate results. Typically, the cement-blast furnace slag or cement/flyash/blast furnace slag formulas exhibited better leaching characteristics from the 5-day static leach test for COCs than the cement/flyash formulas.

C.1.4.6 Additional Treatability Results

Additional results from Remedy Selection (advanced phase) were the following:

- Formulas containing cement/blast furnace slag/flyash did not increase the volume of treated waste as much as the cement/flyash formulas. As might be expected, the addition of bentonite to the waste added to the volume increase. For the given formulas, Silo 3 had the lowest volume increase and Silo 1 had the highest volume increase.

- Preliminary process parameters were also collected. These parameters were designed to indicate if there might be gross processing problems while using the formulas. The parameters are shear strength, waste form temperature rise with reagent addition, penetration resistance, and whether significant amounts of gases were released. An evaluation of the data indicated that the formulation is considered feasible if the treated sample has a low shear strength [less than 1 ton per square foot (ton/ft^2)], minimal temperature rise (less than 7°C), and if the amount of gas released during mixing or curing was small. In addition to improved handling, the treated waste should set to achieve a penetration resistance of greater than 4.5 tons/ft^2 after one day of curing. Silos 1 and 3 Formula 2 (blast furnace slag/cement/flyash) required longer than 24 hours to meet the penetration resistance of 4.5 tons/ft^2. Both formulas for Silo 3 exceeded the 7°C temperature rise upon mixing with water. In addition, the Silo 3 waste tends to set up within 10 minutes after water is added. This latter occurrence can be minimized by agitating the wet material or by adding excess water. All other parameters were successfully met. These processing deviations from the ideal will require additional steps or special handling during processing.

C.1.5 CONCLUSIONS

This treatability study indicated that cement stabilization of the Silos 1, 2, and 3 residues is technically feasible.

C.2.0 CHEMICAL EXTRACTION TREATABILITY STUDY

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C.2.1 INTRODUCTION

Chemical extraction treatability tests were carried out in support of the Operable Unit 4 RI/FS process currently underway at the FEMP site. The tests were performed in accordance with the Treatability Study Work Plan for Operable Unit 4 for cement stabilization and chemical extraction (DOEa 1992).

The testing provided effectiveness data on the use of various acids and chelates to extract metals and radionuclides from silo material thereby creating a small waste stream containing the bulk of the contaminants and a much larger insoluble waste stream with much lower contaminant concentrations.

Remedy Screening (preliminary phase) and Remedy Selection (advanced phase) were performed for this study.

C.2.2 TEST METHODOLOGY

The objective was to determine the effectiveness of various extraction solutions in removing RCRA metals, uranium, thorium, polonium, protactinium, actinium, and radium from the material in Silos 1 and 2. In addition, the effectiveness of various reagents to decontaminate the spent extract was to be determined. Testing was performed in two phases to provide an adequate amount of data for preparation of the FS. The phases consisted of a two stage Remedy Screening (preliminary phase) and a single stage Remedy Selection (advanced phase) followed by additional tests to better define the extraction process and the secondary waste stream treatment requirements (see Figures C.2-1 and C.2-2). In Remedy Screening (preliminary phase) and in some Remedy Selection (advanced phase), the extracts resulting from the application of the various acid and ethylenediaminetetraacetic acid (EDTA) solutions to the samples were analyzed for lead and uranium. The extracted dried solid residues were also analyzed for gross alpha and beta. Uranium and lead were selected as the target compounds in this study because they were present in greater concentrations than thorium or radium. The removal of thorium, uranium, lead, polonium, protactinium, actinium, and radium were to be demonstrated in the Remedy Selection (advanced phase).

C.2.2.1 Remedy Screening (Preliminary Phase) - Stage 1

Stage 1 leaching experiments were conducted on small quantities (1.5 to 3 g) of Silos 1 and 2 composite sample material, using a two-hour extraction time and various extractant concentrations, acid-to-sample ratios and/or dose rates (4:1 and 2:1 acid-to-waste ratio by weight). Nitric,

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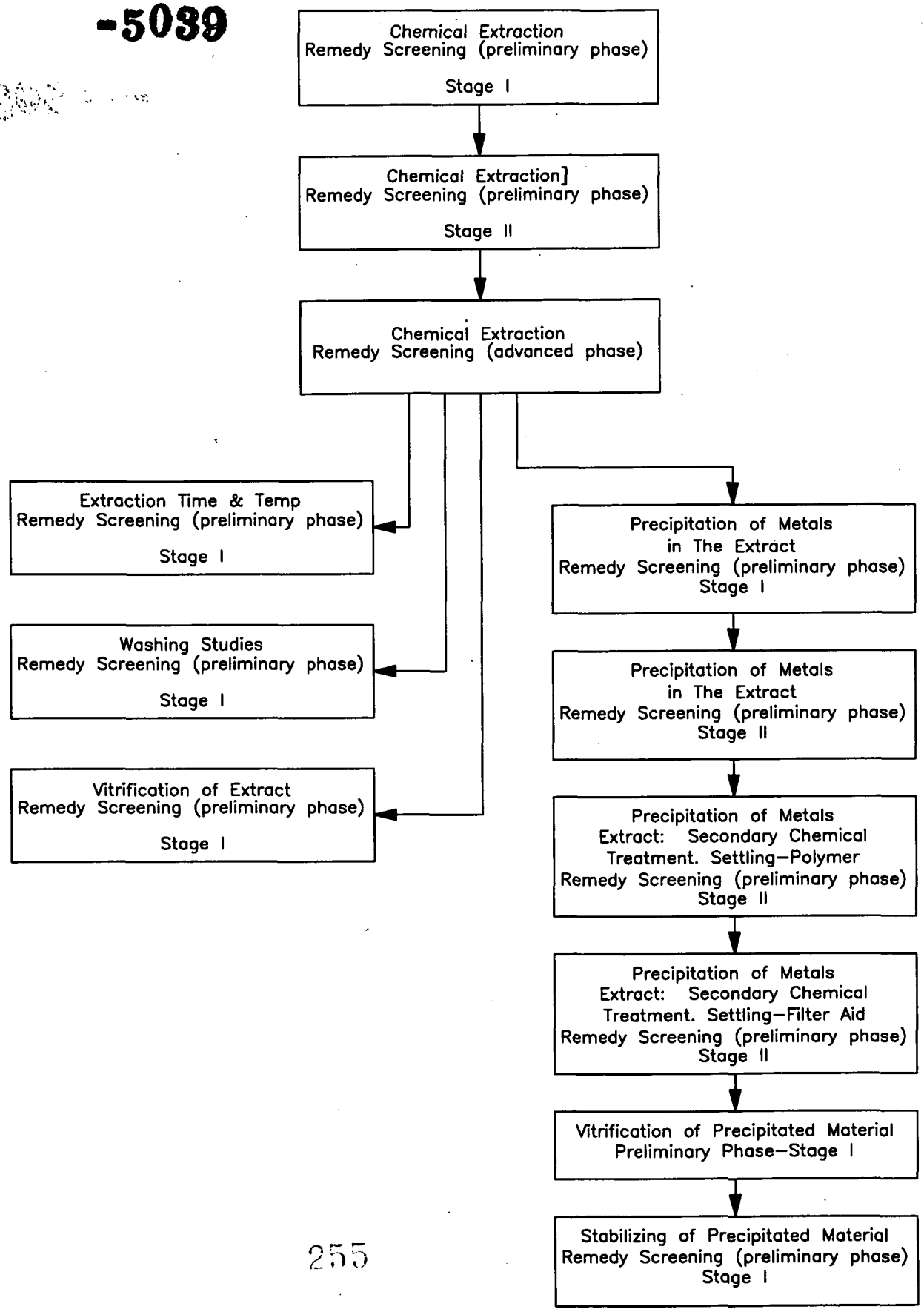

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409194-A-215 OU4 KNOX FS
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FIGURE C.2-1 CEMENT STABILIZATION TREATABILITY PROGRAM
FOR COMPOSITE WASTE SAMPLES FROM SILOS 1 AND 2

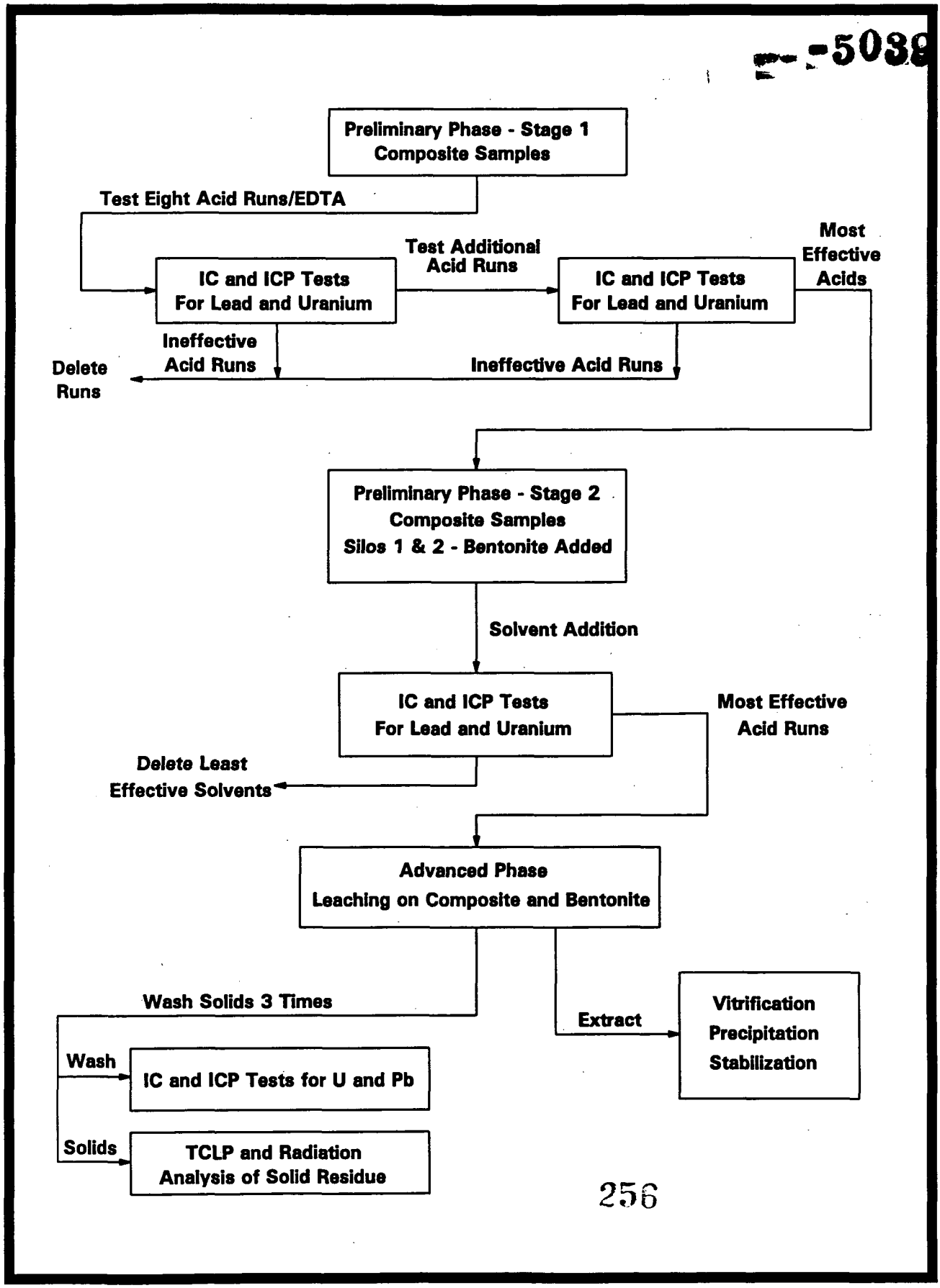

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FIGURE C.2-2 OVERALL CHEMICAL EXTRACTION TEST STRATEGY-SILOS 1 AND 2

hydrochloric, and acetic acids were tested at two different temperatures (ambient and 80°C). During this stage, experiments were conducted to determine trends of solubilities. If it was apparent from the analytical results that a particular acid was not successfully leaching the metals, the acid was eliminated from further testing. If the analytical results indicated that a particular extract contained more uranium and lead than another extract, then that extraction condition was considered promising. Those promising extracts were investigated further during Stage 2 testing to better define the effect of acid concentration and temperature on the metal solubilities.

C.2.2.2 Remedy Screening (Preliminary Phase) - Stage 2

Stage 2 testing verified and expanded upon Stage 1 by testing Silos 1 and 2 composite samples and silo composites with the addition of 20 percent bentonite. This mix then represents the current material within the silos. Higher acid dose rates (4:1 and 10:1) were tested and compared in addition to longer extraction times varying between 2 and 24 hours. The extraction temperature for all tests was 80°C. Also, process conditions were varied by adding extra processing steps. Certain tests were duplicated with the addition of water washes or subsequent extraction steps followed by water washes. The liquid-to-solid ratio for water washes was the same as for the chemical extraction process based on initial sample weight. EDTA was also tested by using it as an extractant; chlorine bleach (NaOCl) was used as an oxidant. The bleach was added to tests using hydrochloric acid (HCl) as the extractant, which oxidized lower valence uranium species to the more soluble uranium (VI) species.

C.2.2.3 Remedy Selection (Advanced Phase)

The objective of the Remedy Selection (advanced phase) was to demonstrate on larger samples (400 g) that the extracted solid is a nonhazardous material as defined by RCRA and that uranium, lead, actinium, protactinium, thorium, polonium, and radium were successfully extracted from the solids. The treatments from the Remedy Screening (preliminary phase) tests that yielded solids with the lowest concentrations of lead and uranium were repeated on a larger scale.

Two composite samples from each silo with bentonite added were extracted using two different extraction processes. Each sample was leached as four individual 100 g aliquots. The first extraction process was to treat with potassium chloride (KCl) and then subject to six successive extractions with EDTA (see Figure C.2-3). The other sample stream from each silo was subjected to six successive extractions with EDTA, followed by nitric acid (HNO_3) (see Figure C.2-4). Solid/liquid separation after each extraction was accomplished using vacuum filtration followed by three solids rinses. During successive rinses, filtration became increasingly difficult. Therefore, the liquid separations

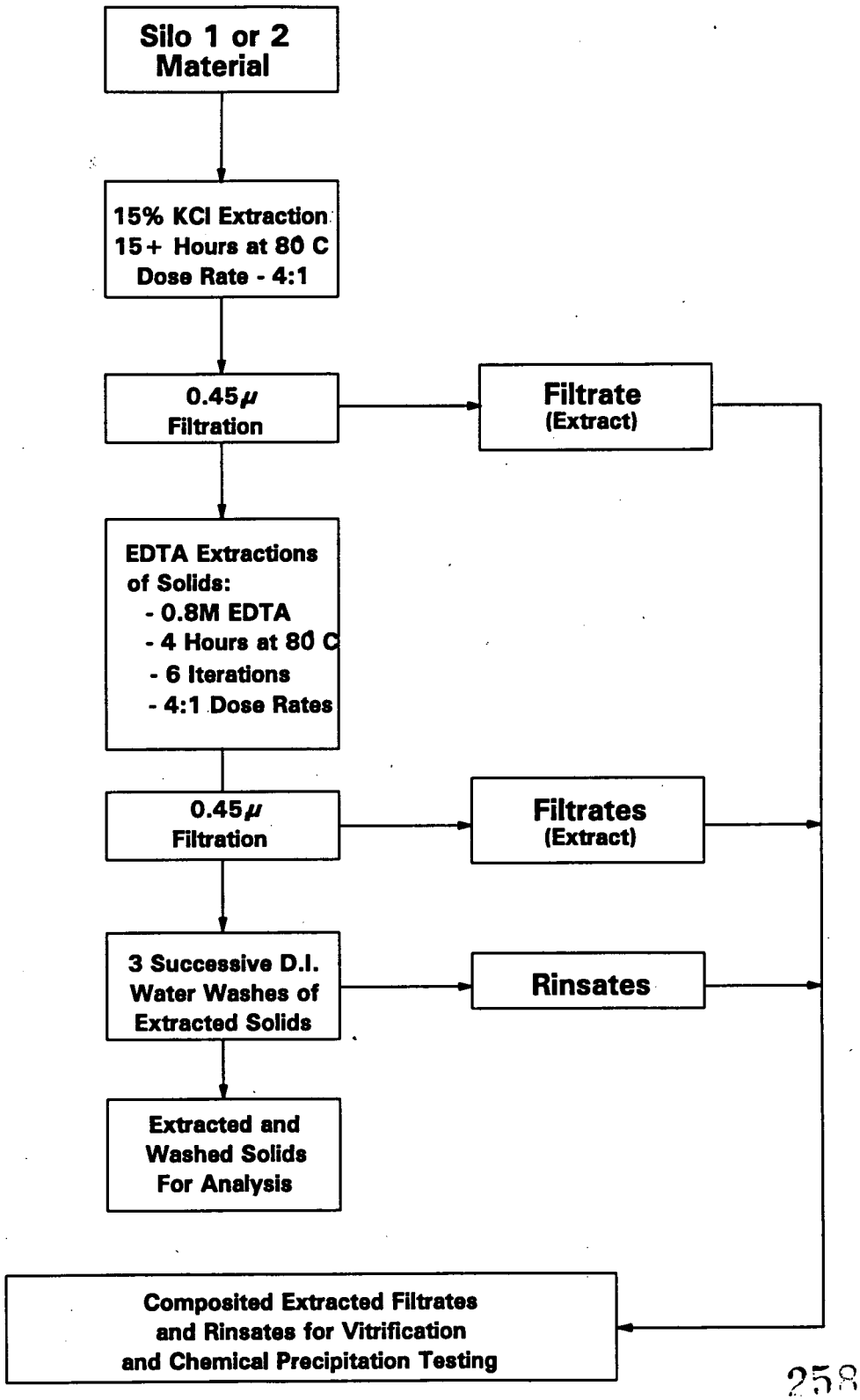

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FIGURE C.2-3 ADVANCED PHASE KCl/EDTA EXTRACTIONS

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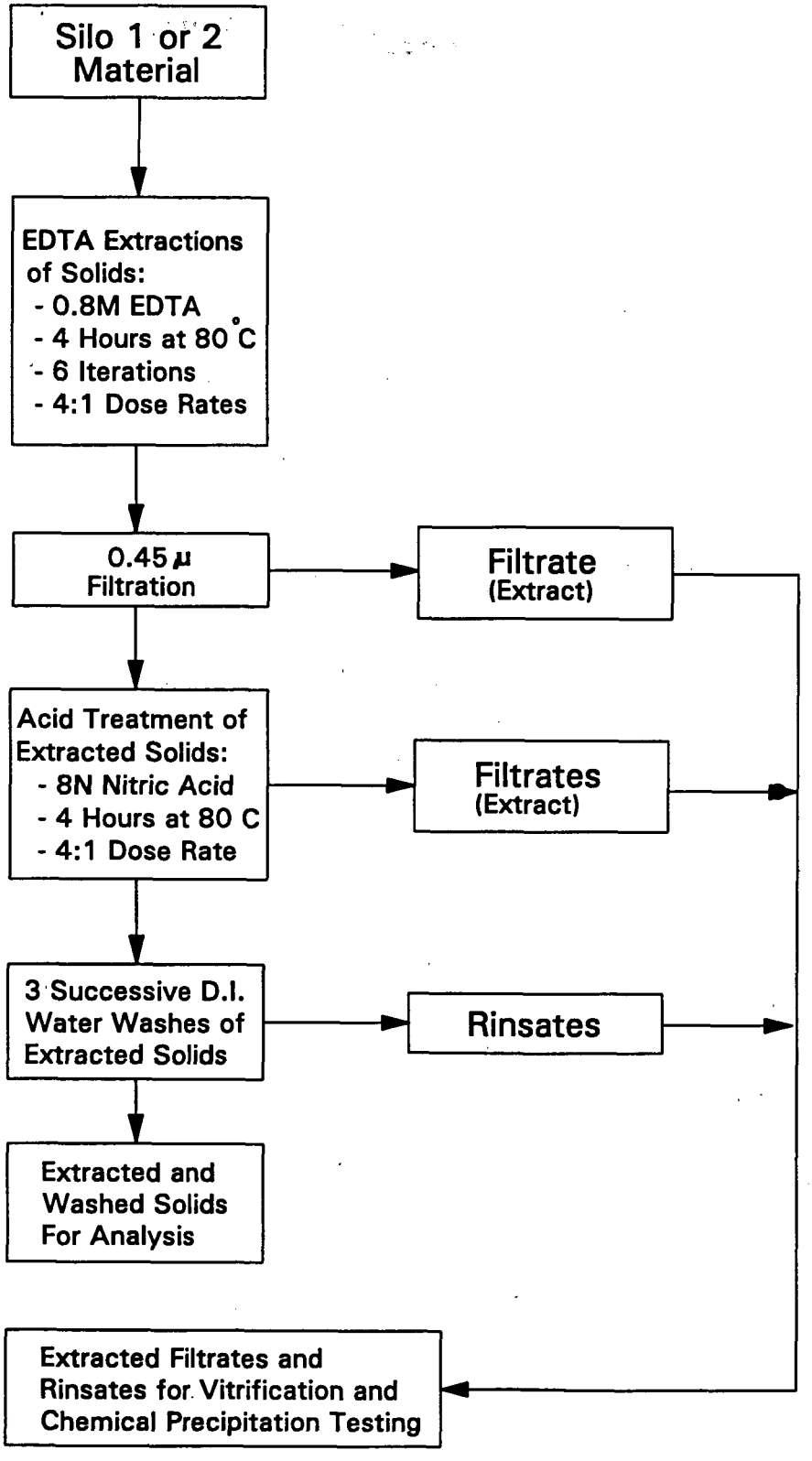

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FIGURE C.2-4 ADVANCED PHASE EDTA/NITRIC ACID EXTRACTIONS

during rinsing operations were continued using centrifugation. Centrifuge times ranged from 20 minutes to 1 hour. During the Remedy Selection (optional phase) study, the filtration problems which occurred during the rinsing operations were successfully eliminated by addition of a nonionic polymer during the rinses. See Appendix H for more details. The extracted solids were subjected to TCLP, with the leachate being analyzed for metals and radionuclides. The solids were also analyzed for radionuclides.

C.2.2.4 Additional Testing

Additional tests were conducted in conjunction with Remedy Selection (advanced phase) testing in order to better define the extraction process and the secondary waste stream (spent extractants) treatment requirements. These tests consisted of the following: sample homogeneity tests to verify the acceptability of the silo/bentonite composite samples; extraction time and temperature tests to identify acceptable extraction times and temperatures; solids washing with deionized water; precipitation of metals from the leachate; stabilization of the precipitated leachate metals; and vitrification of the precipitated solids within the leachate. Two processes were used to vitrify the contaminants in the leachate. The first process was to remove the liquid by evaporation followed by heating the dried waste combined with glass former/modifiers at 1250°C. The second process was to precipitate the metals followed by heating the precipitate combined with glass former/modifiers at 1250°C. The glass former/modifiers tested in this study were alumina-silicates (soil and flyash) and sodium hydroxide and sodium carbonate.

C.2.3 TEST OBJECTIVES AND DESIRED DATA

Specific test objectives were established so that the performance of various acids, precipitation agents, and stabilizing reagents could be evaluated. These test objectives were used to determine if the chemical extraction process option merits further consideration. The objectives are as follows:

- To extract RCRA metals so that the insoluble residue will meet TC regulatory criteria i.e., nonhazardous material as defined by RCRA
- To reduce the level of radioactive components in the insoluble residue
- To determine the extraction time required
- To determine the effect of different waste-to-extraction solution ratios on the extractions
- To determine the reagents and conditions necessary to precipitate the metals in the extract solution

- To determine the leachability of all radionuclides and constituents of concern from the final waste form
- To estimate the volumes of wastes that will be generated by each process
- To minimize the final volume of treated waste
- To provide leaching characteristics information
- To develop preliminary reagent mixture and process parameter data

C.2.4 RESULTS AND DISCUSSION

C.2.4.1 Remedy Screening (Preliminary Phase) Stage 1

As previously indicated, Stage 1 was used to identify promising acid extractants, concentrations and extraction temperatures. The acids investigated within the program were HCl, HCO_3, and acetic. The variables were acid type, acid strength, extract-to-sample ratio or dose rate (see Table C.2-1), and extraction temperature. Performance was measured by gross alpha and gross beta activity in the raffinates, and lead and uranium concentrations in the leachates.

Experimental results indicate that HCl and HNO_3 were more effective than acetic acid in extracting uranium and lead into the extractants. Acetic acid, which is a weak acid used in the TCLP procedure, was about 80 percent as effective as the two strong acids, HCl and HNO_3. The target RCRA metals were most effectively extracted with 27 percent (concentrated) HCl and 30 percent (one part acid to one part water) HNO_3. It is hypothesized that there was not enough free water available in the concentrated HNO_3 (60 percent) to effectively extract the lead and uranium from the silo material. When the HNO_3 was diluted with water, the acid solution was better able to extract the target metals.

Two dose rates (2:1 and 4:1 w/w) and temperatures (ambient and 80°C) were investigated. The 4:1 dose rate and 80°C extraction temperature were most effective at extracting the uranium and lead in a single extraction step.

The conditions and acid type for the maximum decrease in gross alpha and beta were not the same as for maximum lead and uranium removal. The best extractant for reduction in gross alpha and beta in one extraction step was 2 M acetic acid at 80°C. The best performing acid based on the amount of lead in the extract was 2.6 M nitric acid at 80°C. Upon closer analysis of the gross alpha and beta

TABLE C.2-1

ACID EXTRACTIONS REMEDY SCREENING (PRELIMINARY PHASE) - STAGE 1

	Dose (weight acid/ weight sample)		Temperature	
Acid Nominal Concentration	2:1	4:1	Ambient	80°C
60% HNO_3[a](13N)	X	X	X	
60% HNO_3 (13N)	X	X		X
30% HNO_3 (5.6N)		X		X
15% HNO_3 (2.6N)	X	X		X
36% HCl[b] (11.6N)	X	X	X	
36% HCl (11.6N)	X	X		X
18% HCl (5.4N)		X		X
9% HCl (2.6N)	X	X		X
50% HOAc[c, d] (8.8N)	X[d]	X	X	
50% HOAc (8.8N)	X	X		X
25% HOAc (4.3N)		X		X
12.5% HOAc (2N)	X	X		X

[a] Nitric acid
[b] Hydrochloric acid
[c] Acetic acid
[d] Actual ratio is 2.66:1

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data, it was observed that approximately half of the values after one extraction were higher than the untreated waste. This was particularly evident for the Silo 1 material for gross alpha. A possible explanation for this phenomenon is the removal of shielding elements through the extraction process, which are more soluble than radionuclides such as natural lead thus increasing the concentration and availability of the radionuclides. The extractant also may have caused the waste to break up into smaller particles, exposing more surface area.

C.2.4.2 Remedy Screening (Preliminary Phase) Stage 2

An assessment of the Stage 1 data resulted in the identification of the most promising extractants for Stage 2 experiments. The laboratory procedures in Stage 2 were similar to Stage 1. Four acids, HCl, HNO_3, acetic, and EDTA were studied. The conditions for the tests were dose rate (4:1 and 10:1 w/w), temperature (80°C), and extraction time (2 and 4 hours). Multiple extractions were also analyzed. With some of the tests, bentonite was added to the silo waste to simulate the effect of the current silo material.

The gross alpha and beta values of the raffinate were not sufficiently decreased by any of the three Stage 1 acids investigated; therefore, EDTA (0.2 and 0.8M) was also investigated in Stage 2 to improve the total radiological removal from the raffinate. EDTA was significantly more efficient at lowering the gross alpha and beta activity than the acids previously investigated. In addition, analysis of the Stage 2 data indicated that substantial reductions in the total radiological activity of the waste required multiple extraction steps.

Further experiments were conducted to determine if the multiple extraction process was being limited by the saturation of the extractant. Two sets of tests at 80°C were conducted where the dose rate was increased to 10:1 from 4:1 w/w, and the time of extraction was increased from four to 24 hours. The results at the 10:1 dose rate were only slightly better than those achieved at the 4:1 dose rate. It can be concluded that the EDTA extractants at 80°C are not saturated by the dissolving material. Yet there may be a kinetic verses equilibrium phenomenon occurring during the first extraction. During the 24 hour extraction, the raffinate had higher gross alpha and beta values than the four hour extraction. The opposite trend occurred on the third extraction step. A possible explanation of these observations is that several materials dissolved relatively quickly. When these dissolved materials were allowed to stand for longer periods of time, some of the dissolved material reprecipitated. By the third extraction step, the concentration of cations and anions in the extraction solution was low enough that the rate of reprecipitation was diminished or effectively terminated. These results were

the basis for the decision that subsequent tests would be 80°C, 4:1 dose rate, six extractions with EDTA, and four hours extraction time.

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Single and multiple extractions were investigated as follows (see Tables C.2-2 and C.2-3): HCl, HNO_3, EDTA, KCl pretreatment followed by EDTA (KCl/EDTA), HCl and HNO_3 followed by EDTA (HCl/EDTA and HNO_3/EDTA), EDTA followed by HNO_3 (EDTA/HNO_3), and HNO_3 followed by two water rinses with EDTA (HNO_3/RINSE/EDTA). The least reduction in gross alpha and beta activity in the raffinate was measured for six sequential extractions with HCl/EDTA and HNO_3/EDTA. With the latter two experiments, the pH of the raffinate was not adjusted to near neutral conditions before addition of EDTA. Therefore, it is highly likely that most of the EDTA precipitated on the solid residue instead of effectively penetrating the particle to extract the metals. After six or seven extractions the maximum reductions in total gross alpha and beta activity in the raffinate were from KCl/EDTA, EDTA/HNO_3, and HNO_3/RINSE/EDTA. The latter extraction sequence was more effective than HNO_3/EDTA, since the two water rinses raised the pH of the solid above the precipitation pH for EDTA. However, at that time, the KCl/EDTA and EDTA/HNO_3 showed the most promise and were carried forward into the Remedy Selection (advanced phase) extractions. Further small-scale investigations indicated that the HNO_3/RINSE/EDTA may be the most effective process to remove uranium from the silo residue and the most cost effective process of the three best processes investigated.

C.2.4.3 Remedy Selection (Advanced Phase)

The specific reagent combinations tested in the Remedy Selection (advanced phase) were the following: a single 15 percent KCl extraction, followed by six extractions of 0.8M EDTA; and six extractions of 0.8M EDTA, followed by one water rinse and one 0.8m HNO_3 extraction.

Experimental results are presented in Table C.2-4. Analysis of the data in the table indicates that the extracted solid using both the KCl/EDTA and the EDTA/HNO_3 processes, were below the TC regulatory levels for RCRA metals. The percent reduction column is based on a comparison of the TCLP of the raffinate solid with the characterization TCLP. The chemical concentrations in the TCLP leachate, with the exception of barium and mercury, were either reduced or were not detected in the raffinate. Barium showed increased concentrations in the Silo 1 samples and relatively small decreases in the Silo 2 samples. Even with the increase, the highest barium concentrations are still less than five percent of the TC regulatory level. Mercury was undetected in three of the samples but showed a slight increase in the TCLP leachate in the fourth sample (Silo 2 EDTA/HNO_3 extraction

TABLE C.2-2

CHEMICAL EXTRACTION
REMEDY SCREENING (PRELIMINARY PHASE) - STAGE 2[a]
FEED ARE 1990-91 COMPOSITES + 20 PERCENT BENTONITE

					Extractant 1			
Test Number	Silo	Temp.	Time	Liquid/Solid Ratio	Name	Conc.	Extracts # of	Rinses # of
1	1	80°C	2 hrs.	4:1	HCl	5.4 N	1	3
2	1	80°C	2 hrs.	4:1	Nitric	5.6 N	1	3
3	1	80°C	2 hrs.	4:1	Acetic	8.8 N	1	3
4	1	80°C	2 hrs.	4:1	Acetic	4.3 N	1	3
1 dup	1	80°C	2 hrs.	4:1	HCl	5.4 N	1	3
6	1	80°C	2 hrs.	4:1	HCl	9 N	1	3
7	1	80°C	2 hrs.	4:1	HCl + C12	9 N	1	3
2 dup	1	80°C	2 hrs.	4:1	Nitric	5.6 N	1	3
3 dup	1	80°C	2 hrs.	4:1	Acetic	8.8 N	1	3
4 dup	1	80°C	2 hrs.	4:1	Acetic	4.3 N	1	3
1	2	80°C	2 hrs.	4:1	HCl	5.4 N	1	3
2	2	80°C	2 hrs.	4:1	Nitric	5.6 N	1	3
3	2	80°C	2 hrs.	4:1	Acetic	8.8 N	1	3
4	2	80°C	2 hrs.	4:1	Acetic	4.3 N	1	3
1 dup	2	80°C	2 hrs.	4:1	HCl	5.4 N	1	3
6	2	80°C	2 hrs.	4:1	HCl	9 N	1	3
7	2	80°C	2 hrs.	4:1	HCl + Cl	9 N	1	3
2 dup	2	80°C	2 hrs.	4:1	Nitric	5.6 N	1	3
3 dup		80°C	2 hrs.	4:1	Acetic	8.8 N	1	3
4 dup	2	80°C	2 hrs.	4:1	Acetic	4.3 N	1	3

[a] Only one extractant used for Silos 1 and 2 composite samples.

TABLE C.2-3

CHEMICAL EXTRACTION
REMEDY SCREENING (PRELIMINARY PHASE) - STAGE 2[a]

			Extractant 1						Extractant 2				
Test Number	Silo	Temp.	Time	Name	Conc.	Extracts # of	Rinses # of	Liquid/Solid Ratio	Time	Name	Conc	Extracts # of	Rinses # of
8	1 & 2	80°C	4 hrs.	HCl	9 N	6	3	4:1	-[b]	-	-	-	-
9	1 & 2	80°C	4 hrs.	HCl	9 N	3	3	4:1	-	-	-	-	-
10	1 & 2	80°C	4 hrs.	Nitric	5.6 N	6	3	4:1	-	-	-	-	-
11	1 & 2	80°C	4 hrs.	Nitric	5.6 N	3	3	4:1	-	-	-	-	-
12	1 & 2	80°C	4 hrs.	EDTA	0.2 M	6	3	4:1	-	-	-	-	-
13	1 & 2	80°C	4 hrs.	EDTA	0.2 M	3	3	4:1	-	-	-	-	-
14	1 & 2	80°C	4 hrs.	EDTA	0.8 M	6	3	4:1	-	-	-	-	-
15	1 & 2	80°C	4 hrs.	EDTA	0.8 M	3	3	4:1	-	-	-	-	-
16	1 & 2	80°C	4 hrs.	HCl	9 N	3	3	4:1	-	-	-	-	-
17	1 & 2	80°C	4 hrs.	EDTA	0.8 M	1	3	10:1	-	-	-	-	-
18	1 & 2	80°C	4 hrs.	EDTA	0.8 M	2	3	10:1	-	-	-	-	-
19	1 & 2	80°C	4 hrs.	EDTA	0.8 M	3	3	10:1	-	-	-	-	-
20	1 & 2	80°C	24 hrs.	EDTA	0.8 M	1	3	10:1	-	-	-	-	-
21	1 & 2	80°C	24 hrs.	EDTA	0.8 M	2	3	10:1	-	-	-	-	-
22	1 & 2	80°C	24 hrs.	EDTA	0.8 M	3	3	10:1	-	-	-	-	-
23	1 & 2	80°C	15 hrs.	KCl	15%	1	3	10:1	24 hrs.	EDTA	0.8 M	1	3
24	1 & 2	80°C	15 hrs.	KCl	15%	1	3	10:1	24 hrs.	EDTA	0.8 M	2	3
25	1 & 2	80°C	15 hrs.	KCl	15%	1	3	10:1	24 hrs.	EDTA	0.8 M	3	3

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TABLE C.2-3
(Continued)

			Extractant 1						Extractant 2				
Test Number	Silo	Temp.	Time	Name	Conc.	Extracts # of	Rinses # of	Liquid/Solid Ratio	Time	Name	Conc	Extracts # of	Rinses # of
26	1 & 2	80°C	4 hrs.	ETDA	0.8 M	6	3	4:1	4 hrs.	Nitric	5.6 N	1	3
27	1 & 2	80°C	4 hrs.	HCl	9 N	6	3	4:1	4 hrs.	EDTA	0.8 M	1	3
28	1 & 2	80°C	4 hrs.	Nitric	5.6 N	6	3	4:1	4 hrs.	EDTA	0.8 M	1	3

[a] Silo samples are a 50:50 (w/w) blend of waste from Silos 1 and 2.
[b] Only one extractant was used on these samples.

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TABLE C.2-4

RCRA METALS

REMEDY SELECTION (ADVANCED PHASE) CHEMICAL EXTRACTION SOLIDS ANALYZED BY TCLP

Silo No.	Extractant	Arsenic µg/L[a]	Reduction %	Barium µg/L	Reduction %	Cadmium µg/L	Reduction %	Chromium µg/L	Reduction %	Lead µg/L	Reduction %
1	KCI/EDTA	0.2 U	0	4640	-434.6	2 U	100	10 U	100	2120	99.638
1	EDTA/HNO_3	0.2 U	0	2430	-180	2 U	100	31	47.458	677	99.886
2	KCI/EDTA	22.6 +	56.538	1530	36.567	2 U	100	10 U	100	997	99.75
2	EDTA/HNO_3	0.2 U	100	2070	14.179	2 U	100	10 U	100	108	99.973
TC Regulatory Limit (in the extract) 5000				100000		1000		5000		5000	

Silo No.	Extractant	Mercury µg/L	Reduction %	Selenium µg/L	Reduction %	Silver µg/L	Reduction %
1	KCI/EDTA	0.2 U	0	14.9	88.963	10 U	100
1	EDTA/HNO_3	0.2 U	0	28.8 S	78.667	10 U	100
2	KCI/EDTA	0.2 U	0	6.2	93.861	10 U	100
2	EDTA/HNO_3	19.4	-1.94	7.5	92.574	10 U	100
TC Regulatory Limit (in the extract) 200				1000		5000	

[a]Values expressed in micrograms per microgram per L (µg/L)
U - Analyte was analyzed for but not detected.
+ - Correlation coefficient for the Method of Standard Additions (MSA) is less than 0.955.
S - The reported value was determined by the MSA.

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process sample). The result was approximately one percent of the TC regulatory level. The apparent increases may be due to sample heterogeneity. Another possibility is that these metals were chemically altered during the chemical extraction process to make them more soluble. Even if a large fraction was removed by the chemical extraction process, the increased solubility of the metals remaining in the raffinate could give higher concentrations in the TCLP leachate.

Table C.2-5 presents the results of the radiological analysis of the TCLP leachate. This table also compares these results to the characterization TCLP data. The table shows that the leachate concentrations of most radionuclides were greatly reduced; however, the leachable concentrations of uranium and thorium were greatly increased in the KCl/EDTA residue from Silo 1.

Table C.2-6 presents the total radiological analysis of the residues. The table shows concentration increases for several of the radioisotopes, specifically, total thorium and total uranium. It is assumed that radionuclides which are not extracted are concentrated in the solids fraction by the removal of the more chelatable and more acid soluble substances. Also, elements that are detected by measurements that are influenced by self-absorption or self-attenuation can exhibit increased measured activity when the absorbent or attenuating materials are removed from the surface of the particle being measured, as for example, lead by EDTA extraction.

In addition, Table C.2-7 shows that the radionuclide concentrations of the raffinate from both of the KCl/EDTA extractions fell below 100 nanocuries per gram (nCi/g) of long-lived alpha-emitters while the raffinate from one of the Silo 1 EDTA/$HN0_3$ extractions did not.

C.2.5 ADDITIONAL TESTING

C.2.5.1 Homogeneity Tests

These tests indicated that the samples utilized for the treatability samples were acceptable.

C.2.5.2 Time and Temperature Studies

These tests compared extraction efficiencies based on analytical results for residual solids and the uranium, lead, and thorium concentrations in the spent extract. The lead analytical results indicated seven hours and 80°C (176°F) as the preferred time and temperature. Uranium results showed that increased time and elevated temperature were favored, but the differences between 50°C (122°F) and 80°C (176°F) were not apparent. Thorium results indicated no appreciable reduction under any of the

TABLE C.2-5

TCLP FOR RADIONUCLIDES
REMEDY SELECTION (ADVANCED PHASE) CHEMICAL EXTRACTION SOLIDS

		Ac-227 (pCi/L)		Pa-231 (pCi/L)		Pb-210 (pCi/L)		Po-210 (pCi/L)	
Silo No.	Extractant	Treat.	Charact.	Treat.	Charact.	Treat.	Charact.	Treat.	Charact.
1	KCI/EDTA	182	6454	<280		23300	946331	2240	125665
1	EDTA/HNO_3	46.7	6454	<857		25000	946331	2260	125665
2	KCI/EDTA	2920	3359	<1473		20200	139639	1660	23537
2	EDTA/HNO_3	5.87	3359	<631		1280	139639	266	23537

		Ra-226 (pCi/L)		Ra-228 (pCi/L)		Th-total (ug/L)		U-total (ug/L)	
Silo No.	Extractant	Treat.	Charact.	Treat.	Charact.	Treat.	Charact.	Treat.	Charact.
1	KCI/EDTA	1350	48974	<3.0	47	5750	62	5250	1740
1	EDTA/HNO_3	**	48974	**	47	9.05	62	82.9	1740
2	KCI/EDTA	1440	54138	11.5	14.8	<6950	95	4640	4803
2	EDTA/HNO_3	3650	54138	<3.0	14.8	2.87	95	69.1	4803

**Will not have results due to low yield.

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TABLE C.2-6

REMEDY SELECTION (ADVANCED PHASE)
RADIOLOGICAL ANALYSES - 80°C
TOTAL CONSTITUENT ANALYSES

ADVANCED PHASE CHEMICAL EXTRACTION SOLIDS RADIOLOGICAL ANALYSIS

Silo No.	Extractant	Characterization Ac-227 pCi/g[a]	Treatability Ac-227 pCi/g	Reduction %	Characterization Pa-231 pCi/g	Treatability Pa-231 pCi/g	Reduction %
1	KCI/EDTA	8142	5435	33.2474	ND	18640	ND
1	EDTA/HNO_3	8142	5561	31.6998	ND	16140	ND
2	KCI/EDTA	6443.9	3160	50.9614	ND	15350	ND
2	EDTA/HNO_3	6443.9	1948	69.7699	ND	9676	ND

Silo No.	Extractant	Characterization Pb-210 pCi/g	Treatability Pb-210 pCi/g	Reduction %	Characterization Po-210 pCi/g	Treatability Po-210 pCi/g	Reduction %
1	KCI/EDTA	194584.4	26750	86.2528	236533.3	3090	98.6936
1	EDTA/HNO_3	194584.4	55670	71.3903	236533.3	8890	96.2415
2	KCI/EDTA	110671.1	23690	78.5943	120966.7	7570	93.7421
2	EDTA/HNO_3	110671.1	15030	86.4193	120966.7	5620	95.3541

Silo No.	Extractant	Characterization Ra-228 pCi/g	Treatability Ra-228 pCi/g	Reduction %	Characterization Th-total µg/g[b]	Treatability Th-total µg/g	Reduction %
1	KCI/EDTA	ND	<38	ND	4352.1	5450	-25.227
1	EDTA/HNO_3	ND	<86	ND	4352.1	<19200	**
2	KCI/EDTA	ND	<67	ND	131.2	2520	-1820.7
2	EDTA/HNO_3	ND	<53	ND	131.2	141	-7.4695

Silo No.	Extractant	Characterization Ra-226 pCi/g	Treatability Ra-226 pCi/g	Reduction %	Characterization U-total µg/g	Treatability U-total µg/g	Reduction %
1	KCI/EDTA	501217.8	4518	99.0986	1778.6	921	48.2177
1	EDTA/HNO_3	501217.8	16270	96.7539	1778.6	451	74.643
2	KCI/EDTA	254256.7	9750	96.1653	1184	4125	-248.4
2	EDTA/HNO_3	254256.7	7393	97.0923	1184	1992	-68.243

[a]Values expressed in picocuries per gram (pCi/g).
[b]Values expressed in micrograms per gram (µg/g).

ND - No positive results were found: no calculation was performed.
** - Detection limit for treatability sample is higher than the characterization positive result.

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TABLE C.2-7

REMEDY SELECTION (ADVANCED PHASE)
CHEMICAL EXTRACTION SOLIDS TOTAL ACTIVITY OF
RADIONUCLIDES WITH HALF-LIVES GREATER THAN 20 YEARS[a]

Silo Number	Extractant	Total Activity (nCi/g)
1	KCl/EDTA	93
1	EDTA/HNO_3	224
2	KCl/EDTA	59
2	EDTA/HNO_3	36

[a] Composite samples.

test conditions.

C.2.5.3 Water Washing Studies

Several water washes proved necessary to remove residual EDTA and target compounds from the extracted solids. If the EDTA concentration was not sufficiently lowered on the residue, potentially high TCLP analytical results may occur due to the ability of EDTA to increase metals solubility. The results show that the lead and uranium concentrations were a nonlinear function of the number of washes. This phenomenon may be due to the more pH neutral water extracting the alkaline species from the solids, thus decreasing the pH of the solids to the point where the metals would become more soluble, or may be due to a noted decrease in the particle size of the solids, which increases the surface area extracted.

C.2.5.4 Vitrification of Spent Extractant

The extract from the advanced phase was dried in an oven as a pretreatment step for vitrification of the residual solids. Two approaches were used in the vitrification tests. In the first test, some of the spent HNO_3 extract and EDTA filtrate (derived from precipitation of the EDTA) from advanced phase tests were dried to residual solids, then mixed with site soil and vitrified. In the second test, the spent extractants were combined. The EDTA and metals were precipitated separately. The metals precipitate was collected, dried, calcined, blended with site flyash, and vitrified.

Table C.2-8 shows the MTCLP as defined in the Treatability Study Work Plan for Operable Unit 4 and Product Consistency Test (PCT) results from the vitrified extracts. The data show that both the Silos 1 and 2 samples vitrified with site flyash passed the MTCLP. The composite sample vitrified with site soil failed the MTCLP for lead and exhibited higher gross alpha and beta levels in the MTCLP leachate. In the PCT tests, the sample vitrified with site soil had over double the concentration of silicone [24.30 parts per million (ppm) vs 10.29 ppm and 7.99 ppm] than the two site flyash samples. In addition, the uranium concentration was almost four times greater in the site soil samples than in the site flyash samples. The MTCLP and PCT data for these screening tests indicate that a vitrified product can be made and that site flyash may be a better reagent that site soil. This does not necessarily indicate that site soil would not work, but that further testing is needed to identify the appropriate waste/glass and former/flux ratios.

TABLE C.2-8

REMEDY SELECTION (ADVANCED PHASE)
CHEMICAL EXTRACTION- VITRIFICATION

MTCLP

Origin	Sample	Ag (mg/l)	As (mg/l)	Ba (mg/l)	Cd (mg/l)	Cr (mg/l)	Pb (mg/l)	Se (mg/l)	G Alpha (dpm/4 cc)[a]	G Beta (dpm/4 cc)
Nalmet[b] 10504401	Silos 1 and Silo 2 + Site Soil	<0.02	<0.20	<0.066	<0.02	<0.015	31.5	<0.5	25	117
EDTA/HNO_3 10504102	Silo 2 + FA[c]	<0.02	<0.20	0.741	<0.02	<0.015	<0.25	<0.5	17	10
EDTA/HNO_3 10504101	Silo 1 + FA	<0.02	<0.20	1.09	<0.02	<0.015	<0.25	<0.5	NA	NA
Optional	Silo 1 + FA Silo 2 + FA	<.003	4.26	0.234	<0.005	0.198	2.36	0.337	NA	NA

PCT

Origin	Sample	Al (mg/l)	B (mg/l)	Ca (mg/l)	Fe (mg/l)	K (mg/l)	Li (mg/l)	Mg (mg/l)	Na (mg/l)	Si (mg/l)	Th (mg/l)	U (mg/l)	Gross Alpha (dpm/4cc)	Gross Beta (dpm/4cc)
Nalmet[b] 10504401	Silo 2 + Silo 1 + site soil	1.02	0.5	13.33	<0.10	12.0	<0.05	0.1	23.4	24.30	<0.5	0.11	4	0
EDTA/HNO_3 10504102	Silo 2 + FA	3.14	<1.50	2.13	<0.30	<3.0	<1.50	1.0	15.0	10.29	<0.5	0.03	4	0
EDTA/HNO_3 10504101	Silo 1 + FA	<0.50	0.5	9.79	<0.10	1.4	<0.50	1.5	9.80	7.99	<0.5	<0.02	0	4
Optional	Silo 1 + Silo 2 + FA	5.6	0.017	2.69	<0.003	11.2	N/A	0.175	19.8	13.6	<0.040	<0.14	7	4

[a]Values expressed as _____ (dpm/4cc)
[b]Reagents contained KCl/EDTA + EDTA/HNO_3 + Nalmet.
[c]Flyash

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C.2.5.5 Contaminant Removal From Spent Extractant - Preliminary Precipitation Stages 1 and 2

Several different chemical reagents and processing steps were investigated for their ability to remove the COCs. Key criteria include ease of separability and amount of contaminant remaining in the liquid phase after the separation step. The best of these reagents were then tested with larger samples. Free EDTA was recovered by acidification/precipitation/filtration process prior to the addition of other reagents to the spent extract. Some reagents were combined with another sequential precipitation step. Preliminary settling tests were also conducted during this stage to determine which reagent scheme would offer the lowest precipitate sludge volume. The best performances were provided by sulfide and Nalmet 8154. Because of the potential hydrogen sulfide problem encountered with sulfide, only the Nalmet was tested further.

Specifically, additional testing (Stage 2 precipitation tests) used treated EDTA/KCl composites plus 300 ppm of Fe^{3+} (iron), as well as HNO_3/H_2O (water) composites plus 250 ppm of Fe^{3+}. Results of the first set of 21 tests showed that the HNO_3/H_2O composite plus 250 ppm of Fe^{3+} could be treated with calcium hydroxide to pH 9 and produce a fast-settling, easily-filtered sludge, while reducing lead and uranium to less than 1 ppm each. In contrast, the treated EDTA/KCl composite plus 300 ppm of Fe^{3+} (treated to remove EDTA) proved more difficult to treat with respect to Pb removal. A second set of tests focused on the treatment of the treated EDTA/KCl composite. In addition, two other feeds were tested: a 30 percent HNO_3, 70 percent KCL/EDTA w/w blend of the composite with 300 ppm of Fe^{3+}, and the same blend without Fe^{3+}. The process was most effective when Fe^{3+} was added. These experiments are listed in Table C.2-9. The precipitated EDTA contained radium, lead, and uranium (other constituents may have been present but were not analyzed). In the Remedy Selection (optional phase) study, most of the metals were precipitated by adding Nalmet 8154 prior to precipitation of EDTA. This modification of the process proved successful at significantly reducing the contamination of EDTA and producing a spent extractant which had low concentrations of radionuclides and RCRA metals. See Appendix H for more details.

C.2.5.6 Settling Tests

The Stage 2 precipitation tests were performed not only to confirm the most promising treatment processes, but also to obtain range finding information about relative settling rates of various treatments. In addition to the small scale settling tests, a larger scale settling test was performed while preparing precipitated solids for vitrification and stabilization tests. The settling rate for the Nalmet 8154 sludge is plotted with time in Figure C.2-5. This settling rate should be sufficient for standard settling equipment.

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TABLE C.2-9

STAGE 2 PRECIPITATION TEST RESULTS

Feed	Treatment	pH	Lead (ppm)	Uranium (ppm)
Treated EDTA/KCl Composite +300 ppm Fe^{3+}	3.64% (wt) (Na^3PO^4 - 12 H_20), followed by pH adjustment with NaOH	8.9	55.2	0.33
Treated EDTA/KCl Composite +300 ppm Fe^{3+}	3.64% (wt) (Na^3PO^4 - 12 H_20), followed by pH adjustment with Ca(OH)2	8.9	8.03	ND
Treated EDTA/KCl Composite +300 ppm Fe^{3+}	0.82% (wt) Na_2S added to liquid, after adjustment to pH 9 with NaOH	9.1	<0.5	0.23
Treated EDTA/KCl Composite +300 ppm Fe^{3+}	0.62% (wt) Nalmet 8154 added to liquid, after adjustment to pH 3 with NaOH	6.2	<0.5	0.17
Treated EDTA/KCl Composite +300 ppm Fe^{3+}	0.12% (wt) Nalmet 8154 added to liquid, after adjustment to pH 3 with NaOH	6.4	90.8	0.14
Treated EDTA/KCl + HNO_3 Composite +300 ppm Fe^{3+}	0.82% (wt) Na_2S added to liquid, after adjustment to pH 9 with NaOH	9.3	<0.5	4.9
Treated EDTA/KCl + HNO_3 Composite +300 ppm Fe^{3+}	0.62% (wt) Nalmet 8154 added to liquid, after adjustment to pH 3 with NaOH	5	<0.5	0.55
Treated EDTA/KCl + HNO_3 Composite without Fe^{3+}	0.62% (wt) Nalmet 8154 added to liquid, after adjustment to pH 3 with NaOH	4.7	16.2	0.31

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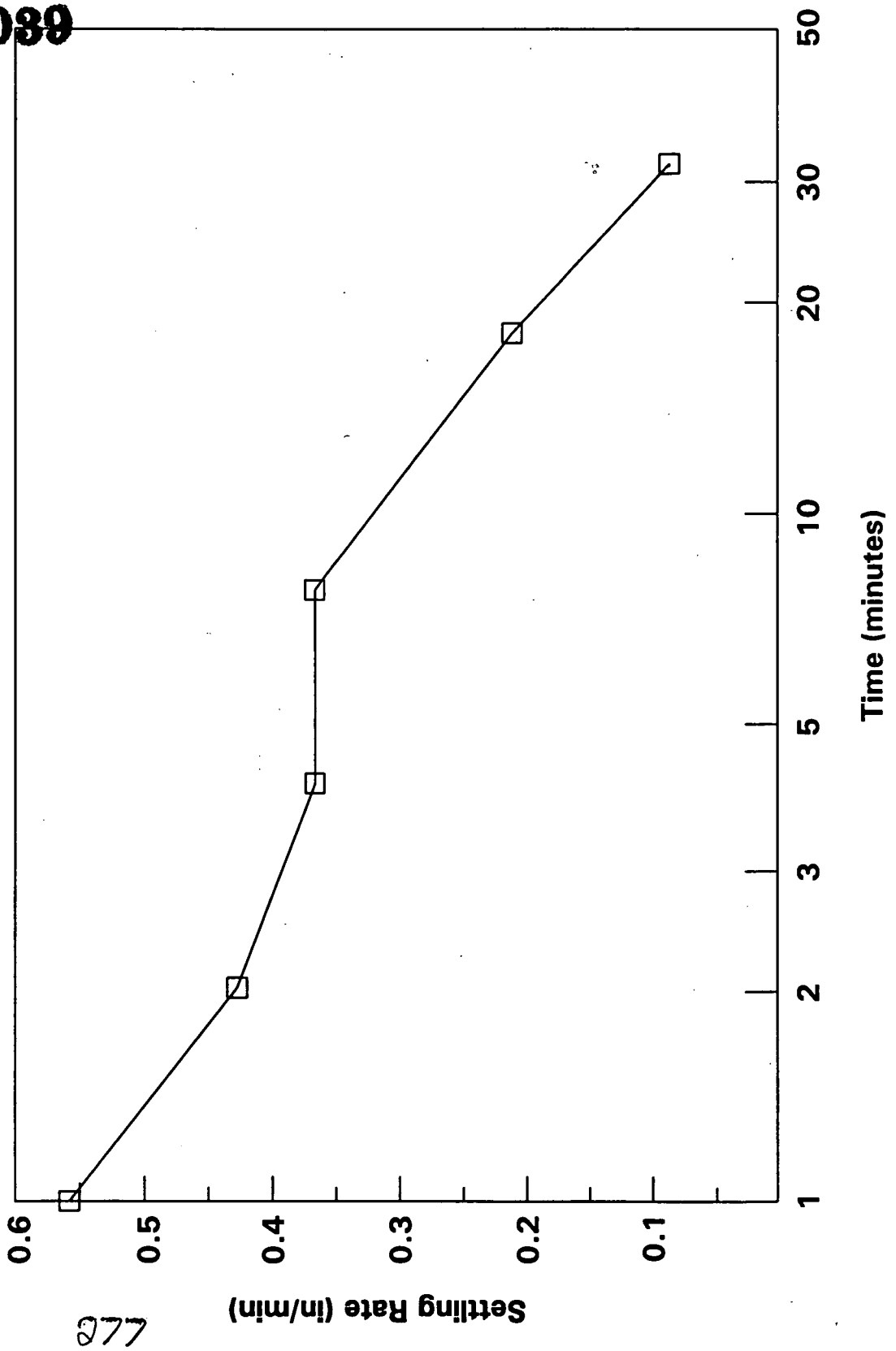

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FIGURE C.2-5 SETTLING RATE OF NALMET SLUDGE

Small aliquots of the Nalmet sludge were also tested with Nalco cationic, anionic, and nonionic organic polymers. The polymers were used to improve settling rates and decrease the Nalmet sludge volume; however, there were no apparent improvements resulting from any of the polymer treatments. Therefore, further testing with polymers was stopped.

C.2.5.7 Cement Stabilization

Precipitate from the previously described precipitation experiments were stabilized with preselected cement stabilization reagents found in Table C.2-10. Samples based on the two formulas were made, then subjected to performance analysis. The UCS for the first formulation was 381 psi and 372 psi for each of the two specimens. The UCS on the second formulation was 1165 psi. It is suspected that the cement was not fully hydrated in first sample. In the second sample, water was mixed with cement before it was added to the waste and other reagents. The analytical data showed that the only detectable RCRA metal was barium at a low level; uranium was nondetectable.

C.2.5.8 Chemical Extraction Process Material Balance

Some of the various waste streams generated as a result of the chemical extraction and subsequent vitrification tests were analyzed in order to track radium, uranium, and lead through the various processes. The composite feed material and the vitrified product were not analyzed for total content. However, with the results gained from the analyses of the other streams, it was possible to perform a mass balance to determine the composition of the feed and vitrified product with respect to radium, uranium, and lead. The results of the analyses and mass balance is given in Figure C.2-6.

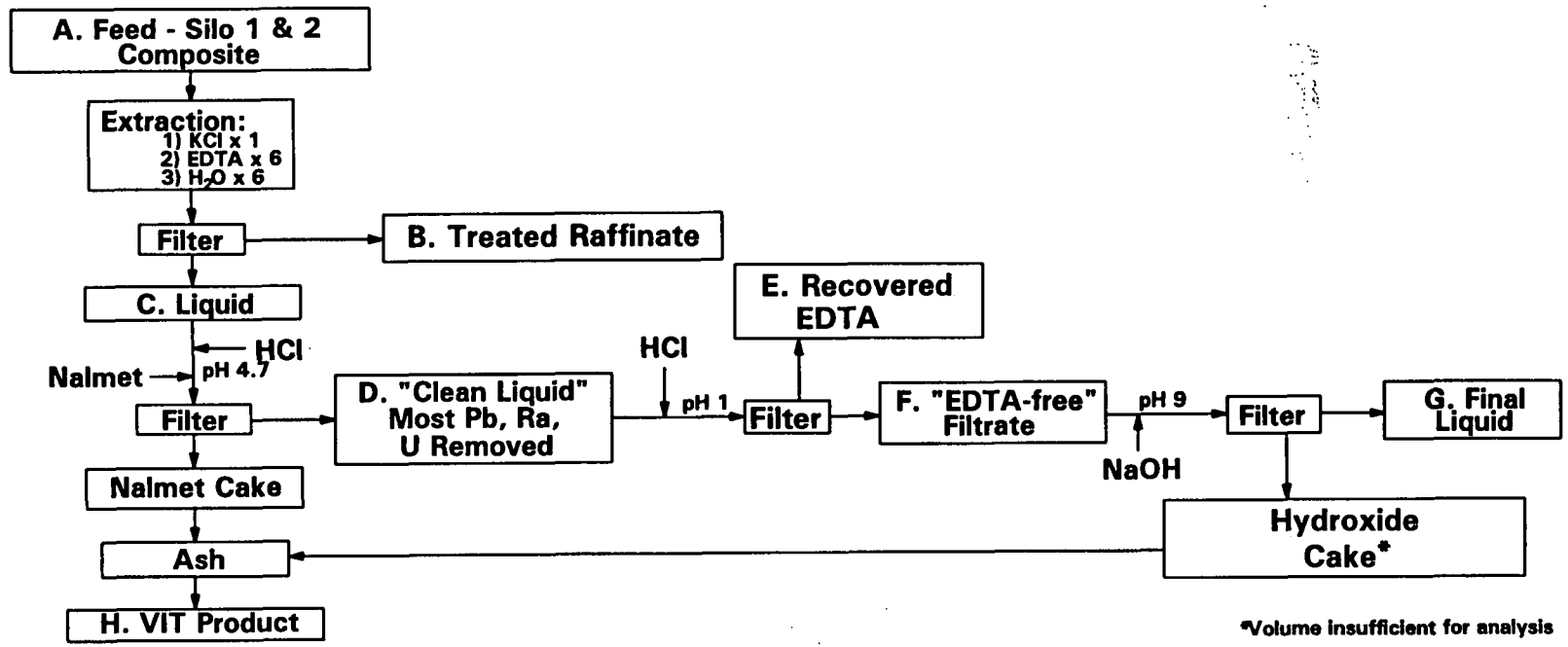
The material balance for radium indicates that more than 99.9 percent of the radium in the feed was extracted, precipitated by the Nalmet, and vitrified. The treated raffinate and clean liquid retained about 0.003 and 0.46 percent of the radium, respectively. The EDTA filter cake contained approximately 0.004 percent of the radium.

The results for lead were similar to those for radium. The material balance indicates that more than 99 percent of the lead was extracted, precipitated by the Nalmet, and vitrified. The treated raffinate retained 0.773 percent of the lead. The EDTA filter cake and the final liquid contained approximately 0.016 percent and 0.052 percent of the lead, respectively.

TABLE C.2-10

CEMENT STABILIZATION OF PRECIPITATE

Run No.	Waste Precipitate (g)	Type II Cement (g)	Blast Furnace Slag (g)	Type F Flyash (g)	Clinoptilolite (g)	Water (g)
1	100	53	31	15	5	61
2	70	42	21.7	13	7	20



*Volume insufficient for analysis

	A	B	C	D	E	F	G	H
	Silo 1 and 2 Composite	Raffinate	EDTA/KCl Composite	Liquid after Nalmet	EDTA Filter Cake	Liquid after EDTA removed	Final Treated Liquid	Vitrified Product
Sample wt. (Kg)	0.750	0.382	23.2	21.7	3.56	19.3	18.4	0.154
Lead**								
mg/kg	59885	909	1921	1.52	2.00	1.17	1.26	289201
total mg	44914	347	44567	33.0	7.12	22.6	23.2	44537
% of total	100	0.773	99.2	0.073	0.016	0.050	0.052	99.2
Uranium***								
mg/kg	909	1251	8.81	5.93	8.20	5.29	0.025	0.004
total mg	682	478	204	129	29.2	102	0.460	175
% of total	100	70.0	30.0	18.9	4.28	15.0	0.067	25.6
Radium 226								
pCi/L	139166746 (Kg)	7580	4500000	22300	1110 (pCi/Kg)	1380	2440	597180 (pCi/Kg)
pCi	104402893	2893	104400000	483910	3952	26634	44896	104351152.0
% of total	100	0.003	99.997	0.464	0.004	0.026	0.043	99.950

** Lead was analyzed by ICP at ETDC
*** Uranium was analyzed by Ion Chromatography at ETDC

FIGURE C.2-6 CHEMICAL EXTRACTION/OPTIONAL PHASE PROCESS MATERIAL BALANCE

The results for uranium in the vitrified product indicate the chemical extraction process was not as effective as for the lead and radium. Of the total uranium in the feed stream, approximately 25 percent ended up in the vitrified product. Seventy percent of the uranium from the feed was not extracted and, therefore, remained in the raffinate. The uranium in the final liquid was reduced to approximately 0.067 percent of the feed or 0.025 milligrams per kilogram (mg/kg).

These results indicate that the existing chemical extraction process is very effective in separating lead and radium from the feed, but not very effective in separating the uranium. The final liquid retained 0.04 percent of the radium, 0.05 percent of the lead, and 0.067 percent of the uranium at concentrations that would allow the liquid to be recycled or polished via ion exchange prior to release.

The chemical extraction process for cement stabilization is identical to the chemical extraction process for vitrification depicted in Figure C.2-6, with the exception that, in the cement stabilization process, the Nalmet cake and the hydroxide cake are not ashed before cement stabilization of the product.

C.2.6 CONCLUSIONS

From the preceding testing, it is evident that the chemical extraction process is technically feasible. This process can be used to extract high activity material from the bulk of the waste stream. This could be accomplished by chemically extracting radioactive and hazardous constituents from the silo material with EDTA. The extracted solids would be rinsed with water and dewatered.

The combined extracts would be treated to recover EDTA and to remove the hazardous and radioactive constituents in three stages. First, the extracted hazardous and radioactive constituents would be precipitated by adding Nalmet 8154. Most of the uranium and remaining metals would be precipitated by pH adjustment of the stream. The combined Nalmet and hydroxide filter cakes would be dewatered, dried, and vitrified to give a resulting product that would be approximately 10 percent of the weight of the original untreated silo material. See Figure C.2-6 for a simplified conceptual illustration of this process.

C.3.0 VITRIFICATION TREATABILITY STUDY -5039

C.3.1 INTRODUCTION

Vitrification treatability tests were carried out in support of the Operable Unit 4 RI/FS process currently underway at the FEMP site. The tests were completed as specified by the EPA approved Operable Unit 4 Treatability Study Work Plan for the Vitrification of Residues from Silos 1, 2, and 3 (DOEb 1992). The purpose of these tests was to allow the performance of vitrification of the Silos 1, 2, and 3 residues to be compared to other remediation technologies for the silo residues. The criteria upon which this comparison was to be based were the leachability of the waste form, the waste volume reduction achieved, and the reduction in radon emanation from the waste.

C.3.2 DESCRIPTION OF REMEDIAL TECHNOLOGY

Vitrification is a versatile process that transforms waste solutions, slurries, moist powders, and/or dry solids into a chemically durable glass form. The feed used in the process can be either combustible or noncombustible. Organics are decomposed and oxidized in the melter plenum while the inorganic residue melts into a molten glass pool. The hazardous inorganic constituents actually become part of the chemical structure of the glass matrix, not merely encapsulated in the waste form. As a result, the glass waste form will pass the TCLP as nonhazardous.

The technology was first adapted by Pacific Northwest Laboratories (PNL) for the U. S. Department of Energy (DOE) complex to transform highly radioactive wastes into a chemically durable glass solid. Reliable equipment and techniques were developed to permit processing of these hazardous wastes essentially without maintenance because the high radiation fields precluded human access to the waste and equipment. Thousands of hours of operating experience in several countries using simulated and radioactive feed have demonstrated the reliability of the ceramic melter for waste processing (Chapman and McElroy 1989). Application of this technology to a variety of other waste streams is being actively pursued.

C.3.2.1 Treatment Process and Scale

The heart of the vitrification system is the melter, a refractory-lined cavity with submerged electrodes. After preheating the cavity and the initial charge, the melt becomes electrically conductive. With an alternating current placed between pairs of electrodes, the molten glass is self-heated. The waste material is mixed with chemical additives as required to achieve suitable product durability or processability. The waste is fed onto the surface of the melt, and molten glass is

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continuously removed from the melt cavity. The molten glass can be cast into monolithic shapes, formed into smaller shapes, or quenched to a frit. Off-gases containing particulates and other pollutants are removed and treated using conventional air pollution control equipment. Recycling this stream minimizes secondary wastes.

The scale of operations for the ceramic melter can range from one to hundreds of tons per day (TPD). Pilot-scale systems at the treatability laboratory can process from hundreds of pounds to several TPD. These systems have demonstrated processing of slurry and dry feed solid inorganic wastes. Although larger systems have yet to be demonstrated for hazardous waste processing, experience within the commercial glass industry demonstrates that it is feasible to process on a scale of hundreds of TPD. The throughput of a given melter will depend on both the feed used and the method of feeding. The conceptual design for the Operable Unit 4 treatment system included a 15 TPD melter with a slurry feed. This same melter with dry feeding could process as much as 60 TPD.

C.3.2.2 Operating Features

The ceramic melter has several features that benefit waste processing. First is the capability to handle a large variety of waste forms. Wastes can be solid, slurry, or liquid. They can be combustible, noncombustible, or a mixture of both. The melter design will remain the same with modification required only in the feed, and possibly the off-gas system.

Second, the melter is useful for treating mixtures of organic and inorganic wastes. The organic contaminants are thermally destroyed at the high processing temperatures [up to 1500°C (2732°F)], while the inorganic contaminants are incorporated into the molten glass. As previously stated, the inorganic contaminants become a part of the chemical structure of the glass; thus, the entire glass structure must be destroyed for the hazardous constituents to be removed from the vitrified waste.

Third, the ceramic melter has a large volume with a corresponding long residence time for the waste glass. This is significant in terms of the consistency of the glass product and the ability to handle variations in the waste stream. Since the residence time of the glass in the melter can range from several hours to several days, variations in the feed stream composition are averaged over a period of days, and the resulting glass product remains very homogeneous with much smaller chemical variation than is present in the feed.

Fourth, secondary streams can be minimized by recycling the streams to the melter. Particulate carryover from the melter can be removed from the off-gas stream and returned to the melter for processing.

Finally, the vitrification process typically will produce a waste form, that is only a fraction of the volume of the initial waste volume. This volume reduction ranges from 50 percent to 70 percent for soils and inorganic wastes to 99 percent or greater for combustible solids. The reduced volume and the nonleaching characteristic of glass are benefits of the vitrification treatment process.

C.3.3 LABORATORY SCREENING TESTS [REMEDY SCREENING (PRELIMINARY PHASE) TESTS

The treatability laboratory received samples of K-65 material from Zones A, B, and C of Silos 1 and 2, as well as samples of a composite material from all zones of Silo 3. A sample of BentoGrout, present in Silos 1 and 2 as a cap over the material to reduce radon emanation, was also received for use in the treatability testing.

Laboratory screening tests included characterization of the physical and chemical properties of the untreated Silo 3 material and the untreated K-65 material (Silos 1 and 2) from each zone. The main purpose of these tests was to provide information to assist in developing appropriate glass formulas for the bench-scale tests. Additionally, data from the laboratory screening tests were used in calculating the volume reduction and reduction in radon emanation between the untreated and the treated material.

The measured physical properties determined in the screening tests are reported in Tables C.3-1 and C.3-2.

Table C.3-2 reports the measured radon emanation rates for the untreated K-65 material. The most useful basis for the measurements made in these tests is the mass of dry material, since in the absence of other effects, the radon emanation should be proportional to the amount of radium in the sample. The emanation rate based on the area of the sample surface or the absolute rate of picocurie/hour (pCi/hr) is useful only for comparison among measurements made on identical amounts of material in identical geometric arrangements. The value of most significance in Table C.3-2 is, therefore, the specific emanation rate based upon grams of dry material.

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TABLE C.3-1

PHYSICAL PROPERTIES OF THE UNTREATED K-65 AND SILO 3 MATERIAL

	Silo 1	Silo 2	Silo 3				
Physical Properties	Zone A	Zone B	Zone C	Zone A	Zone B	Zone C	Zones ABC
Moisture content (%)	26.9	35.3	35.9	27.8	35.6	29.7	4.8
Bulk density (g/cm^3)[a]							
Wet, compacted	1.81	1.67	1.70	1.87	1.71	1.92	0.92
Crushed dry, settled	1.00	0.91	0.90	1.16	0.92	1.13	0.88
Specific gravity	2.79	2.77	2.74	2.72	2.57	2.81	2.86

[a]Values expressed in grams per cubic centimeter (g/cm^3).

TABLE C.3-2

RADON EMANATION FROM UNTREATED K-65 MATERIAL

Sample	pCi/hr	$pCi/m^2/s$[a]	pCi/g/hr[b]
Silo 1A	78,311	2683	525
Silo 1B	198,126	6788	1457
Silo 1C	213,466	7314	1711
Silo 2A	61,360	2102	416
Silo 2B	171,629	5880	1297
Silo 2C	57,933	1985	533

[a]Values expressed in picocuries per square meter per second ($pCi/m^2/s$).
[b]Values expressed in picocuries per gram per hour (pCi/g/hr).

Variation in the measured emanation rate per unit mass among the different samples does not correlate with differences in radium content. A possible cause of the observed variations is the different moisture contents in each zone.

Chemical/Radiochemical Analysis

The inorganic composition of the Silos 1, 2, and 3 material, as determined in the screening tests, is presented in Tables C.3-3 to C.3-5. The elemental composition was determined by Inductively Coupled Plasma (ICP) unless otherwise noted. The oxidation state assumed for each of the oxides is given by the oxide formula in the tables. The composition of the material from each zone of Silos 1 and 2 was measured along with the material from Silo 3. Additionally, data are presented for a composite sample from both Silos 1 and 2 made from equal dry masses of material from the different zones within each silo. The tables also report both the average and the range of the measurements within each silo.

The isotopic analysis of the silo materials was performed using gamma energy analysis. Results are presented in Tables C.3-6 to C.3-8. The fact that many isotopes were below detection limits can be attributed to the isotopes' presence in only very small amounts, their lack of significant gamma emissions, or the obscurance of their emission peaks by interferences. Accurate and quantitative measurements of all the isotopes requested would require analytical techniques which were beyond the scope of these screening studies. The gamma energy analysis was successful in determining the isotopes present in the most significant amounts.

The composition of the Silo 1 material was essentially uniform throughout all three zones, while variability in the composition of the different zones of Silo 2 was observed for several components (lead, iron, and barium). Variability in composition between Silos 1 and 2 was also observed, with the Silo 2 material lower in lead and barium and higher in iron and calcium. Nevertheless, the material from all zones was sufficiently similar to allow combination into a single mixture for use in the treatability tests.

C.3.4 BENCH-SCALE VITRIFICATION TESTS [REMEDY SELECTION (ADVANCED PHASE) TESTS]

The material from each zone of Silos 1 and 2 was combined into a single mixture for use in the bench-scale vitrification tests. Four different combinations of wastes were investigated. Sequence A considered the K-65 material alone; Sequence B investigated a 50:50 mixture by dry weight of the

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TABLE C.3-3

INORGANIC COMPOSITION OF SILO 1 SAMPLES (Dry Weight %)

Component in Waste	Notes	Zone A	Zone B	Zone C	Composite	Average A, B, C	Range A, B, C
SiO_2		52	48	48	49	50	48 - 52
PbO		10	13	13	13	12	10 - 13
BaO		6.0	6.1	6.8	6.3	6.3	6.0 - 6.8
CO_2	a	1.4	3.5	4.6	NA	3.2	1.4 - 4.6
Al_2O_3		2.6	2.7	2.6	2.6	2.6	2.6 - 2.7
Fe_2O_3		2.7	2.3	2.4	2.6	2.5	2.3 - 2.7
SO_3	b	1.9	1.8	1.6	NA	1.8	1.7 - 1.9
Na_2O		1.0	2.2	2.2	1.8	1.8	1.0 - 2.2
MgO		1.2	1.2	1.1	1.2	1.2	1.1 - 1.2
P_2O_5		0.93	0.46	0.48	0.65	0.62	0.46 - .93
K_2O		0.72	0.72	0.60	0.60	0.68	0.60 - .72
MoO_2		0.69	0.27	0.34	0.47	0.43	0.27 - .69
CaO		0.62	0.28	0.22	0.45	0.37	0.22 - .62
La_2O_3		0.65	0.31	0.29	0.41	0.42	0.29 - .65
NiO		0.29	0.51	0.45	0.41	0.42	0.29 - .51
Ce_2O_3		0.64	0.32	0.27	0.35	0.41	0.27 - .64
N_2O_5	c	0.23	0.42	0.21	0.24	0.29	0.21 - .42
TiO_2		0.35	0.24	0.25	0.28	0.28	0.24 - .35
Nd_2O_3		0.30	0.15	0.13	0.20	0.19	0.13 - .30
CoO		0.17	0.22	0.19	0.18	0.19	0.17 - .22
SrO		0.075	0.089	0.084	0.081	0.082	0.07 - .09
Cl	c	0.062	0.10	0.076	0.072	0.079	0.06 - .10
V_2O_3		0.064	0.063	0.057	0.060	0.061	0.06 - .06
CuO		0.053	0.063	0.055	0.052	0.057	0.05 - .06
ZrO_2		0.059	0.036	0.058	0.047	0.051	0.04 - .06
SeO_2		0.035	0.056	0.049	0.042	0.047	0.04 - .06
Cr_2O_3		0.029	0.015	0.015	0.022	0.019	0.01 - .03
MnO		0.016	0.012	0.014	0.014	0.014	0.01 - .02

TABLE C.3-3
(Continued)

Component in Waste	Notes	Zone A	Zone B	Zone C	Composite	Average A, B, C	Range A, B, C
BeO		0.0056	0.0069	0.0056	0.0056	0.0060	0.01 - .02
F	c	0.0035	0.0070	0.0040	0.0040	0.0048	0.00 - .01
As_2O_3		ND	ND	ND	ND	ND	--
CdO		ND	ND	ND	ND	ND	--
SnO_2		ND	ND	ND	ND	ND	--
ThO_2		ND	ND	ND	ND	ND	--
UO_2		ND	ND	ND	ND	ND	--
ZnO		ND	ND	ND	ND	ND	--
Total		85	86	86	81	86	--

[a]Determined from the difference between total carbon and total organic carbon, expressed as carbonate.
[b]Sulfate was determined as total sulfur using ICP and expressed as sulfate.
[c]Determined by IC on a leachate from the sample leached in distilled water.
NA - signifies "not analyzed."
ND - indicates less than detection limits. ICP results are valid to a maximum of 2 significant figures. Typical precision is ±10%.

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TABLE C.3-4

INORGANIC COMPOSITION OF SILO 2 SAMPLES (Dry Weight%)

Component in waste	Notes	Zone A	Zone B	Zone C	Composite	Average A, B, C	Range A, B, C
SiO_2		49	57	46	58	51	46 - 57
PbO		4.9	7.2	6.4	6.6	6.2	4.9 - 7.2
Fe_2O_3		8.4	3.4	6.4	5.8	6.1	3.4 - 8.4
Al_2O_3		3.7	3.2	3.2	3.4	3.4	3.2 - 3.7
CO_2	a	3.3	3.5	3.3	NA	3.4	3.3 - 3.5
BaO		1.5	3.7	3.8	3.1	3.0	1.5 - 3.8
CaO		3.1	2.2	2.2	2.7	2.5	2.2 - 3.1
MgO		2.3	1.1	1.6	1.7	1.7	1.1 - 2.3
SO_3	b	1.4	0.87	2.7	NA	1.7	0.87 - 2.8
Na_2O		0.61	0.98	1.0	0.93	0.88	0.61 - 1.0
K_2O		0.72	0.60	0.72	0.84	0.68	0.60 - 0.72
P_2O_5		0.70	0.73	0.61	0.68	0.68	0.61 - 0.73
N_2O_5	c	0.66	0.63	0.57	0.67	0.62	0.57 - 0.66
UO_2		0.45	0.51	0.45	0.51	0.47	0.45 - 0.51
NiO		0.31	0.46	0.33	0.38	0.36	0.31 - 0.46
TiO_2		0.36	0.30	0.32	0.36	0.33	0.30 - 0.36
Ce_2O_3		0.31	0.40	0.29	0.35	0.33	0.29 - 0.40
La_2O_3		0.27	0.36	0.23	0.30	0.29	0.23 - 0.36
ZrO_2		0.12	0.12	0.18	0.28	0.14	0.12 - 0.18
Nd_2O_3		0.16	0.19	0.13	0.23	0.16	0.13 - 0.19
CoO		0.18	0.25	0.20	0.22	0.21	0.18 - 0.25
CuO		0.068	0.084	0.10	0.083	0.084	0.07 - 0.10
Cr_2O_3		0.120	0.037	0.10	0.080	0.083	0.04 - 0.12
MoO_2		0.040	0.120	0.079	0.077	0.080	0.04 - 0.12
SrO		0.035	0.078	0.072	0.064	0.062	0.03 - 0.08
As_2O_3		0.033	0.033	0.079	0.053	0.048	0.03 - 0.08
SeO_2		0.042	0.042	0.042	0.042	0.042	0.04 - 0.04
MnO		0.031	0.030	0.036	0.035	0.032	0.03 - 0.04

TABLE C.3-4
(Continued)

Component in waste	Notes	Zone A	Zone B	Zone C	Composite	Average A, B, C	Range A, B, C
V_2O_3		0.078	0.077	0.088	0.022	0.081	0.08 - 0.09
ZnO		0.011	0.011	0.012	0.017	0.011	0.01 - 0.01
Cl	c	0.0080	0.0030	0.0030	0.0040	0.0047	0.00 - 0.01
F	c	0.0030	0.0050	0.0050	0.0040	0.0043	0.00 - 0.01
BeO		ND	ND	ND	ND	ND	ND
CdO		ND	ND	ND	ND	ND	ND
SnO_2		ND	ND	ND	ND	ND	ND
ThO_2		ND	ND	ND	ND	ND	ND
Total		83	88	81	87	84	

[a]Determined from the difference between total carbon and total organic carbon, expressed as carbonate.
[b]Sulfate was determined as total sulfur using ICP and expressed as sulfate.
[c]Determined by IC on a leachate from the sample leached in distilled water.
NA - signifies "not analyzed."
ND - indicates less than detection limits. ICP results are valid to a maximum of 2 significant figures. Typical precision is $\pm 10\%$.

TABLE C.3-5

INORGANIC COMPOSITION OF SILO 3 SAMPLES (DRY Weight %) -5039

Component in Waste	Notes	Sample #1	Sample #2	Sample #3	Sample #4	Average #1 - #4	Range #1 - #4
SO_4	a	15	15	15	15	15	NA
SiO_2		14	13	13	16	14	13 - 16
MgO		11	9.6	9.9	10	10	9.6 - 11
P_2O_5		10	8.4	9.5	9.2	9.3	8.4 - 10
Fe_2O_3		8.0	8.1	7.5	8.6	8.0	7.5 - 8.6
N_2O5		6.0	6.1	6.3	6.1	6.1	6.0 - 6.3
NA_2O	b	NA	5.9	5.7	6.2	5.9	5.7 - 6.2
CaO		5.2	4.1	5.0	4.5	4.7	4.1 - 5.2
Al_2O_3		4.3	5.8	4.6	6.4	5.3	4.4 - 6.4
CO_2	a	1.9	1.9	1.9	1.9	1.9	NA
K_2O		1.8	2.3	1.8	1.2	1.8	1.2 - 2.3
MnO		0.65	0.70	0.62	0.72	0.67	0.62 - 0.72
Li_2O		0.45	0.51	0.46	NA	0.47	0.45 - 0.51
NiO		0.47	0.57	0.43	0.59	0.52	0.43 - 0.59
V_2O_3		0.35	0.65	0.36	0.64	0.50	0.35 - 0.65
ThO_2		0.34	0.34	0.34	0.23	0.31	0.23 - 0.34
UO_2		0.23	0.34	0.34	0.45	0.34	0.23 - 0.45
CuO		0.36	0.46	0.34	0.46	0.41	0.34 - 0.46
CoO		0.36	0.36	0.32	0.39	0.36	0.32 - 0.39
As_2O_3		0.18	0.33	0.23	0.40	0.29	0.18 - 0.40
TiO_2		0.25	0.21	0.22	0.21	0.22	0.21 - 0.25
PbO		0.18	0.21	0.16	0.22	0.19	0.16 - 0.22
MoO_2		0.15	0.22	0.12	0.23	0.18	0.12 - 0.23
F		0.077	0.090	0.10	0.053	0.079	0.05 - 0.10
Cr_2O_3		0.086	0.089	0.075	0.082	0.083	0.08 - 0.09
ZnO		0.059	0.069	0.055	0.082	0.066	0.06 - 0.08
BaO		0.037	0.030	0.036	0.028	0.033	0.03 - 0.04
Y_2O_3		0.036	0.044	0.036	NA	0.039	0.04 - 0.04

TABLE C.3-5
(Continued)

Component in Waste	Notes	Sample #1	Sample #2	Sample #3	Sample #4	Average #1 - #4	Range #1 - #4
SrO		0.025	0.028	0.024	0.028	0.026	0.02 - 0.03
ZrO_2	b	NA	0.018	0.020	0.014	0.017	0.01 - 0.02
Cl		0.013	0.021	0.017	0.013	0.016	0.01 - 0.02
Ce_2O_3		0.0000	0.023	0.012	0.035	0.018	0.00 - 0.04
La_2O_3		0.0082	0.010	0.0088	0.018	0.011	0.01 - 0.02
Nd_2O_3		ND	0.012	0.0082	0.017	0.0124	0.00 - 0.02
BeO		ND	0.0056	0.0056	0.0069	0.0060	0.00 - 0.01
CdO		0.0011	0.0043	0.0046	0.0074	0.0044	0.00 - 0.01
SeO_2		NA	NA	NA	0.028	0.028	NA
SnO_2		NA	NA	NA	ND	ND	NA
Total		81	85	84	90	87	NA

[a]Sulfate and carbonate were determined from a single sample separate from these analyses.
[b]Only the NA_2O_2 fusion was performed, so values for NA and Zr could not be obtained.

NA - signifies "not analyzed."
ND - indicates less than detection limits. ICP results are valid to a maximum of 2 significant figures. Typical precision is $\pm 10\%$.

TABLE C.3-6

ISOTOPIC CONTENT OF SILO 1 MATERIAL[a]

Isotope	Zone A	Zone B	Zone C	Average	Composite
Bi-214	368	414	441	408	439
Pb-214	368	414	438	407	437
Ra-226	368	414	441	408	439
Pb-210	212	327	316	285	292
Th-230	45	69	ND	38	54
Pb-211	18	14	19	17	19
Ra-223	15	16	16	15	14
Rn-219	14	12	15	14	15

[a]Values expressed in nanocuries per gram (nCi/g)

Isotopes other than those listed are likely to be present.

ND - signifies isotope was not detected; additionally, Ac-227, Po-210, Ra-228, Th-228, and U-234 were not detected.

TABLE C.3-7

ISOTOPIC CONTENT OF SILO 2 MATERIAL[a]

Isotope	Zone A	Zone B	Zone C	Average	Composite
Bi-214	176	259	242	226	230
Ra-226	176	259	242	226	230
Pb-214	178	253	246	226	229
Pb-210	182	236	247	222	233
Th-230	184	25	35	81	32
Ra-223	7	10	8	8	8
Rn-219	5	9	8	7	7
Pb-211	Unresolved	8	8	8	7

[a]Values expressed in nanocuries per gram (nCi/g).
Isotopes other than those listed are likely to be present.
ND - signifies isotope was not detected; additionally, Ac-227, Po-210, Ra-228, Th-228, and U-234 were not detected.
"Unresolved" - indicates the isotope was present, but could not be resolved due to interferences.

TABLE C.3-8

ISOTOPIC CONTENT OF SILO 3 MATERIAL[a]

Isotope	Sample #1	Sample #2	Sample #3	Sample #4
Th-230	51.0	64.5	51.3	142.0
U-238	2.7	1.3	2.3	ND
Pb-210	1.8	3.0	2.1	9.8
Pb-214	1.0	1.1	1.1	4.6
Ra-226	0.8	0.8	0.9	4.7
Bi-214	0.8	0.8	0.9	4.7
Pb-211	0.6	0.6	Unresolved	ND
Ra-223	0.5	0.7	0.4	Unresolved
Pa-231	0.5	1.0	0.7	ND
Ra-224	0.4	0.3	0.4	0.4
Th-232	0.3	0.3	0.3	0.3
Rn-219	ND	ND	ND	0.7
U-235	Unresolved	Unresolved	Unresolved	Unresolved

[a]Values expressed in nanocuries per gram (nCi/g).

Isotopes other than those listed are likely to be present.

ND - signifies isotope was not detected; additionally, Ac-227, Po-210, Ra-228, Th-228, and U-234 were not detected.

"Unresolved" - indicates the isotope was present, but could not be resolved due to interferences.

K-65 material and BentoGrout; Sequence C consisted of the Silo 3 material alone; and Sequence D considered a 70:30 mixture by dry weight of the K-65 and Silo 3 material, respectively. The four sequences represent potential waste compositions expected from various retrieval options.

Screening melts of about 100 g (.22lb) each were carried out to investigate different glass formulas (waste plus additives) for each sequence. Two of the screening melts performed for each sequence were tested by the TCLP to verify the durability of the formulas. Eight bench-scale melts of approximately 1000 g (2.2lb) each were then performed using the glass formulas chosen for each of the sequences. Two melts of each sequence were performed using an open system and then a closed system; the radon released during vitrification was measured during the closed system test from each sequence. Table C.3-9 summarizes the vitrification tests.

Glass Formulation Data

Table C.3-10 reports the formulation data for each open system and closed system test for each sequence. The mass of material as well as the measured moisture content of all components of the formulas are reported. Additionally, various masses are reported. The total dry weight is the mass of dry material before vitrification. The total glass is the measured mass of material in the crucible after vitrification. The total oxide from formers is the calculated mass present in the final glass that came from the nonwaste additives. The total oxide from waste is calculated as the difference between the mass of the glass and the mass of the oxide from formers. The waste loading is defined as the mass fraction of waste material in the final waste product. It is obtained by dividing the total amount of oxide from the waste by the total amount of glass. Expressed as a percent, the waste loading ranges from 66 percent for Sequence C to 89 percent for Sequence B.

Essentially all of the radon initially present in the sample is released during vitrification, providing an upper bound to the expected radon concentration in the off-gas from the vitrification system (see Table C.3-11).

Radon Emanation from the Vitrified Waste

Table C.3-12 reports the radon emanation measured from the vitrified waste. The total activity in equilibrium with the glass sample is reported along with the radon emanation rate.

The radon emanation rate from the vitrified K-65 material ranged from 0.01 to 0.06 pCi/m^2/s, more than two orders of magnitude less than the EPA limit of 20 pCi/m^2/s for radon emanation from

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TABLE C.3-9

SUMMARY OF VITRIFICATION TESTS FOR OPERABLE UNIT 4 TREATABILITY TESTING

Sequence	Test	Material	Approximate Amount of Dry Material	Description
Zero		K-65 Silo 3 BentoGrout	As required	Small melts of approximately 100 g to 150 g each to develop glass formulations for the Sequence A through D tests and to test the system and operating procedures.
A	Open	K-65	1 kg	K-65 material and glass-forming reagents as determined in the Sequence Zero tests. Radon concentration monitored in the off-gas stream.
A	Closed	K-65	1 kg	Duplicate of open system test. Off-gas collected for analysis.
B	Open	K-65 BentoGrout	0.5 kg 0.5 kg	K-65 material, BentoGrout, and glass-forming reagents as determined in the Sequence Zero tests. Radon concentration monitored in the off-gas stream.
B	Closed	K-65 BentoGrout	0.5 kg 0.5 kg	Duplicate of open system test. Off-gas collected for analysis.
C	Open	Silo 3	1 kg	Silo 3 material and glass-forming reagents as determined in the Sequence Zero tests.
C	Closed	Silo 3	1 kg	Duplicate of open system test. Off-gas collected for analysis.
D	Open	K-65 Silo 3	0.7 kg 0.3 kg	K-65/Silo 3 material and glass-forming reagents as determined in the Sequence Zero tests. Radon concentration monitored in the off-gas stream.
D	Closed	K-65 Silo 3	0.7 kg 0.3 kg	Duplicated of open system test. Off-gas collected for analysis.

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TABLE C.3-10

GLASS FORMULATION DATA FOR SEQUENCE A THROUGH D BENCH-SCALE MELTS

		Test Number							
Component	% H_2O	AO.1	BO.1	CO.1	DO.1	AC.1	BC.1	CC.1	DC.1
Weight in grams:									
K-65	a	1518	741	—	887	1509	756	—	908
Silo 3	a	—	—	1045	283	—	—	1045	283
BentoGrout	8.1	—	577	—	—	—	577	—	—
Na_2CO_3	6.4	247	233	—	229	247	233	—	229
SiO_2	0.3	—	—	159	193	—	—	159	193
Al_2O_3	0.1	—	—	147	—	—	—	147	—
H_3BO_3		—	—	88	—	—	—	88	—
Carbon	4.7	2	2	—	9	5	2	—	4
Total		1767	1553	1439	1601	1761	1568	1439	1617
%Water In[a]:									
K-65 mix	28.6	28.5	—	28.2	28.2	29.9	—	29.9	
Silo 3 mix	—	—	3.5	3.6	—	—	3.5	3.6	
Weights in grams:									
Total dry weight	1317	1280	1402	1325	1319	1280	1402	1320	
Total glass[b]	1117	1109	1038	1104	1102	1111	1032	1113	
Oxide from formers	135	127	355	317	135	127	355	317	
Oxide from waste	982	982	683	787	967	984	677	796	
Waste loading	0.88	0.89	0.66	0.71	0.88	0.89	0.66	0.72	

[a]The moisture content of the waste material was measured before the various runs.
[b]This is the mass of glass actually produced from the melt.

TABLE C.3-11

RADON RELEASED DURING VITRIFICATION OF OPERABLE UNIT 4 MATERIAL[a]

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Sequence	Measured Rn-222 Activity[b]	Maximum Rn-222 Activity[c]
A	320	363
B	151	178
C	5	5
D	199	215

[a]Values expressed in microcuries (μCi).
[b]Obtained by integrating the emanation profile from the open system run and multiplying by the flow rate.
[c]Equal to the Ra-226 activity in the waste being vitrified.

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TABLE C.3-12

RADON EMANATION FROM VITRIFIED WASTE

Radon Emanation Rate						
Test Number	Sample Mass (g)	Estimated Area (m^2)[b]	Radon Activity (pCi)[d] at:		Radon Activity ($pCi/m^2/s$) at:	
			7 days	30 days	7 days	30 days
AO.1	12.7	0.0068	79.4	190.5	0.025	0.059
AC.1	14.3	0.0077	86.4	148.4	0.024	0.041
BO.1	9.6	0.0051	34.3	59.3	0.014	0.024
BC.1	18.0	0.0096	27.5	41.3	0.006	0.009
DO.1	10.4	0.0056	42.6	78.9	0.016	0.030
DC.1	21.5	0.0115	69.7	109.0	0.013	0.020

[a]Values expressed in picocuries (pCi).
[b]Values expressed in square meters (m^2)

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uranium mill tailings. The measured radon emanation rate from the glass is approximately equal to the emanation rate from natural building materials such as brick and concrete, even though the radium content of the waste glass is 10^3 to 10^6 times greater than that of natural building materials. The radon emanation rate from the vitrified K-65 material was compared to the measured radon emanation rates for the K-65 material, as presented in Table C.3-2. A reduction in the radon emanation rate of about 500,000 times was obtained in the bench-scale vitrification tests (see Figure C.3-1).

Waste Volume Reduction

Table C.3-13 reports the specific gravity of the vitrified waste along with the calculated volume reduction. The volume reduction is based upon the difference between the volume of the final glass product (including additives) and the initial volume of the waste in its current state. The waste volume was calculated using the wet, compacted density, which is assumed to be the most representative of the material in its current state. Significant volume reductions ranging from 50 percent to 68 percent are achieved through vitrification of the waste. In summary, the final waste volume ranged from 32 percent of the initial waste volume at best to only 50 percent of the initial waste volume at the worst.

Full TCLP

A sample of the vitrified product from the Sequence A through D bench-scale melts was crushed and sieved to a particle size of less than 4 millimeter (mm) (0.16 in) in diameter and sent to an independent analytical laboratory where the TCLP was performed and the leachate analyzed. Table C.3-14 reports the average leachate concentrations for the Sequence A through D glasses. The results presented are the average of the two glasses from each sequence. While the absolute leachate concentrations are useful for determining compliance with regulatory limits for the specific metals to which the test applies (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), the fractional release is a more significant measure of the leaching of the glass, since it relates the leachate concentration of each element to its initial concentration in the glass. The fractional release is the total amount of an element leached from the sample divided by the total amount of that element initially present in the sample. Table C.3-15 reports the fractional release from the Sequence A through D glasses.

The vitrified residue from all sequences tested nonhazardous as measured by the TCLP. Previous testing found that the untreated K-65 and Silo 3 materials tested hazardous for several metals (lead for Silos 1 and 2, arsenic, cadmium, chromium, and selenium for Silo 3). Lead concentrations in the

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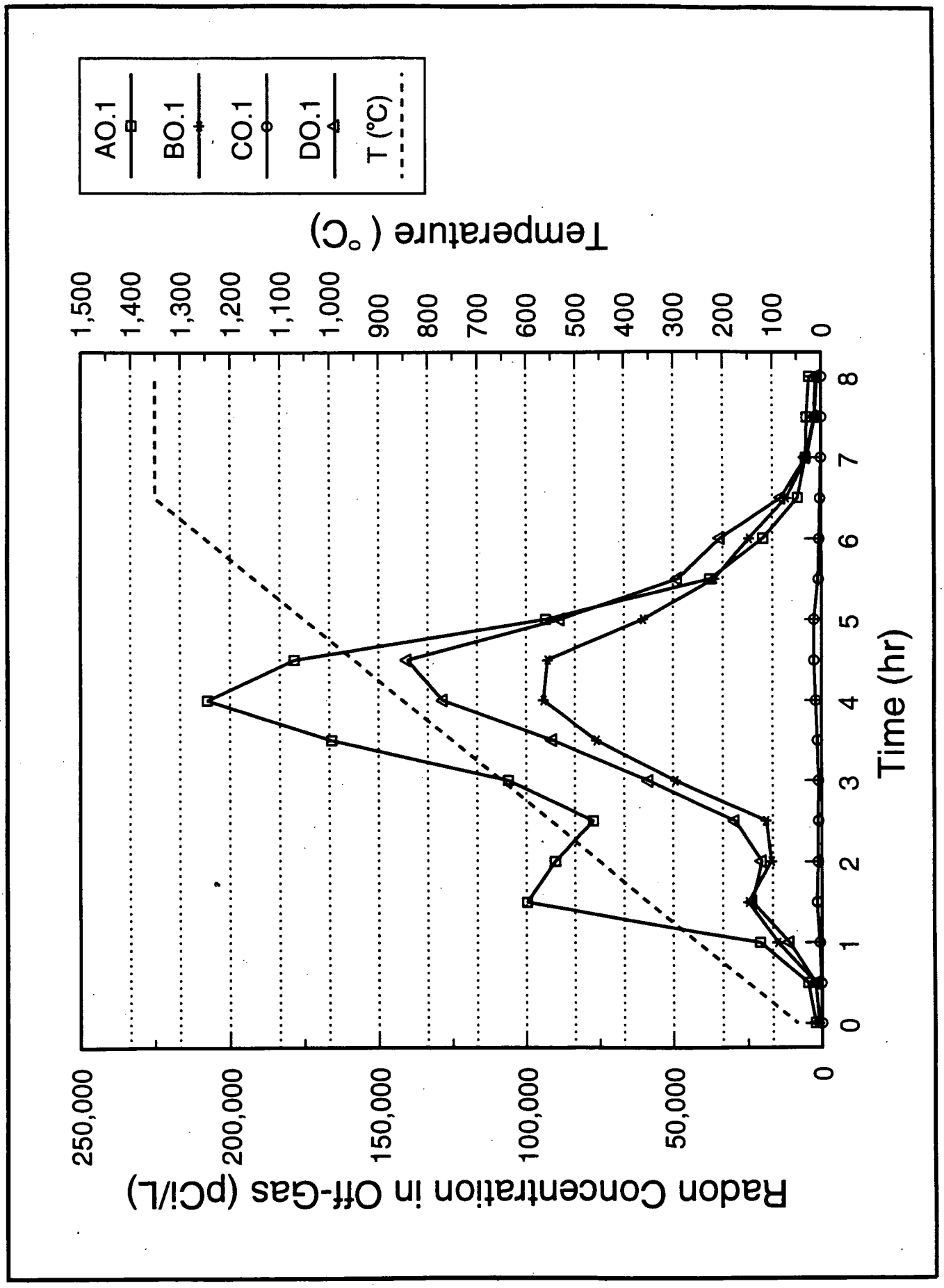

FIGURE C.3-1 RADON EMANATION PROFILES DURING BENCH-SCALE VITRIFICATION OF OPERABLE UNIT 4 MATERIAL (OFF-GAS FLOW RATE OF 9.4 L/MIN.)

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TABLE C.3-13

WASTE VOLUME REDUCTION ACHIEVED THROUGH VITRIFICATION

Test Number	Volume of Waste (mL)[a]	Specific Gravity of Glass	Mass of Glass (g)	Volume of Glass (mL)	% Volume Reduction
AO.1	857.4	2.87	1116.6	389.1	54.6
AC.1	852.7	2.84	1102.2	388.1	54.5
BO.1	916.0	2.69	1109.1	412.4	55.0
BC.1	924.3	2.68	1111.1	415.1	55.1
CO.1	1135.8	2.86	1037.5	363.0	68.0
CC.1	1135.8	2.84	1032.2	363.3	68.0
DO.1	808.7	2.75	1104.1	401.9	50.3
DC.1	820.9	2.75	1113.9	404.3	50.7

[a]Values expressed in milliliters (mL).

TABLE C.3-14

TCLP LEACHATE CONCENTRATIONS FROM THE BENCH-SCALE MELT GLASSES

Element (mg/L)	Sequence A	Sequence B	Sequence C	Sequence D
Ag	ND	ND	ND	ND
Al	0.155	0.286	0.397	0.126
As	0.004	0.016	0.628	0.052
B	0.017	0.029	1.281	0.009
Ba	0.779	0.495	0.051	1.780
Be	ND	ND	0.003	ND
Ca	0.295	0.683	8.590	1.218
Cd	ND	ND	0.009	ND
Co	0.024	0.011	0.112	0.028
Cr	ND	ND	ND	ND
Cu	0.029	0.030	0.381	0.085
Hg	ND	ND	ND	ND
K	0.248	0.249	0.685	0.272
Li	ND	ND	0.382	ND
Mg	0.144	0.360	11.910	0.587
Mn	0.006	0.035	0.991	0.039
Mo	0.037	0.032	0.261	0.036
Na	ND	ND	ND	ND
Ni	0.052	0.078	ND	0.060
P	0.070	0.450	9.535	0.860
Pb	1.003	0.425	0.018	0.538
Sb	ND	ND	ND	ND
Se	ND	ND	ND	ND
Si	1.750	1.295	2.645	1.585
Th	0.040	0.003	0.001	0.005
U	0.038	0.026	0.285	0.034
V	ND	0.009	0.380	0.028
Zn	0.054	0.072	0.049	0.048

TABLE C.3-14
(Continued)

Element (mg/L)	Sequence A	Sequence B	Sequence C	Sequence D
Radionuclides (pCi/L)				
Pb-210	3470	1690	55	2170
Ra-226	4415	2553	45	2145
Th-230	502	123	17	125
Th-232	ND	ND	ND	ND
U-238	ND	ND	95	11

ND - indicates the leachate concentration was below detection limits.

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TABLE C.3-15

TCLP FRACTIONAL RELEASE FROM THE BENCH-SCALE MELT GLASSES[a]

Element	Sequence A	Sequence B	Sequence C	Sequence D
Ag	ND	ND	ND	ND
Al	0.018	0.012	0.007	0.015
As	0.059	0.444	0.576	0.162
B	ND	ND	0.165	ND
Ba	0.032	0.042	0.341	0.131
Be	ND	ND	0.151	ND
Ca	0.051	0.121	0.507	0.169
Cd	ND	ND	ND	ND
Co	0.028	0.027	0.078	0.033
Cr	ND	ND	ND	ND
Cu	0.099	0.211	0.232	0.145
Hg	ND	ND	ND	ND
K	0.036	0.038	0.074	0.037
Li	ND	ND	0.344	ND
Mg	0.032	0.033	0.388	0.057
Mn	0.065	0.238	0.377	0.054
Mo	0.028	0.050	0.310	0.038
Na	ND	ND	ND	ND
Ni	0.031	0.096	ND	0.042
P	0.044	0.206	0.467	0.141
Pb	0.020	0.018	0.016	0.019
Sb	ND	ND	ND	ND
Se	ND	ND	ND	ND
Si	0.014	0.010	0.038	0.012
Th	ND	ND	0.001	0.015
U	0.046	0.064	0.188	0.040
V	ND	0.078	0.221	0.050
Zn	3.007	8.272	0.172	0.580
Pb-210	0.031	0.030	0.017	0.034

TABLE C.3-15
(Continued)

Element	Sequence A	Sequence B	Sequence C	Sequence D
Ra-226	0.030	0.034	0.029	0.026
Th-230	0.017	0.008	0.0003	0.004
Th-232	ND	ND	ND	ND
U-238	ND	ND	0.136	0.050

[a]Values expressed as a percent.
ND - indicates leachate concentration was below detection limits or the initial concentration of the element was not known.

leachate from the glass were reduced several hundred times relative to the untreated K-65 material, while for the Silo 3 material, arsenic was reduced about 100 times, and cadmium, chromium, and selenium were reduced to less than, or near less than, detection limits. The vitrified product effectively immobilizes the hazardous elements and reduces their release to levels less than the regulatory limits.

The fractional release data presented in Table C.3-15 normalizes the leachate concentration of an element based on its initial concentration in the TCLP sample, providing a basis for comparing the leach rate of different elements. The fractional release of elements present in the glass at concentrations greater than 0.1 weight percent for the Sequence A and B glasses generally ranges from about 0.01 percent to 0.1 percent. The fractional release is in this same range for some of these elements in the Sequence C and D glasses, while for other elements, the fractional release is an order of magnitude higher, indicating that some elements (mainly magnesium, calcium, barium, and phosphorus for both sequences, and a number of other elements for Sequence C) were leached at greater rates. The radionuclides (including Ra-226) were observed to leach at lower rates for all the glasses. Although some elements appeared to be leached at higher rates from the Sequence C and D glasses, the ability of the glasses to retain the hazardous constituents was not compromised. Radionuclides (including Ra-226) were leached from the glass at the lower rate comparable to silica, alumina, and lead.

The fractional release for elements present in the glass in small amounts typically shows a great degree of variation, since a small change in the leachate concentration results in a large change in the fractional release rate. Most notable for the results presented here is the fractional release observed for zinc. A likely contamination source for zinc was the brass screens through which the material was sieved. A small amount of contamination would result in a large fractional release for Sequence A and B glasses because of the extremely low concentration of zinc in the glass, while the effect is much less for Sequence C and D glasses because of their higher zinc content. Contamination from the brass screens could have also affected the fractional release values for copper, although not as significantly because copper is present in higher concentrations.

The TCLP was also performed on untreated samples of K-65 material from each zone of Silos 1 and 2 and on untreated samples of Silo 3 material. The leachate from each test was analyzed for radionuclides. Table C.3-16 reports leachate concentrations for untreated K-65 and Silo 3 materials. The values for each zone of the K-65 material were averaged to give a composite leachate

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TABLE C.3-16

TCLP LEACHATE CONCENTRATIONS FROM UNTREATED OPERABLE UNIT 4 MATERIAL

Radionuclides (pCi/L)	K-65	Silo 3
Ac-227	5474	15
Pa-231	a	a
Pb-210	763,694	b
Po-210	79,796	119
Ra-226	53,194	1954
Ra-228	48	a
Th-228	60	3
Th-230	285	17
Th-232	6	a
U-234	1063	85
U-235/236	50	4
U-238	1089	87
Elements[c] (mg/L)		
Pb	630	N/A
Ba	0.76	N/A

[a]Leachate concentration was less than detection limits.
[b]Pb-210 concentration in blank leachate was greater than in the leachate from Silo 3; assume zero concentration.
[c]Data for Pb and Ba for K-65 material are from Janke and Chapman (1991).
[d]N/A - Not Available.

concentration representative of leaching from the mix of K-65 material that was used in the treatability tests. The leachate concentrations from each zone were averaged in proportion to the amount of the material from each zone in the mix of K-65 material. Table C.3-17 reports the fractional release of several radionuclides from the untreated waste. Only a few radionuclides are listed because initial concentrations of the other radionuclides in the waste were not known.

Table C.3-18 presents a comparison of the leachate activity from the untreated wastes to the leachate activity from the vitrified wastes. There is a wide variation in leach reduction among the various radionuclides through vitrification. While leaching of Ac-227 from the untreated waste is reduced by a factor of thousands through vitrification, leaching of some radionuclides is unchanged. The low ratios observed do not necessarily indicate a failure of the glass to immobilize some of the radionuclides. The ratios show that some radionuclides are not leached as readily as others from the untreated waste. This is demonstrated clearly by the data in Table C.3-17. While nearly nine percent of the Pb-210 in the K-65 material is leached from the untreated waste, only 0.45 percent of the Ra-226 and 0.01 percent of Th-230 are leached. Such differences can arise because of differences in solubility among the various elements at the conditions encountered in the leachate (Reimus et al. 1988; Strachan et al. 1985). The leaching of Ra-226 will be considered as an example of how solubility limitations affect the leaching results.

Radium sulfate has limited solubility in aqueous solution ($K_{sp} = 4 \times 10^{-15}$ in cold water, although the solubility is likely to be somewhat different from this value at the conditions of the TCLP leachate), so only very small amounts of radium can be in solution when the leachate contains significant amounts of sulfates. At a sulfate concentration of 50 mg/L, the maximum radium concentration in a water solution is about 2000 pCi/L. If more radium were added to a solution at these conditions, the additional radium would precipitate as radium sulfate, and the solution concentration of radium would remain unchanged. Therefore, if the concentration of radium in the leachate from a material is limited by the solubility of radium sulfate, the radium concentration will not reflect the extent of the dissolution of the waste.

A comparison of the concentrations of radium and barium in the leachate from the untreated and vitrified residues indicates that the radium concentration in the TCLP leachate is likely to be solubility limited in the case of untreated waste, while from the vitrified residue, the radium concentration appears to be limited by the leaching of radium from the glass. The ratio of the molar concentration of barium to radium in the leachate from the untreated waste is approximately 23,000, while the ratio

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TABLE C.3-17

TCLP FRACTIONAL RELEASE FROM THE UNTREATED OPERABLE UNIT 4 MATERIAL[a]

Element	K-65	Silo 3
Pb-210	8.6	ND
Ra-226	0.45	0.87
Th-230	0.01	0.0003
U-238	ND	0.09
Pb	15	ND
Ba	0.03	ND

[a]Values expressed as a percent.
ND - Not Detected.
Note: Values for Pb and Ba are based upon data from Janke and Chapman (1991).

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TABLE C.3-18

RATIO OF THE ACTIVITY IN THE LEACHATE FROM THE UNTREATED WASTE TO THE ACTIVITY IN THE LEACHATE FROM THE VITRIFIED WASTE

Radionuclide	A	B	C	D
Ac-227	3655	>2737	>10	1856
Pb-210	229	226	ND	246
Po-210	186	137	15	217
Ra-226	12	12	44	18
Ra-228	4	2	ND	1
Th-228	12	20	2	17
Th-230	1	1	2	2
Th-232	>3	>3	ND	>4
U-234	90	52	1	68
U-235/236	>50	>15	1	>34
U-238	89	75	1	701

ND - indicates activity in leachate from glass was less than detection limits.

of the solubility product of barium sulfate to that of radium sulfate is about 29,000. The similarity of these two numbers, along with the observation that the sulfate concentration is sufficiently high (estimated at 50 mg/L) to approach the solubility limits of these two elements, indicates that the solution is saturated with radium and barium. Therefore, the radium concentration in solution will not be proportional to the amount of solid which has dissolved. In contrast, the ratio of the molar concentration of barium to radium in the leachate from the vitrified K-65 residue is 262,000, an order of magnitude higher than the ratio of the solubility products, indicating that the radium concentration in solution is not limited by the solubility of radium sulfate. The leachate concentration of radium should, therefore, be proportional to the degree of dissolution of the vitrified material, as was observed.

Consideration of solubility limitations explains the large variations observed in the fractional release from the untreated K-65 material. The relatively high sulfate concentration in the leachate prevented additional radium and barium from entering solution once the saturation limit was reached, while the more soluble lead sulfate was leached into solution to a much greater extent. For the vitrified waste, the fractional releases of radium, barium, and lead from the glass were approximately equal, indicating the absence of solubility limitations. The absence of solubility limitations would be expected since both radium and sulfate concentrations in the leachate from the vitrified waste are at least an order of magnitude lower than from the untreated waste.

Although the above discussion is somewhat qualitative, it provides an explanation based upon the available data for the observed leaching behavior of Ra-226 from the vitrified and untreated K-65 material. Solubility limitations are likely to be a factor for other radionuclides also, explaining the wide range of values presented in Table C.3-18.

The TCLP results for the vitrified wastes demonstrated the effectiveness of glass as a waste form for Operable Unit 4. Leachate concentrations of hazardous metals were below regulatory limits for all of the glasses made in these tests. The TCLP leachate concentration of lead from the vitrified residue is about 500 times less than from the untreated waste. Radionuclides (in particular, Ra-226) were found to leach from the glasses at the same rate as the major glass constituents, indicating the absence of selective leaching of radionuclides. A comparison of TCLP data from the untreated and vitrified residues indicates that leaching of radium (and probably other radionuclides) from the untreated waste is limited by solubility constraints, resulting in a relatively low concentration of radium in the leachate from the untreated waste.

PCT

Leach testing was also performed on samples from each of the bench-scale melts using the PCT. The PCT is a seven-day static leach test developed for the high-level waste vitrification program. The test uses deionized water at 90°C to leach a glass sample, which has been crushed and sieved to a size fraction of -100/+200 mesh. The PCT leach test was performed at the treatability laboratory on vitrified product samples from the Sequences A through D bench-scale melts. The leachates obtained from these tests were sent to an independent laboratory for analysis. Table C.3-19 presents the measured PCT leachate concentrations for the Sequence A through D glasses (average of the two glass samples from each sequence).

The absolute leachate concentrations reported above are not an accurate measure of the leach rate of the glass. The leachate concentration is greatly dependent on the surface area to volume ratio of the sample material, the duration of the leach test, and the initial concentration of the element in the sample. For this reason, leach rates are typically expressed as grams of an element leached per square meter of surface per day, normalized based upon the initial concentration of the element in the sample. Therefore, the normalized leach rate for each element represents the rate at which the glass would be leached if the glass as a whole were leached at the same rate as that element. Table C.3-20 reports the normalized leach rates determined using the data from Table C.3-19.

The normalized leach rates reported above indicate that all of the glass formulas tested exhibit exceptional durability comparable to glasses developed for the vitrification of high-level wastes. The normalized leach rates for the Sequences A through D glasses are an order of magnitude less than the Defense Waste Processing Facility Environmental Assessment (EA) glass leach rates (Jantzen et al. 1992) and are comparable to those measured for simulated high-level waste glasses (Piepel et al. 1989). Leach rates for the EA glass were found to be 0.28 g per square mile per day ($g/m^2/d$) for silica and 0.97 $g/m^2/d$ for sodium, while for simulated waste glasses, typical values were 0.03 $g/m^2/d$ for silica and 0.07 $g/m^2/d$ for sodium. The EA glass is designed to be a standard representing the maximum acceptable leach rate for high-level waste glasses; therefore, the Sequences A through D glasses are substantially more durable than the minimum standard for high-level waste glasses. The leaching of radionuclides in the PCT was one to two orders of magnitude less than leaching of the major elemental constituents of the glass. These low values are likely to be a result of solubility limitations in the leachate.

TABLE C.3-19

PCT LEACHATE CONCENTRATIONS FOR THE BENCH-SCALE MELT GLASSES

	Sequence			
Elements (μg/L)	A	B	C	D
K	1620	561	1383	1605
Na	124,983	40,650	7132	59,800
Si	69,867	34,633	14,850	58,467
Li	ND	ND	689	242
B	144	77.4	2052	151
U	0.9	11.2	14.7	2.1
Th	ND	ND	7.1	4.0
Ra-226	7810	1445	< 1323	2520

ND - indicates the leachate concentration was less than detection limits.

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TABLE C.3-20

NORMALIZED LEACH RATES FOR 7-DAY PCT LEACHING OF BENCH-SCALE MELT GLASSES ($g/m^2/d$)

	Sequence			
Element	A	B	C	D
K	0.019	0.007	0.007	0.016
Na	0.079	0.026	0.011	0.039
Si	0.020	0.009	0.008	0.016
Li	a	a	0.022	0.031
B	a	a	0.009	a
U	b	0.0010	0.0003	0.0001
Th	a	a	0.0002	0.0004
Ra-226	0.0019	0.0007	b	0.0011

[a]Initial concentration in glass is not known.
[b]Leachate concentration was less than the detection limit.

A comparison of the PCT data to the TCLP data is difficult, if not impossible. The tests are carried out at very different conditions, and wide variations in the results are possible. Past experience has shown that a glass, which is durable under neutral conditions is often attacked under acidic conditions, and vice versa (Chick et al. 1981). Absolute concentrations in the leachate from the two tests are not comparable, nor is a fractional release rate, because the surface area of the sample in the PCT is as much as a factor of 50 higher than the area of the TCLP sample. PCT data are normalized to a leach rate per unit surface area of the sample, while the lack of a well defined surface area prevents an accurate presentation of TCLP data on this basis; however, a normalized leach rate can be crudely estimated for the TCLP by estimating the surface area of the sample.

Using the most conservative estimate of the surface area for the TCLP [assuming all particles are spherical with a diameter of 4 mm (0.16 in) , giving the minimum surface area for leaching and hence the maximum leach rate], the estimated leach rates observed in the TCLP tests are in the range of 0.2 to 1 $g/m^2/d$ (except for the previously identified elements selectively leached from the Sequences C and D glasses). The TCLP appears to leach the glass more aggressively than the PCT; however, the points discussed above must be considered. The difference between the acid conditions of the TCLP and the neutral to basic conditions of the PCT can result in great differences in the leaching behavior. Additionally, most particles are smaller than the mesh size through which they pass and substantial quantities of very fine particles are generated during crushing of the TCLP sample; therefore, the actual surface area of the TCLP sample is likely to be greater than the value estimated above, resulting in an inflated value of the normalized leach rate.

The results of leaching the Sequences A through D glasses by the PCT have shown these glasses to be very durable on a comparable basis to glasses developed for the disposal of high-level waste. A semiquantitative comparison of the PCT results to the TCLP results indicates that the glasses may be more aggressively leached by the TCLP. Nevertheless, the PCT leach testing has demonstrated a high degree of durability for the vitrified Operable Unit 4 wastes.

Viscosity and Electrical Conductivity

The viscosity and electrical conductivity of the glasses from the Sequences A through D tests were measured as a function of temperature. Measurements were made using 100 to 140 g of glass from the open system melts. Figures C.3-2 and C.3-3 present results of these measurements, which are plotted as the logarithm of the viscosity versus inverse temperature. Straight lines indicate that the viscosity data demonstrate typical temperature dependence for glass melts (Kingery 1976). Using

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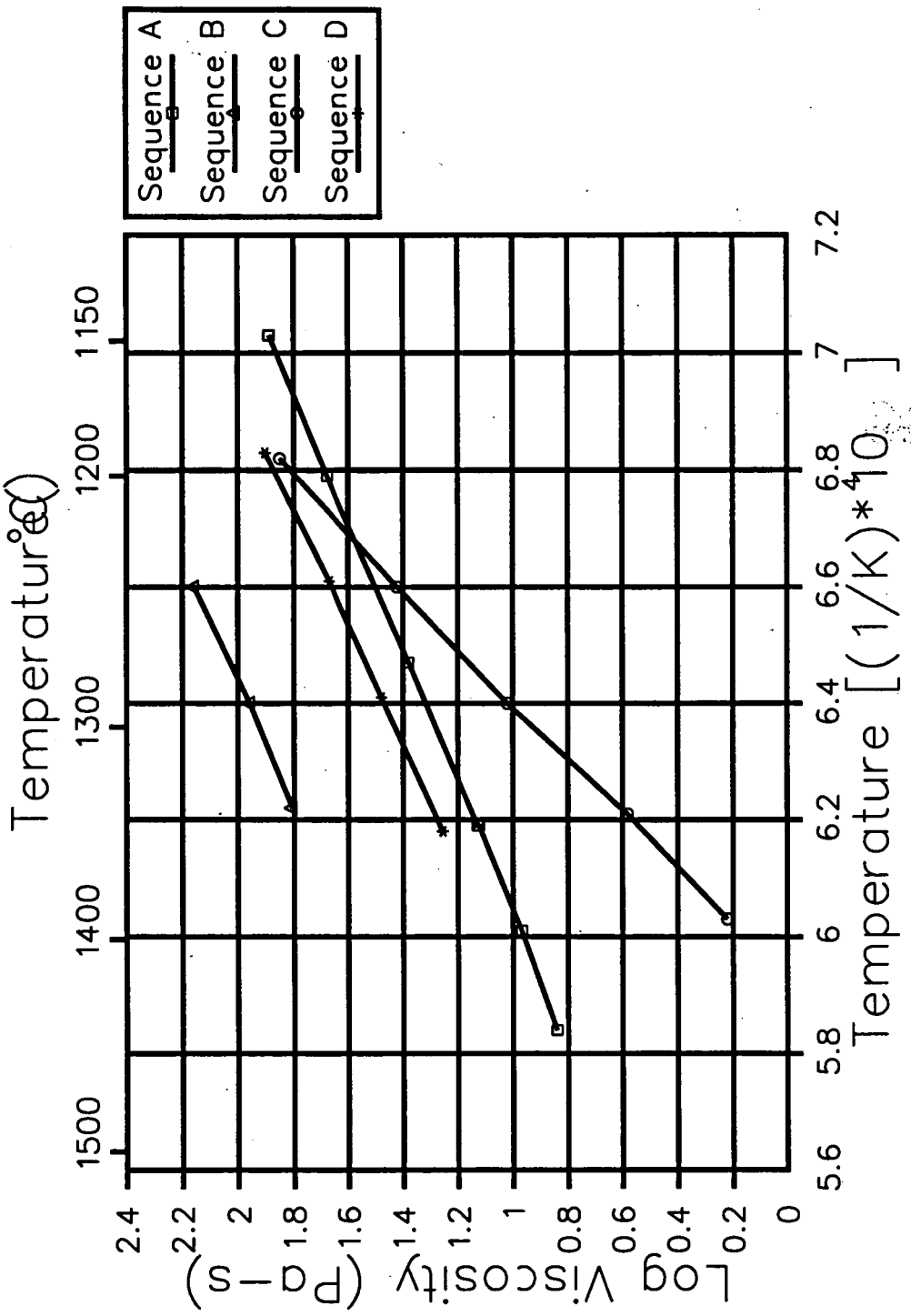

Figure C.3-2

VISCOSITY OF FERNALD GLASSES AS A FUNCTION OF TEMPERATURE

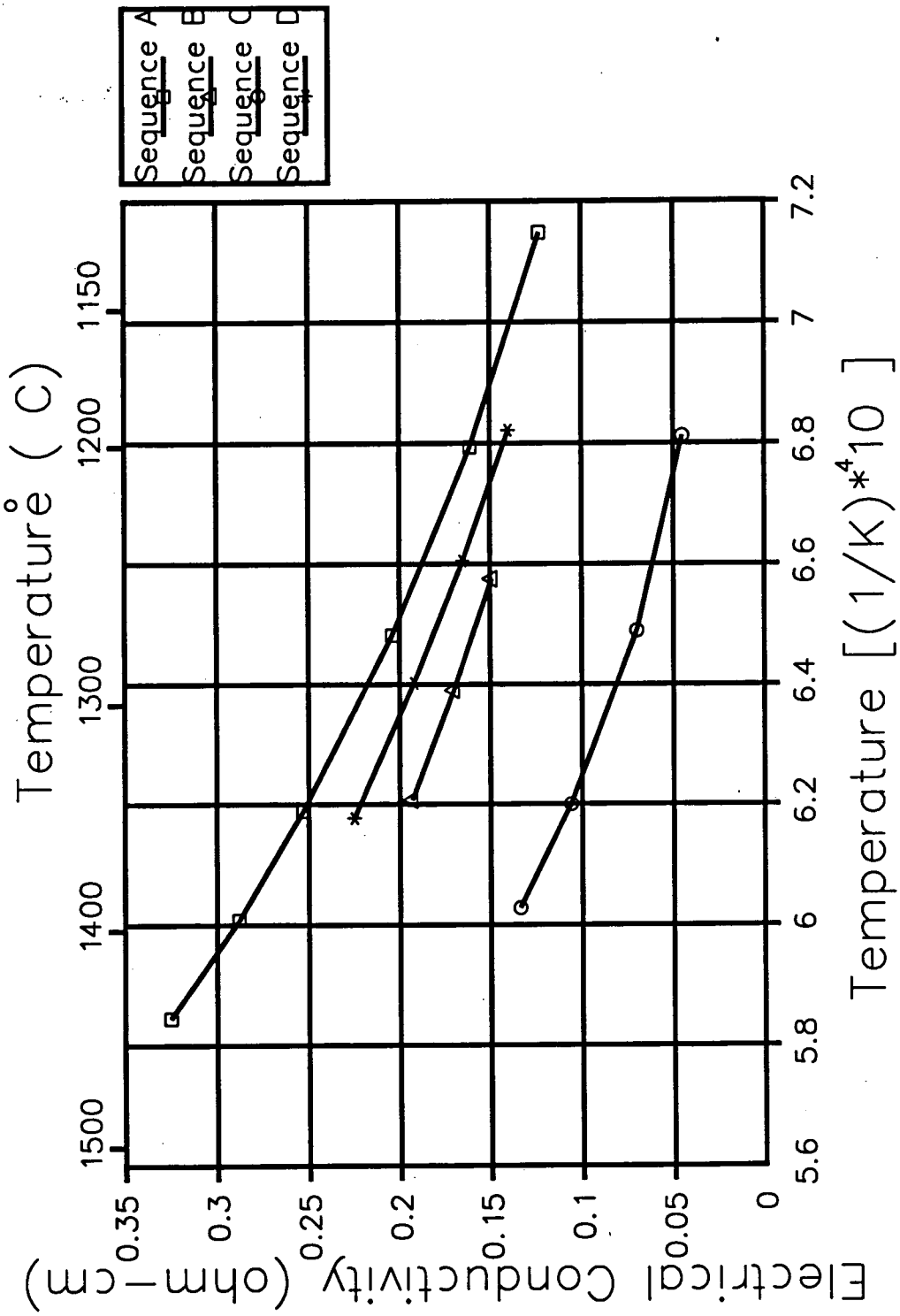

FIGURE C.3-3
ELECTRICAL CONDUCTIVITY OF FERNALD GLASSES AS A FUNCTION OF TEMPERATURE

curve fitting techniques, the viscosity and conductivity of the glasses were predicted every 100°C over the range of 1150°C to 1450°C. Tables C.3-21 and C.3-22 report these values. Only the glass from Sequence A was measured over this entire temperature range. Samples from Sequences B and D were not measured at the higher temperatures because of reboil of the glass at temperatures above approximately 1375°C. For the Sequence C glass, the viscosity was below the measurement limits of the test apparatus above approximately 1400°C. These extrapolated values should be used with caution.

The viscosity data show that the glass from Sequences A, C, and D to have reasonable viscosities for processing (about 2 to 15 Pa•s) within the temperature range reported, while the glass from Sequence B was too viscous in this temperature range. The higher viscosity for the Sequence B glass results from the high alumina content in the BentoGrout. The viscosity for Sequence B could be brought within acceptable ranges by increasing the fluxing additives or reducing the BentoGrout content of the waste mixture.

The viscosity of the Sequence C glass is much more dependent on temperature than the other glasses. At higher temperatures, the glass is, therefore, much less viscous. This could be a cause of the observed attack on the crucible for the Sequence C tests. Another observation during the viscosity measurements on the Sequence C glass was an increase in viscosity at constant temperature at all temperatures except the highest measured, indicating crystal growth in the melt.

The conductivity values for all the glasses are near typical ranges for glass processing [about 0.1 to 0.5 $(ohm \bullet cm)^{-1}$]. The conductivity data all show a similar dependence on temperature. For the Sequence A, B, and D glasses, the conductivity at a given temperature is lower for the more viscous glasses. The Sequence C glass, while showing a similar dependence on temperature, is substantially lower in conductivity than the other glasses despite a generally lower viscosity. The lower conductivity of the Sequence C glass is likely to result from a lower alkali content and a higher alumina content relative to the other glasses.

The conductivity of the glass primarily affects the power system design. A higher conductivity requires more current and less voltage, while the opposite is true for a lower conductivity. If two different glass formulas are to be processed in the same equipment, it will be necessary to assure that both are compatible with the system design.

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TABLE C.3-21

GLASS VISCOSITY AS A FUNCTION OF TEMPERATURE[a]

	Temperature (°C)			
Sequence	1150	1250	1350	1450
A	76.5	29.6	12.9	6.2
B	351.1	131.7	55.7	26.0
C	200.3	22.0	3.2	0.6
D	125.6	43.3	17.0	7.5

[a]Values expressed as pascal second (pa·s).
Note: The values at 1150°C and 1450°C are extrapolated from the measured data for all sequences except Sequence A.

TABLE C.3-22

GLASS CONDUCTIVITY AS A FUNCTION OF TEMPERATURE[a]

	Temperature (°C)			
Sequence	1150	1250	1350	1450
A	0.135	0.191	0.258	0.336
B	0.108	0.150	0.199	0.257
C	0.033	0.063	0.111	0.183
D	0.121	0.169	0.228	0.297

[a]Values expressed as ohm centimeter^{-1} [(ohm·cm)$^{-1}$].
Note: The values at 1150°C and 1450°C are extrapolated from the measured data for all sequences except Sequence A.

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The results presented above show that the K-65 and Silo 3 material can be made into glasses with reasonable conductivity and viscosity for processing in a joule-heated ceramic melter; however, it is also evident that further development of these glass formulas is needed.

Off-Gas Composition

Table C.3-23 reports the composition of the off-gas samples collected during the closed system vitrification tests. The entire off-gas was collected using a closed system, as required by the Treatability Study Work Plan for Operable Unit 4. As a result, these measurements are useful only for qualitative evaluation of the off-gases generated during vitrification. Quantitative evaluation is not possible since the off-gas generated from the melt is diluted and mixed with the atmosphere initially present in the furnace. Additionally, the composition of the gas in the furnace at the end of the run will be different from the composition of the gas collected during the run. More quantitative results would be obtained by using an open system and performing periodic grab-sampling of the off-gas throughout the test.

During the open system tests, the off-gas was observed to change color in certain temperature ranges. From about 600°C to 1100°C, the off-gas became red-orange in Sequences C and D melts. At about 1100°C, the off-gas became a milky white in all the melts. During Sequence C, the off-gas was, therefore, collected over three temperature ranges to investigate the observed color changes.

The off-gas compositions mainly show significant generation of carbon dioxide for all the melts, in part because of the addition of sodium carbonate as a flux for Sequences A, B, and D. Carbonate in the waste is also a source. Nitrogen oxides were found in the off-gas from the Sequences C and D melts. The absence of sulfur dioxide in all the off-gas samples was unexpected. Significant amounts of sulfur, however, were found in the condensate from the open system tests, indicating that sulfur in the off-gas was removed before collection of the off-gas in the sample bag. The red-orange gas observed in the off-gas is believed to be nitrogen oxides generated from the decomposition of nitrates in the waste. This coloring of the off-gas was observed only with Silo 3 glasses, since the levels of nitrates in the Silo 3 material are 10 times higher than those in the K-65 material. The cause of the milky white color is unknown.

Condensate Composition

The off-gas from the vitrification tests was cooled in a shell and tube heat exchanger and the condensate collected for analysis. Table C.3-24 presents results of these analyses. Quantitative

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TABLE C.3-23

COMPOSITION OF THE OFF-GAS COLLECTED IN THE CLOSED SYSTEM TESTS[a]

Component	Test # AC.1	Test # BC.1	Test # CC.1-1	Test # CC.1-2	Test # CC.1-3	Test # DC.1
N_2	75.6	66.4	77.6	77.3	77.0	66.8
O_2	19.4	13.8	19.6	19.5	17.7	13.5
CO_2	4.11	19.0	1.5	2.2	4.4	19.0
Ar	0.89	0.76	0.95	0.91	0.88	0.79
CO	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
NO_x	<0.01	<0.01	<0.01	0.02	0.05	0.01
He	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
H_2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CH_4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SO_2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

[a]Values expressed in mole percent (mole %).

Notes: The off-gas for sequence C was collected over three temperature intervals. The first interval was from start to 500°C, the second from 500°C to 1100°C, and the third from 1100°C to 1350°C.

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TABLE C.3-24

CONDENSATE ANALYSIS FROM BENCH-SCALE MELTS

	Test Number			
Radionuclides:[a]	AO.1	BO.1	CO.1	DO.1
Radium-226	30	36	377	7
Radon-222	13,233	145	20	8471
Inorganic Analysis:[b]				
Lead	4.5	4.3	7.1	11.1
Sulfur	2530	2020	29,700	3720
Total Thorium	1.0	1.0	2.6	1.1
Total Uranium	<0.001	<0.001	<0.001	<0.001

[a]Values expressed in picouries per liter (pCi/L).
[b]Values expressed in milligrams per liter (mg/L).

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analysis is not possible. The amount of condensate, and thus the concentration of the analytes, is not a controlled variable. Results are presented only for the open system tests since no condensate was obtained from the closed system tests. Without a convective flow through the furnace, water vapor apparently diffused to cooler areas of the furnace and condensed in the interior of the furnace.

Most interesting of these results is the high sulfur levels. Sulfur was found in the condensate at a level of 3 weight percent for Sequence C and about 0.3 weight percent for the other sequences. Apparently, the sulfur oxides from the decomposition of the sulfate were readily absorbed by the condensate. The results also show the volatilization of some metals, as evidenced by lead, thorium, and radium. The radon concentrations show a wide variation. The level for Sequence C is expected to be lower because of the much lower radium content of the waste. The level for Sequence B is very low compared to Sequences A and D. Radon levels in the off-gas during Sequence B were comparable to those of Sequences A and D, so the difference must result from sampling, handling, or analytical methods.

Gamma Dose Rate from the Vitrified Waste

Table C.3-25 presents the gamma dose rate from the vitrified waste. It was measured along the crucible axis at the specified distance from the bottom of the crucible. The usefulness of these data is limited, since the gamma dose rate is dependent upon the amount of material present. In order to predict the gamma dose rate for other geometries and amounts of material, it is necessary to know the concentration of gamma-producing nuclides in the glass. Existing models can then be used to estimate dose rates for any geometry and size.

C.3.5 COMPARISON TO TREATABILITY STUDY TEST OBJECTIVES

The general objectives of the treatability study tests were successfully met. The data generated allow the comparison of vitrification technology with other technologies based upon the criteria for the established Operable Unit 4 remediation goals. Specifically, these criteria were the leachability of the waste form, the volume reduction achieved through treatment, and the reduction in radon emanation from the waste.

The chemical and physical properties of the wastes were determined and used in developing the glass formulas for the tests. Each of the waste streams identified in the Treatability Study Work Plan for Operable Unit 4 (Sequences A through D) was successfully vitrified using the developed glass formulas. Various analyses were carried out on the glass in support of the test objectives. The

TABLE C.3-25

GAMMA DOSE RATE FROM THE VITRIFIED WASTE[a]

	Distance from Crucible Bottom[b]			
Test Number	0	6	12	24
AO.1	7.2	0.5	0.2	0.0
AC.1	5.3	0.5	0.2	0.0
BO.1	6.5	0.8	0.2	0.0
BC.1	2.6	0.2	0.1	0.0
CO.1	0.0	0.0	0.0	0.0
CC.1	0.3	0.1	0.0	0.0
DO.1	3.2	0.1	0.0	0.0
DC.1	3.8	0.4	0.1	0.0

[a]Values expressed in millirem per hour (mrem/hr).
[b]Values expressed in inches (in).

TCLP data for each of the glasses allow comparison of the leachability to other waste forms based upon a standard procedure. Radon emanation from the vitrified product was measured, and the volume reduction was calculated based upon measurements of the specific gravity of the vitrified waste. The total radon released during vitrification was determined to facilitate preliminary design of radon collection and treatment systems. Finally, the composition of the off-gas and condensate from these tests was determined, providing a qualitative indication of the species to be expected during continuous melter operation.

C.3.6 CONCLUSION

This treatability study indicated that vitrification of the Silos 1, 2, and 3 residues is technically feasible.

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C.4.0 COMPARISON OF TREATABILITY STUDY RESULTS

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C.4.1 INTRODUCTION

Remedy screening and selection treatability studies have been conducted in support of the Operable Unit 4 Remedial Investigation/Feasibility Study (RI/FS) on three process options for treatment of waste in Subunit A (Silos 1 and 2 residues) and Subunit B (Silo 3 residue). These process options are cement stabilization (see C.1.0), chemical extraction (see C.2.0), and vitrification (see C.3.0). This section provides a comparison of results from two of these studies, cement stabilization and vitrification. Chemical extraction is not included in this comparison since it was eliminated from further consideration during the initial screening of alternatives (see Section 3 of this FS).

The comparison consists of a simplified summary presentation of test data and a brief discussion relative to the key evaluation criteria (see sections C.1.0 and C.3.0 for more details). These parameters consist of the following: Durability - treated waste, Leachability - treated versus untreated waste, Radon Emanation - treated waste, and Volume Changes - treated versus untreated waste.

Durability information is presented and discussed in section C.4.2; leachability data is presented and discussed in section C.4.3; radon emanation data is presented and discussed in section C.4.4; volume change information is presented and discussed in section C.4.5; and a conclusion is contained in section C.4.6. More detailed discussions of these criteria and the associated test methodologies can be found in sections C.1.0, C.3.0, and Appendix H of this FS.

C.4.2 DURABILITY

Durability tests were performed on cement stabilized and vitrified waste from each of the three Operable Unit 4 silos containing residues, i.e., Silos 1, 2, and 3. The durability tests for cement stabilized waste forms were performed in accordance with American Society for Testing and Materials (ASTM) D 4842, "Standard Test Method for Determining the Resistance of Solid Wastes to Freezing and Thawing" (freeze-thaw test) and ASTM D 4843, "Standard Test Method for Wetting and Drying Test of Solid Waste" (wet-dry test). For vitrified waste forms, the Nuclear Waste Glass Product Consistency Test (PCT) was used to measure durability, in addition to providing leachability data.

For the vitrification process waste forms, PCT durability results based on normalized leach rates indicated that all of the formulations tested exhibited "exceptional durability comparable to glasses developed for the vitrification of high-level wastes" (see section 3.0 - PCT). The normalized leach

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rates for all formulations were an order of magnitude less than the Defense Waste Processing Facility Environmental Assessment (EA) glass leach rates (Jantzen et al. 1992). These rates are also comparable to those measured for simulated high-level waste glasses (Piepel et al. 1989).

For the cement stabilization process waste forms, results from the related durability tests are summarized in Table H.I-2 in Attachment H.I. Average weight loss numbers are indicated in that table. Each number represents the corrected average weight loss (in percent) of three test specimens. Corrections were made (consistent with the ASTM method) by subtracting the average weight loss of the three control specimens from the weight loss of the test specimens with the same sample formula.

The ASTM test methods for both freeze-thaw and wet-dry give the same criterion for judging success or failure. No standards are currently established for determining whether stabilized material has passed the durability testing. In ASTM procedures D4842 and D4843, the durability tests are terminated when the weight loss exceeds 30 percent. Vick et al. suggest that greater than 15 percent weight loss is unacceptable [U.S. Environmental Protection Agency (EPA) 1989]. Table H.I-2 provides measured corrected weight loss data, and it also provides a comparison to both of the suggested levels, i.e., 15 and 30 percent.

Test results indicated that the corrected weight losses ranged up to 13 percent for the freeze-thaw specimens and up to 34 percent for the wet-dry specimens. For Silos 1 and 2 wastes, only one of the 84 specimens had corrected weight losses greater than 15 percent. That specimen was a wet-dry specimen utilized for Silo 1, Zone A, Formula 1 (portland cement/flyash) wet-dry testing. Conversely, the corrected weight losses of all 9 individual Silo 3, Formula 2 (portland cement/flyash/blast furnace slag) specimens for the wet-dry testing exceeded 15 percent. These losses ranged from 18 to 34 percent.

After performance of the wet-dry and freeze-thaw tests, unconfined compressive strength (UCS) tests were performed on the specimens to determine the effect of the climatic stresses simulated by the freeze-thaw and wet-dry tests. The results showed that the specimens prepared with the Silo 3 formulation which had the significant weight loss also failed the UCS test. Essentially, all Formula 2 specimens lost their compressive strength. All the other Silos 1, 2, and 3 specimens met the UCS criteria of approximately 500 psi or greater.

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Based on the preceding discussion of the durability results from the vitrified and cement stabilized waste form tests, it appears that the vitrification and cement stabilization processes both yield durable waste forms relative to Silos 1, 2 and 3. However, the durability of the cement stabilization formulation that best resists leaching for treatment of Silo 3 residues (Formula 2) is highly suspect.

C.4.3 LEACHABILITY

An important treatability test criterion is the ability of a treated waste form to minimize COC leaching. Leachability tests were performed on cement stabilized and vitrified waste forms to determine their resistance to leaching of a wide variety of radiological and chemical COCs. The primary analytical test methodology employed was the toxicity characteristic leaching procedure (TCLP). Additional leachability tests performed on these treated waste forms included the PCT for vitrified waste forms and the Five-Day Static Leach Test for cement stabilized waste forms. For purposes of this summary level comparative discussion, the primary focus will be on four radionuclides of particular importance: radium (Ra)-226, lead (Pb)-210, thorium (Th)-230, and uranium (U)-238.

Silos 1 and 2 Leachability

For Silos 1 and 2 treated waste, TCLP analysis was performed and results were compared to untreated residue TCLP results. Table C.4-1 reports leachate concentrations for the four radionuclides identified in the preceding paragraph. Note that the concentrations presented in this table for untreated residues represent an average value as results were originally obtained for each silo by zone. Average values give a composite leachate concentration representative of leaching from the K-65 residue mixture that was used in the vitrification treatability study. Also note, for the cement stabilization process, analysis was performed on multiple samples from each of the silo zones. The data, however is reported as a range of values encompassing all samples from all zones for each individual silo formulation. These data have also been dilution adjusted to account for the addition of stabilizing reagents.

Finally, for the cement stabilization process, total thorium and total uranium analytical data were reported in mg/l rather than pCi/L by isotope. In order to obtain U-238 and Th-230, activity thus allowing this comparative analysis of treatability processes, it was assumed that the isotopic ratio in the leachate was the same as that of the unleached material [see Final RI Report for Operable Unit 4 (November, 1993) Appendices A and B]. For specific zone-by-zone analytical data incorporating the complete list of radionuclides and chemicals, see section C.1.0 and the Final RI Report for Operable Unit 4 (November, 1993).

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TABLE C.4-1

SUMMARY COMPARISON OF TCLP RESULTS

SILOS 1 AND 2 RESIDUES (pCi/L)

RADIONUCLIDE	VITRIFICATION	CEMENT STABILIZATION		
		FORMULA 1	FORMULA 2	UNTREATED RESIDUES[a]
Ra-226	4415	9417 - 94368	6996 - 21863	56050
Pb-210	3470	156 - 961	56 - 268	603500
Th-230	502	7 - 34	5 - 45	272
U-238	12.6	.7 - 2.6	.7 - 2.3	1623

[a] Values for untreated residues are a composited average of Silo 1 and Silo 2 values from Final RI Report for Operable Unit 4 (November, 1993).

Comparison of the leach results reported in Table C.4-1 indicates that the vitrification process reduced the Ra-226 concentration by approximately 92 percent versus the Ra-226 concentration in the untreated residues. The cement stabilization process results ranged from an 88 percent decrease to a 68 percent increase in Ra-226 leachate concentration versus the untreated residue. Upon evaluation of these results, it is important to note both the range of leach results and the fact that the vitrification process outperforms the cement stabilization process for this radionuclide. It appears that the cement stabilization process is more difficult to apply when the waste to be stabilized is not homogeneous, as is the case with the K-65 residues.

In contrast to the leach results for Ra-226, the leach results for Pb-210 and U-238 favor the cement stabilization process. It should be noted, however, that the percent reductions versus the untreated residue concentrations are over 99 percent for both the vitrification and the cement stabilization processes.

For Th-230, the vitrification process results in a 85 percent increase versus a decrease ranging from 83 to 98 percent relative to untreated residues for the cement stabilization process. These results definitely favor cement stabilization.

Based on the preceding leach results from the TCLP on the Silo 1 and 2 residues, the following conclusions can be drawn:

- The vitrification process outperformed cement stabilization for the retention of Ra-226.
- Cement stabilization outperformed vitrification for retention of Th-230.
- Both process options performed well for Pb-210 and U-238, however, cement stabilization provided some advantages.
- Significant variations in the TCLP leach results for Ra-226 indicated that the cement stabilization process may be somewhat susceptible to waste stream variations due to non-homogeneous K-65 residues contained in Silos 1 and 2.

As was previously indicated, additional leachability information was obtained via the PCT for the vitrification process and via the 5-day Static Leach Test for the cement stabilization process. Both of these tests utilize deionized water instead of the acids used for the TCLP. The deionized water provides a reasonable simulation of leaching from waste exposed to groundwater. These two tests, however, are quite different in methodology. The 5-day Static Leach Test is applied to an intact 1.4 inch by 2.9 inch cement stabilized cylinder which is placed in stagnant room temperature water (approximately 20 degrees centigrade). After five days, the water is sampled for the constituents

being investigated. The PCT test, conversely, utilizes water at 90 degrees centigrade on a crushed vitrified waste form subjected to a seven day soak. The PCT, therefore, appears to be a more aggressive test than the 5-day Static Leach Test.

Results from the PCT and 5-day Static Leach Tests follow for two of the four radionuclides discussed in this section. These nuclides were selected because Ra-226 TCLP results favored the vitrification process and uranium results favored the cement stabilization process. The 5-day Static results are based on 14 data points, whereas the PCT results are based on a single data point:

Radionuclide	PCT	5-day Static Leach Test		
		Range	Mean	Median
Ra-226 (in pCi/L)	7810	416 - 37000	12400	9580 - 10800
Total - U (in Mg/l)	.0009	.0010 - .00331	.0045	.0016 - .0018

The leach results for both radionuclides seem to range from being about equal to slightly favoring vitrification over cement stabilization. When the test methodologies are taken under consideration, the vitrification process appears even more favorable. Factors such as much higher temperatures for the PCT and much smaller particle size which results in much higher surface area would typically increase the expected leaching concentrations. This is particularly true for Ra-226 which is 2 to 5 times more soluble in water at 90 degrees centigrade versus water at room temperature.

Silo 3 Leachability

For Silo 3 treated waste, TCLP analysis was also performed on both treated waste and untreated residues. Table C.4-2 reports the leachate concentrations for the same radionuclides considered in the Silos 1 and 2 discussion. This table reports the cement stabilization results as dilution adjusted for the reasons cited in the previous TCLP discussion. Also, the same adjustment to convert total-U to U-238 has been performed. Note that TCLP tests were performed on two cement stabilization formulas and that only the results from Silo 3 Formula 1 are presented here. The elimination of Silo 3 Formula 2 from further consideration in this comparative discussion is due to the disappointing wet-dry durability test results obtained for that formulation.

TABLE C.4-2

SUMMARY COMPARISON OF TCLP RESULTS 5039

SILO 3 MATERIAL (pCi/L)			
RADIONUCLIDE	VITRIFICATION	CEMENT STABILIZATION (FORMULA 1)	UNTREATED RESIDUE
Ra-226	45	1712	2455
Pb-210	55	360	87
Th-230	17	no result	10
U-238	95	4	86

[a]Values for Untreated Residues come from Final RI Report for Operable Unit 4 (November, 1993) Table 4-22.

Comparison of the leach results reported in Table C.4-2 indicates that the vitrification process reduced the Ra-226 concentration by approximately 98 percent versus the untreated residues. The cement stabilization process achieved a 30 percent reduction.

The vitrification process reduced Pb-210 concentrations by 37 percent versus the untreated residue while the cement stabilization formulation resulted in an increase of over 300 percent.

The vitrified waste resulted in a 70 percent increase in concentration versus the untreated residue leach results for Th-230. However, both the 10 pCi/L untreated residue Th-230 concentration and the 17 pCi/L treated waste concentration are relatively low concentrations. For Th-230, no cement stabilization result was recorded.

For U-238, the vitrification process yielded results approximately 9 percent above the untreated residue concentration. The results are sufficiently similar to conclude that there was little observed effect from the vitrification process for this radionuclide. Conversely, the cement stabilization process achieved a 95 percent reduction in concentration for U-238.

Based on the preceding leach results from the TCLP on the Silo 3 residues, the following conclusions can be drawn:

- The vitrification process outperformed cement stabilization for the retention of Ra-226.
- Cement stabilization outperformed vitrification for retention of U-238.
- Neither process option provided a significant benefit to control leaching of Pb-210.
- Vitrification provided no apparent benefit in controlling leaching of Th-230.

C.4.4 RADON EMANATION

Treatability tests were performed on both vitrified and cement stabilized Silos 1 and 2 (K-65 Silos) residues. See Appendix C.3.0 for more information about measured vitrified waste radon releases and Appendix H for cement stabilization radon emanation information.

It is a commonly known fact among the scientific community that waste forms resulting from the vitrification and cement stabilization processes have distinctly different abilities to retain radon. The radon which is released must come from a decay of a Ra-226 atom close enough to the surface of the waste form to be able to reach the open atmosphere at the surface. If the radon gas does not escape the surface, it decays into a daughter product in place, i.e., wherever it is physically located when the

daughter product is produced from the gas. This concept is significant in evaluating the emanation rate (the rate at which radon is released) of the two waste forms.

The two treatment processes produce waste forms with significantly different physical characteristics. The surface of the vitrified waste form is smooth and impervious to the passage of radon (except for an extremely thin layer at the surface). In contrast, the surface of the cement stabilized waste form is irregular in shape possessing a much greater surface area than the vitrified waste form. Also, the physical structure of the cement stabilized waste form has a limited ability to retard the passage of the radon gas through the waste form.

The range of emanation rates measured during the treatability tests is listed below. Not only should these measured rates be compared between the two process options, they should be compared with the untreated K-65 emanation rate and the 40 CFR § 61 limit of 20 pCi/m^2/s.

Vitrification	Cement Stabilization	Untreated K-65 Residues
.0009 - .059 pCi/m^2/s	220 - 1391 pCi/m^2/s	1985 - 7314 pCi/m^2/s

Reviewing these results yields the following findings:

- At the much higher radon emanation rates from the cement stabilized waste form, there is little difference between it, and the emanation rate from the untreated waste.
- The vitrification process resulted in a waste form with radon emanation rates well below the 40 CFR § 61 limit.
- The vitrification process provided much better radon emanation performance than the cement stabilized waste form.

C.4.5 VOLUME CHANGES

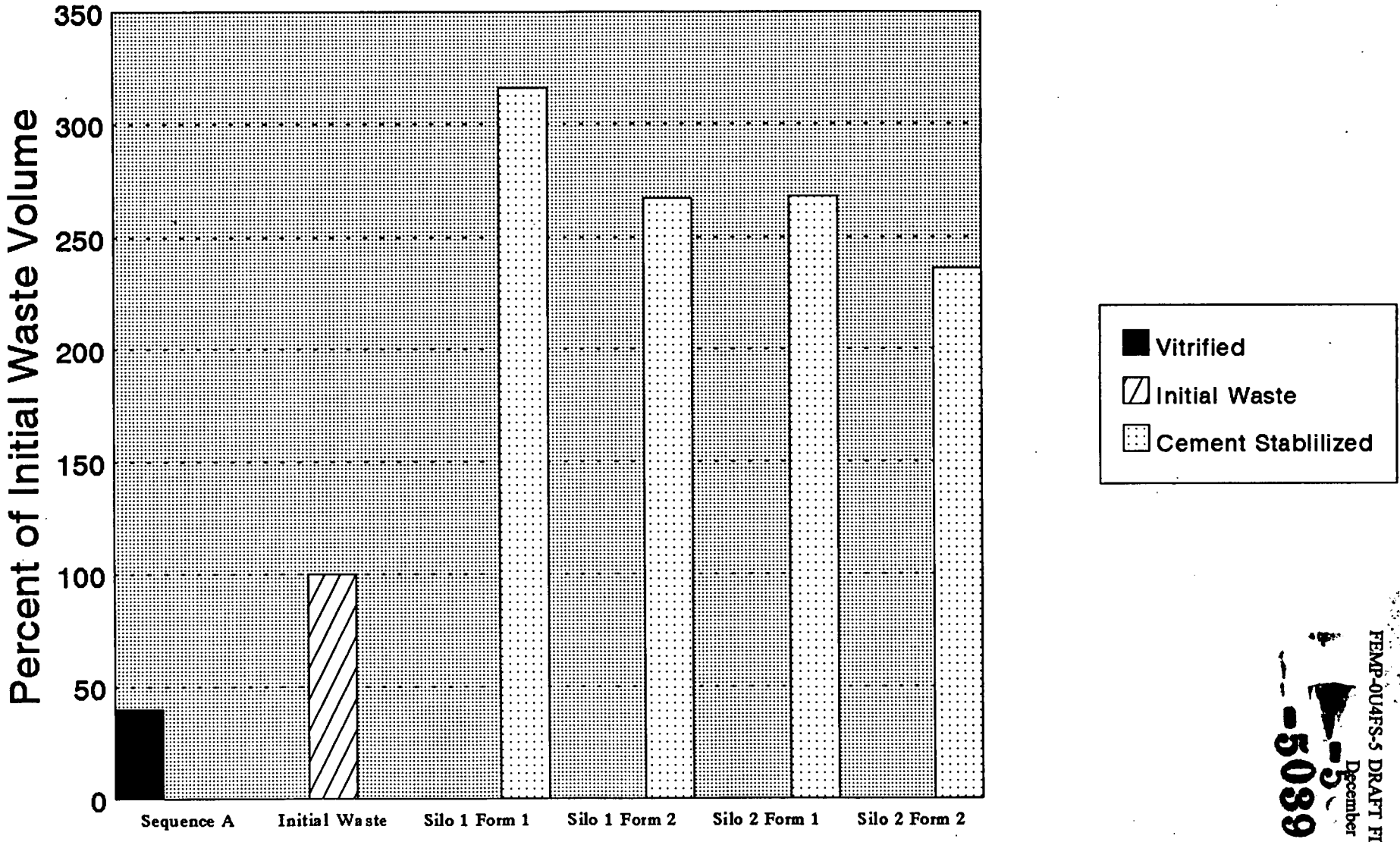
Cement Stabilization formulations used to fix contaminants in the waste form matrix included cement and the following reagents in various proportions: flyash, attapulgite, clinoptilolite, ferrous chloride, and blast furnace slag. For the vitrification process formulations, reagents consisting of sodium carbonate and for Silos 1 and 2 and silica, alumina, and boric acid for Silo 3 were utilized. These additives provided near optimal conditions for the necessary heat transfer process to occur based on the specific chemical make-up of the silo residues.

Figure C.4-1 provides a graphical comparison of the effect of the vitrification and cement stabilization process options on final waste form volume for Silos 1 and 2 waste. From this table, it can be seen that the cement stabilized waste form was two to three and a half times larger than that of the original untreated residues. In contrast, the vitrified waste form was roughly half the original untreated residue volume.

Figure C.4-2 provides a graphical comparison of the effect of the vitrification and cement stabilization process options on final waste form volume for Silo 3 waste. For this silo, cement stabilized waste forms resulted in a one and a half to one and two-thirds larger waste form than the original untreated residues. In contrast, the final vitrified waste form was one-third the volume of the untreated residues.

Figure C.4-1

Comparison of Volume Increase of Vitrified vs Cement Stablilized Material



(as compared to Silos 1 and 2 initial waste volume)

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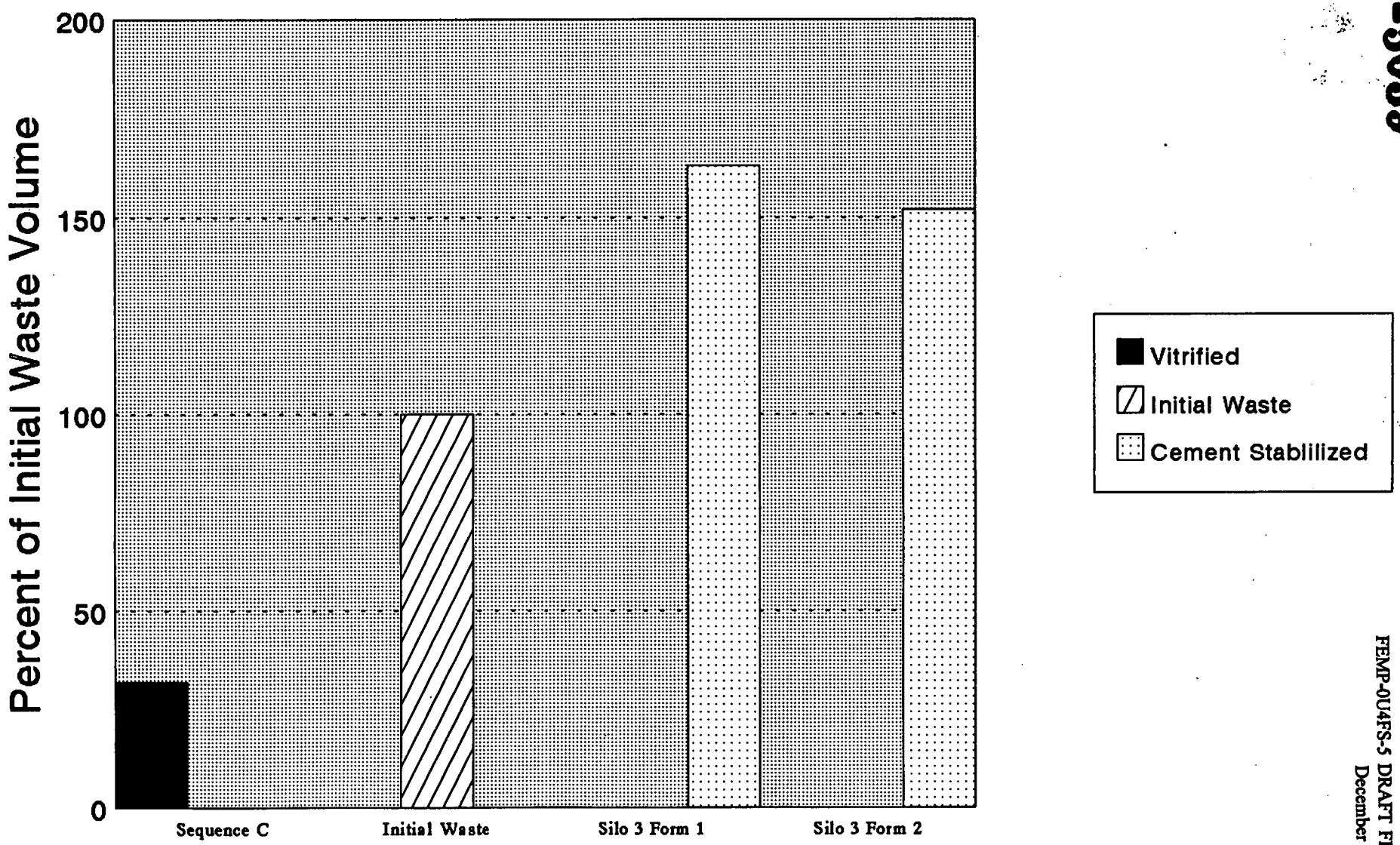
Figure C.4-2
Comparison of Volume Increase of Vitrified vs Cement Stabilized Material



(as compared to Silo 3 initial waste volume)

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C.4.6 CONCLUSIONS

Based on the preceding discussion comparing the vitrification and cement stabilization process options for treatment of Operable Unit 4 silo wastes, it is apparent that both processes are technically feasible treatment options for Operable Unit 4 silo residues. In addition, conclusions can be drawn for each of the evaluation criteria. These conclusions are listed by the individual evaluation criteria as follows:

Durability

- Both process options resulted in waste forms that are considered durable for all three silos, however, one of the two Silo 3 cement stabilization formulas was susceptible to relatively high weight loss during wet-dry durability testing.

Leachability

- Both process options resulted in waste forms that minimized leaching of key COCs for Silos 1 and 2 residues. The vitrification process outperformed cement stabilization for Ra-226 retention; while the cement stabilization process outperformed vitrification for Th-230 retention. Both processes performed well for minimizing Pb-210 and U-238 leaching, however, the cement stabilization process had a slight edge. There also may be an indication that the cement stabilization process may be more difficult to apply when waste is not homogeneous.

- Both process options resulted in waste forms that minimized leaching of key COCs for Silo 3 residues. The vitrification process outperformed cement stabilization for the retention of Ra-226. Cement stabilization outperformed vitrification for retention of U-238.

Radon Emanation

- The vitrification process provided much better radon emanation performance than the cement stabilized waste form. The cement stabilization process yielded little apparent benefit versus untreated residues relative to radon emanation performance.

Volume Changes

- The vitrification process resulted in significantly reduced volumes of waste versus significant increases in waste volume for the cement stabilization process option.

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APPENDIX D

PUBLIC HEALTH AND OCCUPATIONAL RISK CONSIDERATION FOR OPERABLE UNIT 4 FEASIBILITY STUDY AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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LIST OF ACRONYMS

ABS	adsorption factor
Ac	actinium
ACGIH	American Conference of Governmental and Industrial Hygienists
AF	skin adherence factor
ARAR	Applicable or Relevant and Appropriate Requirements
AT	averaging time
BEHP	bis(2-ethylhexyl)phthalate
BW	body weight
Ca	exposure point concentration in air
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CF	conversion factor
Ci	curie
cm	centimeter
CRARE	Comprehensive Response Action Risk Evaluation
CSF	cancer slope factor
CSV	chemical specific value
COC	constituents of concern
CPC	constituents of potential concern
CT	central tendency
DOE	United States Department of Energy
ED	exposure duration
EF	exposure frequency
EPA	United States Environmental Protection Agency
ET	Exposure Time
FEMP	Fernald Environmental Management Project
FI	fraction ingested from contaminated source
FS	Feasibility Study
ft	feet
g	gram
gal.	gallon
HEAST	Health Effects Assessment Summary Tables
HELP	hydrogeological evaluation of land performance
HEPA	high-efficiency particulate air
HI	Hazard Index
HQ	hazard quotient
hr	hour
IARC	International Agency for Research on Cancer
ICRP	International Commission of Radiological Production
ILCR	incremental lifetime cancer risk
in.	inch
IR	ingestion rate
IR	inhalation rate
IRIS	Integrated Risk Information System
K_d	soil partitioning coefficient
kg	kilogram
km	kilometer
km^2	square kilometers
L	liter
lb	pound

LIST OF ACRONYMS
(Continued)

LOAEL	lowest observed adverse effect level
m	meter
m^3	cubic meter
MCL	Maximum Contaminant Level
mg	milligram
mi	mile
mi^2	square miles
μg	microgram
mL	milliliter
mm	millimeter
mrem	milli-roentgen equivalent man
NA	not applicable
NCP	National Contingency Plan
NCRP	National Council of Radiation Protection
ND	not detected
NE	northeast
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NOAEL	no observed adverse effect level
NRC	Nuclear Regulatory Commission
NS	not selected
NTS	Nevada Test Site
NW	northwest
OAC	Ohio Administrative Code
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
Pa	proactinium
PAH	polyaromatic hydrocarbon(s)
Pb	lead
PCB	polychlorinated biphenyls
pCi	picocurie
Po	polonium
PRLs	proposed remediation levels
RA	remedial action
Ra	radium
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
Rn	radon
RTS	Radon Treatment System
Ru	ruthenium
SA	skin surface area available for contact
SE	southeast
SF	inhalation slope factor
SOWC	Southwest Ohio Water Company
Sr	strontium
SVOC	semi-volatile organic compounds
SW	southwest

LIST OF ACRONYMS
(Continued)

Tc	technetium
Th	thorium
TCLP	Toxicity Characteristic Leaching Procedure
TLV	threshold limit value
TWA	time-weighted average
U	uranium
UCL	upper confidence level
UF	uncertainty factor
VOC	volatile organic compounds
yr	year

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D.1.0 INTRODUCTION

The purpose of Appendix D is to provide risk assessment information and data for the remedial alternative selection process for Operable Unit 4 at the Fernald Environmental Management Project (FEMP) site. This appendix presents a summary of the baseline conditions at the site, including a list of radionuclides and other constituents of potential concern (CPC) along with information describing toxicity, mobility, and environmental persistence. This information establishes "baseline" physicochemical properties of the Operable Unit 4 material for engineers concerned with the Feasibility Study (FS) Section 4.0 detailed analyses of alternatives balancing criteria "reduction of toxicity, mobility, or volume through treatment." A summary of the baseline risk characterization, which indicates that baseline conditions do not meet acceptable public health risk criteria, is also presented.

This appendix also provides the risk assessment information and data necessary to support the FS Section 4.0 detailed analyses of alternatives balancing criteria, "long-term effectiveness and permanence" and "short-term effectiveness." This information and data includes risk assessments for alternatives from both short-term (risks due to remedial action) and long-term (residual risk following remedial action) viewpoints.

D.2.0 SUMMARY OF BASELINE RISK ASSESSMENT

This section contains a summary of risk characterization results from the Operable Unit 4 Baseline Risk Assessment as reported in the Remedial Investigation (RI) Report. A presentation and discussion of the risks associated with exposure to background concentrations of chemicals and radionuclides in soil is also included for comparison.

D.2.1 BASELINE RISK ASSESSMENT RESULTS

The Baseline Risk Assessment was performed in accordance with available U.S. Environmental Protection Agency (EPA) guidance for conducting Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) risk assessments and the methodology described in the Risk Assessment Work Plan Addendum (DOE 1992) for performing risk assessments at the FEMP. The process of selecting CPCs is summarized in Section D.2.0 of the RI Report for Operable Unit 4. Tables D.2-3 and D.2-4 of the Baseline Risk Assessment list CPCs for the material inside the K-65 Silos and Silo 3, respectively. These CPCs are listed in Tables 2-3 and 2-4 of the FS Report. These CPCs include members of the uranium (U)-238, U-235, and thorium (Th)-232 decay series as well as a number of organic compounds and inorganics.

Tables D.2-5, D.2-6, and D.2-7 of the Baseline Risk Assessment contain a listing of CPCs for three data sets: surface soil plus berm fill material; berm fill material only; and surface soil respectively. The summary that represents surface soil plus berm fill material is used for the quantitative risk assessment because the data and corresponding data summaries for these three data sets are similar. The CPCs for this data set include the members of the U-238 and Th-232 decay series, Technetium (Tc)-99, Strontium (Sr)-90, and a number of inorganics and organic compounds. These CPCs are listed in Tables 2-3 and 2-4 of the FS.

The Risk Assessment Work Plan Addendum defines land use and receptor combinations to be considered, as appropriate, in FEMP risk assessments. The Baseline Risk Assessment for Operable Unit 4 evaluated the following land use/receptor combinations:

- Current land use, without access controls, current source term
  - trespassing child
  - groundskeeper
  - off-property resident farmer
  - off-property user of surface water

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- Current land use, without access controls, future source term
  - trespassing child
  - groundskeeper
  - off-property resident farmer
  - off-property user of surface water

- Current land use, with access controls, current source term
  - trespassing child
  - off-property resident farmer
  - off-property user of surface water

- Future land use, current source term
  - off-property resident farmer
  - off-property user of surface water
  - central tendency (CT) on-property resident farmer
  - reasonable maximum exposure (RME) on-property resident farmer
  - on-property resident child

- Future land use, future source term
  - off-property resident farmer
  - off-property user of surface water
  - CT on-property resident farmer
  - RME on-property resident farmer
  - on-property resident child

The current source term assumes that the silos, domes, and bentonite covers (bentonite layer covering the Silos 1 and 2 residue) remain intact and there is no release of silo contents. The future source term assumes that domes of Silos 1 and 2, and the domes and walls of Silo 3 collapse, exposing the Silos 1 and 2 bentonite covers and the Silo 3 residues to the atmosphere.

Estimated risks for each receptor exposure route quantitatively evaluated under current and future land-use scenarios are tabulated in Attachment D.II of the Baseline Risk Assessment. Estimated risks summed across pathways within each exposure medium for each receptor under current and future land-use conditions are tabulated and briefly discussed in Section D.5.0 of the Baseline Risk Assessment. Total radiological incremental lifetime cancer risk (ILCR) and chemical ILCR values for each receptor and exposure medium combination under the future source-term scenario are presented in Table D.2-1 of this appendix.

The future source-term scenario is summarized because it represents the worst-case scenario for risk. Under the future source-term scenario, the trespassing child is exposed to soil, air, surface water, and

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TABLE D.2-1

SUMMARY OF BASELINE ILCR BY RECEPTOR FOR THE FUTURE SOURCE TERM

	Risk Type	Receptor: Trespassing Child	Groundskeeper	Off-Property Resident Farmer	Off-Property Surface Water User	On-Property Farmer (CT)	On-Property Farmer (RME) Great Miami Aquifer	On-Property Farmer (RME) Perched Water	On-Property Resident Child
GROUNDWATER	Radiological	N/A[a]	N/A	1E-05	N/A	5E-06	7E-05	3E-01	2E-05
	Chemical	N/A	N/A	None	N/A	None	None	1E-02	None
	Total	N/A	N/A	1E-05	N/A	5E-06	7E-05	3E-01	2E-05
AIR	Radiological	8E-07	2E-06	2E-06	N/A	3E-06	5E-05	5E-05	9E-07
	Chemical	2E-05	4E-05	2E-04	N/A	2E-04	3E-03	3E-03	1E-03
	Total	2E-05	4E-05	2E-04	N/A	2E-04	3E-03	3E-03	1E-03
SOIL	Radiological	8E-03	2E-02	N/A	N/A	1E-01	1E+00	1E+00	1E-01
	Chemical	4E-04	5E-04	N/A	N/A	1E-02	2E-01	2E-01	9E-02
	Total	9E-03	2E-02	N/A	N/A	1E-01	1E+00	1E+00	2E-01
SURFACE WATER	Radiological	2E-06	N/A	N/A	1E-06	N/A	N/A	N/A	8E-07
	Chemical	9E-05	N/A	N/A	7E-07	N/A	N/A	N/A	2E-06
	Total	9E-05	N/A	N/A	2E-06	N/A	N/A	N/A	2E-06
SEDIMENT	Radiological	9E-04	N/A	N/A	N/A	N/A	N/A	N/A	8E-03
	Chemical	2E-06	N/A	N/A	N/A	N/A	N/A	N/A	9E-05
	Total	9E-04	N/A	N/A	N/A	N/A	N/A	N/A	8E-03
TOTAL ALL MEDIA	Radiological	9E-03	2E-02	1E-05	1E-06	1E-01	1E+00	1E+00	1E-01
	Chemical	5E-04	6E-04	2E-04	7E-07	1E-02	2E-01	2E-01	9E-02
	Total	1E-02	2E-02	2E-04	2E-06	1E-01	>UNITY	>UNITY	2E-01

[a]N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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sediment exposure routes. The total radiological plus chemical ILCR from exposure to all of these media is 1 x 10^{-2} (Table D.2-1). This risk is primarily attributable to radiological risk from radium (Ra)-226 + 5 daughters and Th-228 + 7 daughters in soil from the external radiation exposure route (Tables D.II-2 and D.5-4 of the Baseline Risk Assessment). The risks contributed by the exposure routes associated with air (2 x 10^{-5}), surface water (9 x 10^{-5}), and sediment (9 x 10^{-4}) media are relatively minor in comparison to risks from direct radiation from soil (8 x 10^{-3}).

Under the future source-term scenario, the groundskeeper is exposed to soil and air exposure routes. The total radiological plus chemical ILCR from exposure to both media is 2 x 10^{-2} (Table D.2-1). This risk is primarily attributable to radiological risk from Ra-226 + 5 daughters and Th-228 + 7 daughters in soil from the external radiation exposure route (Tables D.II-6 and D.5-8 of the Baseline Risk Assessment). The risks contributed by air related exposure routes (4 x 10^{-5}) are minor in comparison to risks from soil related exposure routes (2 x 10^{-2}).

Under the future source-term scenario, the hypothetical off-property resident farmer could be exposed to CPCs through exposure routes associated with groundwater and air. The total radiological plus chemical ILCR from exposure to both of these media is 2 x 10^{-4}. This risk is primarily attributable to chemical risk from arsenic in foodstuffs subject to deposition of contaminants from air (Tables D.II-10 and D.5-13 of the Baseline Risk Assessment). The risks contributed by groundwater (1 x 10^{-5}) are minor in comparison to risks from air exposure routes (2 x 10^{-4}).

Under the future source-term scenario, the off-property user of surface water is exposed to surface water exposure routes from use of the Great Miami River. The total radiological plus chemical ILCR from all of the surface water exposure routes is 2 x 10^{-6} (Table D.2-1). This risk is primarily attributable to radiological risk from drinking river water containing U-234 and U-238 and chemical risk from drinking river water containing arsenic and eating fish from the river (Tables D.II-14 and D.5-17 of the Baseline Risk Assessment).

Under the future source-term scenario, the CT on-property resident farmer is exposed to soil, air, and groundwater exposure routes. The total radiological plus chemical ILCR from exposure to all of these media is 1 x 10^{-1} (Table D.2-1). This risk is primarily attributable to radiological risk from Ra-226 + 5 daughters and Th-228 + 7 daughters in soil from the external radiation exposure route (Tables D.II-18 and D.5-21 of the Baseline Risk Assessment). Although they are greater than 1x10^{-6},

the risks contributed by air (2×10^{-4}) and groundwater (5×10^{-6}) exposure routes are minor in comparison to risks from soil exposure routes (1×10^{-1}).

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Under the future source-term scenario, the RME on-property resident farmer is exposed to soil, air, and groundwater exposure routes. The total radiological plus chemical ILCR is greater than unity (Table D.2-1) and is primarily attributable to radiological risk from Ra-226 + 5 daughters and Th-228 + 7 daughters in soil from the external radiation exposure route (Tables D.II-22 and D.5-25 of the Baseline Risk Assessment). Although the risks contributed by air (3×10^{-3}) and groundwater (7×10^{-5}) exposure routes are considerably greater than 1×10^{-6}, they are minor in comparison to risks from soil exposure routes (greater than unity).

If the RME on-property resident farmer is exposed to perched groundwater as an alternative to groundwater from the Great Miami Aquifer and to soil and air exposure routes as described above, the total radiological plus chemical ILCR is again greater than unity (Table D.2-1). As discussed above, this risk is primarily attributable to radiological risk from Ra-226 + 5 daughters and Th-228 + 7 daughters in soil from the external radiation exposure route (Tables D.II-25 and D.5-26 of the Baseline Risk Assessment). The risk contributed by air is 3×10^{-3} as discussed above; however, the risk contributed by perched groundwater increases to 3×10^{-1}. These risks are minor in comparison to risks from soil exposure routes (unity).

Under the future source-term scenario, the on-property resident child is exposed to soil, air, groundwater, surface water, and sediment exposure routes. The total radiological plus chemical ILCR is 2×10^{-1} (Table D.2-1). This risk is primarily attributable to radiological risk from Ra-226 + 5 daughters and Th-228 + 7 daughters in soil from the external radiation exposure route and chemical risk from arsenic and Indeno(1,2,3-cd)pyrene in foodstuffs subject to root uptake from soil (Tables D.II-28 and D.5-31 of the Baseline Risk Assessment). Although the risk contributed by air (1×10^{-3}), groundwater (2×10^{-5}), surface water (2×10^{-6}), and sediment (8×10^{-3}) exposure routes are all greater than 1×10^{-6}, they are minor in comparison to risks from soil (2×10^{-1}).

Total Hazard Index (HI) toxicity values for each receptor and exposure medium combination under the future source-term scenarios are presented in Table D.2-2 . The future source-term scenario is summarized because it represents the worst-case scenario for hazards associated with non-carcinogenic CPCs.

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TABLE D.2-2

SUMMARY OF BASELINE TOXICITY HI BY RECEPTOR FOR THE FUTURE SOURCE TERM[a]

Medium	Receptor							
	Trespassing Child	Groundskeeper	Off-Property Resident Farmer	Off-Property Surface Water User	On-Property Farmer (CT)	On-Property Farmer (RME) Great Miami Aquifer	On-Property Farmer (RME) Perched Water	On-Property Resident Child
GROUNDWATER	N/A	N/A	0.1	N/A	0.5	0.9	30	3
AIR	20	10	5	N/A	50	100	100	200
SOIL	50	4	N/A	N/A	200	400	400	2000
SURFACE WATER	20	N/A	N/A	0.002	N/A	N/A	N/A	0.5
SEDIMENT	0.09	N/A	N/A	N/A	N/A	N/A	N/A	6
TOTAL ALL MEDIA	80	20	5	0.002	300	500	500	2000

[a]All values have been rounded to the nearest significant number as presented in the Final RI Report for Operable Unit 4 (November 1993).
N/A signifies that exposure of the receptor to the indicated medium is not applicable.

Under the future source-term scenario, the trespassing child is exposed to air, soil, surface water, and sediment exposure routes (Tables D.II-4 and D.5-5 of the Baseline Risk Assessment). The total HI from exposure to all of these media is 80. The highest medium-specific HI (50) is for soil, with major contributing chemicals being uranium, arsenic, chromium, manganese, thallium, and vanadium from the dermal exposure route. The next highest HI (20) is for air, attributable almost entirely to cobalt. As discussed in Section D.4.2.9.2 of the Baseline Risk Assessment; however, the relevance of the inhalation reference dose (R_fD) [hence the Hazard Quotient (HQ)] for environmental exposure to cobalt is doubtful. The HI for surface water (20) is attributable largely to dermal contact with uranium. The exposure to HI for sediment (0.09) does not represent a significant hazard.

Under the future source-term scenario, the groundskeeper is exposed to air and soil exposure routes (Tables D.II-8 and D.5-9 of the Baseline Risk Assessment). The total HI from exposure to both these media is 20. The highest medium-specific HI (10) is for air, attributable almost entirely to the effects of cobalt on the respiratory system. As previously discussed, however, the relevance of the HQ for cobalt to environmental exposure is doubtful. The HI for soil (4) is attributable almost entirely to dermal contact with uranium.

Under the future source-term scenario, the off-property resident farmer is exposed to groundwater and air exposure routes (Tables D.II-12 and D.5-14 of the Baseline Risk Assessment). The total HI from exposure to both these media is 5. The HI for air (5) is attributable almost entirely to cobalt, which, as previously noted, is probably not relevant to environmental exposure. The HI for exposure to groundwater (0.1) does not represent a significant hazard.

Under the future source-term scenario, the surface water user is exposed only to surface water exposure routes (Tables D.II-16 and D.5-18 of the Baseline Risk Assessment). The total HI for exposure to surface water 0.002, does not represent a significant hazard.

Under the future source-term scenario, the CT on-property resident farmer is exposed to groundwater, air, and soil exposure routes (Tables D.II-20 and D.5-22 of the Baseline Risk Assessment). The total HI from exposure to all these media is 300. The highest HI (200) is for exposure to soil, attributable largely to antimony, arsenic, cadmium (food), manganese (food), nickel, selenium, silver, thallium, uranium, vanadium, and zinc via ingestion of foodstuffs impacted by soil. The next highest HI (50) is for exposure to air, which is attributable almost entirely to cobalt. As

previously noted, the relevance of the HQ for cobalt to environmental exposure is doubtful. The HI for exposure to groundwater (0.5) represents no significant hazard.

Under the future source-term scenario, the RME on-property resident farmer is exposed to groundwater, air, and soil exposure routes. Two analyses are provided: one for exposure to groundwater from the Great Miami Aquifer and one for exposure to perched water. The total HI for all media, including groundwater from the Great Miami Aquifer, is 500 (Tables D.II-24 and D.5-27 of the Baseline Risk Assessment). The highest HI (400) is for exposure to soil, attributable largely to arsenic, cadmium (food), mercury, nickel, thallium, and uranium via ingestion of foodstuffs impacted by soil. The next highest HI (100) is for exposure to air, attributable largely to inhalation of cobalt. As noted above, the HQ for inhalation of cobalt is probably not relevant for environmental exposure. Significant hazard is also associated with arsenic via ingestion of foodstuffs impacted by deposition from air. The HI of 0.9 for groundwater is attributed entirely to uranium, largely via ingestion in drinking water and foodstuffs impacted by ingestion.

The total HI for the RME on-property resident farmer for all media, including groundwater from perched water, is 500 (Tables D.II-26 and D.5-28 of the Baseline Risk Assessment). The HI values for soil pathways (400) and air pathways (100) are the same as described above for this receptor exposed to soil, air, and groundwater from the Great Miami Aquifer. The HI for exposure to groundwater from perched water (30) is markedly greater than the HI for exposure to groundwater from the Great Miami Aquifer (0.9). The HI for perched water is due largely to arsenic, cadmium (water), thallium, and vanadium; drinking water ingestion was the only exposure pathway evaluated for perched water.

Under the future source-term scenario, the on-property resident child is exposed to groundwater, air, surface water, sediment, and soil exposure routes (Tables D.II-30 and D.5-32 of the Baseline Risk Assessment). The total HI from exposure to all these media is 2000. The highest HI (2000) is for exposure to soil, attributable largely to antimony, arsenic, cadmium (food), chromium, manganese, mercury, nickel, selenium, silver, thallium, uranium, vanadium, and zinc, predominantly from ingestion of foodstuffs impacted by soil. The next highest HI (200) is for exposure to air. The major contribution is from inhalation exposure to cobalt, which as previously noted, is probably not relevant for environmental exposure. Other significant contributions to hazard from air come from arsenic, manganese, nickel, thallium and uranium via ingestion of foodstuffs impacted by deposition from air. The HI for exposure to sediment (6) arises largely from incidental ingestion of arsenic, cadmium

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(food), selenium, thallium, and vanadium. The HI for exposure to groundwater (3) arises entirely from uranium, predominantly from ingestion of drinking water.

Under the current source term scenario, the silos are assumed to be intact, resulting in significantly reduced exposure point concentrations and estimated risks. Tables D.2-3 and D.2-4 provide the estimated ILCR and toxicity HI values, respectively, for each of the previously identified receptors under the current source-term scenario.

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TABLE D.2-3

SUMMARY OF BASELINE ILCR BY RECEPTOR FOR THE CURRENT SOURCE TERM

Medium	Risk Type	Receptor: Trespassing Child	Groundskeeper	Off-Property Resident Farmer	Off-Property Surface Water User	On-Property Farmer (CT)	On-Property Farmer (RME) Great Miami Aquifer	On-Property Farmer (RME) Perched Water	On-Property Resident Child
GROUNDWATER	Radiological	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Chemical	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Total	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
AIR	Radiological	2E-08	5E-08	1E-08	N/A	8E-08	1E-06	N/A	2E-08
	Chemical	5E-07	8E-07	1E-04	N/A	9E-05	1E-03	N/A	9E-04
	Total	**5E-07**	**9E-07**	**1E-04**	**N/A**	**9E-05**	**1E-03**	**N/A**	**9E-04**
SOIL	Radiological	1E-05	3E-05	N/A	N/A	2E-04	2E-03	N/A	2E-04
	Chemical	1E-05	2E-05	N/A	N/A	5E-03	8E-02	N/A	5E-02
	Total	**2E-05**	**4E-05**	**N/A**	**N/A**	**5E-03**	**8E-02**	**N/A**	**5E-02**
SURFACE WATER	Radiological	1E-08	N/A	N/A	1E-07	N/A	N/A	N/A	5E-09
	Chemical	1E-06	N/A	N/A	1E-07	N/A	N/A	N/A	2E-08
	Total	**1E-06**	**N/A**	**N/A**	**2E-07**	**N/A**	**N/A**	**N/A**	**2E-08**
SEDIMENT	Radiological	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Chemical	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Total	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
SILOS	Radiological	5E-03	1E-04	N/A	N/A	2E-04	2E-03	N/A	9E-03
TOTAL ALL MEDIA		**5E-03**	**2E-04**	**1E-04**	**2E-07**	**5E-03**	**1E-01**	**N/A**	**6E-02**

N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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TABLE D.2-4

SUMMARY OF BASELINE TOXICITY III BY RECEPTOR FOR THE CURRENT SOURCE TERM

Medium	Receptor							
	Trespassing Child	Groundskeeper	Off-Property Resident Farmer	Off-Property Surface Water User	On-Property Farmer (CT)	On-Property Farmer (RME) Great Miami Aquifer	On-Property Farmer (RME) Perched Water	On-Property Resident Child
GROUNDWATER	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AIR	3E-02	3E-02	5E-02	N/A	3E-01	5E-01	N/A	2E+00
SOIL	1E+00	8E-02	N/A	N/A	8E+00	2E+01	N/A	1E+02
SURFACE WATER	2E+00	N/A	N/A	4E-04	N/A	N/A	N/A	6E-02
SEDIMENT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TOTAL ALL MEDIA	**3E+00**	**1E-01**	**5E-02**	**4E-04**	**8E+00**	**2E+01**	**N/A**	**1E+02**

N/A signifies that exposure of the receptor to the indicated medium is not applicable.

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D.2.2 RISKS FROM NATURAL BACKGROUND

All site-related risks in the risk assessment are calculated without subtracting the contribution from natural background. In some areas in Operable Unit 4, the CPC concentrations are only slightly above background levels. Therefore, it is important to calculate the risks from background contributions to provide a point of comparison for the site-related risk estimates.

Risks and HQs are calculated for background concentrations of CPCs in soil. These results are tabulated in Tables D.2-5 and D.2-6 and include the same exposure pathways quantitatively evaluated for the RME on-property resident farmer for soil. Risks and HQs for the RME on-property resident farmer from site-related CPC exposure point concentrations in soil are also presented in Tables D.2-5 and D.2-6. The risk assessment models and parameter values used for these background calculations are the same as those used for evaluating site-related risks to the RME on-property resident farmer. Soil concentrations used for background risk and HQ calculations are calculated upper confidence level (UCL) values for the site-specific background soil sample analytical results.

Background risks from radionuclides and their short-lived daughters exceed 1×10^{-4}. The exposure pathway that contributes nearly all of this risk is external radiation exposure from Ra-226, Th-228, and Ra-228 (and their short-lived daughters) in surface soil. It is also important to note that the overall lifetime risk from natural background radiation sources (such as cosmic radiation, primordial radionuclides in surface soil, and radon) is approximately 1×10^{-2}. Risks from background concentrations of arsenic and beryllium in soil also exceed 1×10^{-4}.

HQs have been calculated for natural background concentrations of inorganic chemicals in soil. Results of these calculations for the RME on-property resident adult are given in Table D.2-6. The soil concentrations are calculated UCLs for the site-specific background soil sample analytical results. The HQs estimated, using background UCLs and EPA methodology, exceed 0.1 for six metals: arsenic, boron, cadmium, manganese, mercury, and thallium. The HQ for natural background levels of mercury exceeds one. The results of the calculation of risks and the potential for toxic effects from natural background concentrations of radionuclides and inorganic chemicals suggest that the risk assessment methodology has a conservative bias.

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TABLE D.2-5

ILCR FOR THE RME ON-PROPERTY RESIDENT FARMER, FUTURE LAND USE, EXPOSED TO BACKGROUND SOIL CONCENTRATIONS VERSUS SITE-RELATED SOIL CONCENTRATIONS FROM THE FUTURE SOURCE-TERM SCENARIO

Radionuclide	0"-6" UCL Background Soil Concentration[a] (pCi/g)	Background Risk	Site-Related Soil Concentration (pCi/g)	Site-Related Risk
Ac-227 + 7 daughters	9.0×10^{-2}	3×10^{-6}	9.3×10^{2}	3×10^{-2}
Cs-137 + 1 daughter	4.4×10^{-1}	4×10^{-5}	ND[b]	--
Pb-210 + 2 daughters	1.0×10^{0}	3×10^{-5}	3.5×10^{3}	8×10^{-2}
Ra-226 + 5 daughters	1.2×10^{0}	3×10^{-4}	3.9×10^{3}	6×10^{-1}
Ra-228 + 1 daughter	1.1×10^{0}	1×10^{-4}	4.1×10^{2}	5×10^{-2}
Th-228 + 7 daughters	1.1×10^{0}	3×10^{-4}	7.5×10^{2}	2×10^{-1}
Th-230	1.5×10^{0}	1×10^{-7}	6.0×10^{4}	4×10^{-3}
Th-232	1.1×10^{0}	6×10^{-8}	8.4×10^{2}	5×10^{-5}
U-234	1.0×10^{0}	3×10^{-7}	1.7×10^{3}	6×10^{-4}
U-235 + 1 daughter	8.8×10^{-2}	9×10^{-7}	1.2×10^{2}	1×10^{-3}
U-238 + 2 daughters	1.1×10^{0}	2×10^{-6}	1.8×10^{3}	4×10^{-3}
Total	--	**8×10^{-4}**	--	**1×10^{0}**

Chemical	0"-6" UCL Background Soil Concentration[c] (mg/kg)	Background Risk	Site-Related Soil Concentration (mg/kg)	Site-Related Risk[d]
Arsenic	6.0×10^{0}	2×10^{-4}	3.2×10^{3}	1×10^{-1}
Beryllium[e]	6.0×10^{-1}	2×10^{-4}	2.9×10^{1}	1×10^{-2}
Total	--	**4.0×10^{-4}**	--	**2×10^{-1}**

[a]Radionuclide UCL background concentrations in soil (0"-6") are obtained from Table 4-9 of the CERCLA/RCRA Background Soil Study dated March 19, 1993.
[b]ND - Not detectable at minimal detect levels.
[c]Chemical UCL background concentrations in soil (0"-6") are obtained from Table 4-8 of the CERCLA/RCRA Background Soil Study dated March 19, 1993.
[d]Total site-related risk includes additional contributions from organic contaminants not listed in this table because there are no background levels for comparison.
[e]UCL was not calculated; frequency of detection was 1/30.

TABLE D.2-6

HAZARD QUOTIENTS FOR THE RME ON-PROPERTY RESIDENT FARMER, FUTURE LAND USE, EXPOSED TO BACKGROUND SOIL CONCENTRATIONS VERSUS SITE-RELATED SOIL CONCENTRATIONS FROM THE FUTURE SOURCE-TERM SCENARIO

Chemical	0"-6" UCL Background Soil Concentration[a] (mg/kg)	Background Hazard Quotient	Site-Related Soil Concentration (mg/kg)	Site-Related Hazard Quotient
Arsenic	6.0×10^{0}	3.6×10^{-1}	3.2×10^{3}	2×10^{2}
Beryllium	6.0×10^{-1}	9×10^{-3}	2.9×10^{1}	5×10^{-1}
Barium	7.9×10^{1}	4×10^{-2}	2.8×10^{2}	2×10^{-1}
Boron	1.2×10^{1}	5×10^{-1}	b	--
Cadmium	4.0×10^{-1}	1×10^{-1}	9.4×10^{1}	4×10^{1}
Chromium	1.2×10^{1}	8×10^{-3}	4.0×10^{2}	3×10^{0}
Cobalt	1.1×10^{1}	8×10^{-3}	2.6×10^{3}	3×10^{0}
Manganese	9.8×10^{2}	9×10^{-1}	5.2×10^{3}	5×10^{0}
Mercury[c]	3.0×10^{-1}	6×10^{0}	7.0×10^{-1}	3×10^{1}
Molybdenum	ND[d]	--	6.1×10^{0}	3×10^{-1}
Nickel	1.3×10^{1}	8×10^{-2}	4.3×10^{3}	3×10^{1}
Silver	ND	--	1.8×10^{1}	7×10^{0}
Thallium[c]	5.8×10^{-1}	3×10^{-1}	5.6×10^{1}	4×10^{1}
Uranium[e]	2.3×10^{0}	2×10^{-2}	3.7×10^{3}	4×10^{1}
Vanadium	2.2×10^{1}	3×10^{-2}	3.5×10^{3}	6×10^{0}
TOTAL HAZARD INDEX				**400**

[a]Chemical UCL background concentrations in soil (0"-6") are obtained from Table 4-8 of the CERCLA/RCRA Background Soil Study dated March 19, 1993.
[b]Not a CPC.
[c]UCL was not calculated; frequency of detection was 1/30.
[d]ND - Not detectable at minimun detection limits.
[e]Total uranium arithmetic mean background concentration in soil is obtained from Table 4-9 of the CERCLA/RCRA Background Soil Study dated March 19, 1993.

D.3.0 FEASIBILITY STUDY RISK CONSIDERATIONS

Section D.3.1 summarizes the Operable Unit 4 subunits and remedial action alternatives. Section D.3.2 discusses potential receptors and exposure pathways, and presents the parameters used in the exposure calculations. As presented in Section D.3.2, short-term and long-term conceptual models have been developed to ensure that the range of potential release mechanisms and exposure pathways have been identified. Hypothetical receptors have been identified for each exposure scenario to ensure that RMEs to an individual in the remediation workforce or public are approximated. This approach is consistent with EPA guidance and the Risk Assessment Work Plan Addendum, and provides a measure of risk that can be used to 1) evaluate the relative effectiveness of various remediation alternatives and 2) evaluate the absolute effectiveness of each alternative relative to risk criteria and ARARs. Lastly, the RME approach ensures that potential risks to other individuals in the potentially exposed populations are less than the RME.

Short-term and long-term exposures are evaluated separately in Sections D.3.2.1 and D.3.2.2, respectively. Toxicity data relevant to the assessment of both short-term and long-term risks is presented in Section D.3.3. Short-term risks are assessed in Section D.3.4 while long-term risks are assessed in Section D.3.5. Section D.4 summarizes the risk assessment results, and Section D.5 discusses uncertainties present in the assessment.

The detailed analysis of Operable Unit 4 remedial action alternatives is presented in Section 4.0 of the FS, where each alternative is evaluated relative to the nine National Contingency Plan (NCP) criteria. Two of these criteria are short-term effectiveness and long-term effectiveness.

The short-term effectiveness criterion addresses the effect of an alternative during the construction and implementation phase until the remedial action objectives are achieved. The evaluation considers the effects on human health and the environment posed by operations conducted during the remedial action. The long-term effectiveness criterion evaluates the extent to which an alternative achieves an overall reduction in risk to human health and the environment after the remedial action objectives have been met.

The risk assessment presented in this appendix supports the application of these criteria through the evaluation of human health risks resulting from potential short-term and long-term exposures associated with the Operable Unit 4 remedial action alternatives. Section D.3.1 summarizes the Operable Unit 4 subunits and remedial action alternatives. Section D.3.2 discusses potential receptors and exposure

pathways and presents the parameters used in the exposure calculations. Short-term and long-term exposures are evaluated separately in Sections D.3.2.1 and D.3.2.2 respectively. Toxicity data relevant to the assessment of both short-term and long-term risks are assessed in Section D.3.5. Section D.4 summarizes the risk assessment results, and Section D.5 discusses uncertainties present in the assessment.

D.3.1 DESCRIPTION OF SUBUNITS AND REMEDIAL ALTERNATIVES ACTIVITIES

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D.3.1.1 Subunits

Operable Unit 4 is divided into three subunits in the FS process to facilitate dealing separately with the contents of the silos, the soil, and the silo structural materials. These three subunits are:

- Subunit A - the contents of Silos 1 and 2 and the sludge in the bottom of the decant sump tank
- Subunit B - the cold metal oxides contained in Silo 3
- Subunit C - the berm fill material, surface and subsurface soil associated with the operable unit, Silos 1, 2, 3, and 4 structures, standing water within Silo 4 (if any), the decant sump tank, any liquid within the tank, and debris generated consequential to remedial activities for Subunits A and B

Individual discussions follow for each of the three subunits.

Subunit A - Contents of Silos 1 and 2: Remedial alternatives that handle the contents of Silos 1 and 2 and the sludge in the decant sump tank are referred to by the letter "A." The material inside Silos 1 and 2 is a residual product of the K-65 uranium ore processing activities performed at the FEMP site and other facilities. The residues contain radionuclides of the uranium, actinium, and thorium natural decay series that remain after processing to extract uranium isotopes. These radionuclides include actinium (Ac)-227, proactinium (Pa)-231, lead (Pb)-210, polonium (Po)-210, Ra-224, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-234, U-235, and U-238. The residues inside Silos 1 and 2 contain particularly high concentrations of Ra-226, which produces radon (Rn)-222 gas. The 2.54-centimeter (cm) [1-inch (in.)] layer of sludge in the decant tank is considered part of Subunit A, while the decant system itself is part of Subunit C.

Subunit B - Contents of Silo 3: Remedial alternatives for the Silo 3 contents are referred to by the letter "B." The residual material inside Silo 3 is a metal oxide byproduct of uranium ore processing that contains concentrates of radionuclides of the three natural decay series, but in proportions different from the residues in Silos 1 and 2. The list of radionuclides includes those identified above for Silos 1 and 2; however, Silo 3 contains much lower concentrations of Ra-226 but higher concentrations of uranium.

Subunit C - Surface Soil, Berm Fill, and Subsurface Soil; Decant System, Silo 4, and Silos 1, 2, and 3 Structures: Remedial alternatives for this subunit are referred to by the letter "C." The surface soil

source term included in the conceptual model is defined by the coordinate boundaries of the Operable Unit 4 Study Area, as presented in the Risk Assessment Work Plan Addendum (DOE 1992). This surface soil is contaminated, possibly by historical spills during silo filling operations, transport of contaminated soil from areas outside Operable Unit 4 by natural erosive forces, or movement of contaminated soil to Operable Unit 4 from other areas of the FEMP as a result of operational activities at the site.

The berm fill source term included in the conceptual model represents fill material put in place after construction of Silos 1 and 2 to support the silo walls and eliminate the potential for wall collapse. The berm fill material may be a contaminant source because it is a large quantity of lightly contaminated material that is in direct contact with the exterior of the silo walls.

A quantity of subsurface soil beneath the Operable Unit 4 silos exhibits above-background contamination (based on sample analytical results from the slant boring samples of radionuclides). This soil is considered in the conceptual model because of the potential for migration of contaminants from the soil and from the silos and berms through the soil.

The decant system and silo structures are also part of Subunit C, and remedial alternatives for them are also referred to by the letter "C." The decant system is comprised of a series of gravity-fed drain lines beneath Silos 1 and 2 connecting to a decant sump tank. The tank is monitored regularly to estimate the quantity of material accumulating in the tank and to collect samples for radiological and chemical analyses. The liquid in the decant system represents a relatively small accumulation of contamination, and the tank will be removed during the implementation of all alternatives being considered under detailed analyses during remediation. As mentioned previously, the 2.54-cm (1-in.) inner layer of sludge within the tank is considered part of Subunit A.

The silo structures include the concrete walls, dome, and floor, as well as the asphalt-concrete base beneath the silos. The inner surfaces of the walls of Silos 1, 2, and 3 are contaminated because they are in direct contact with the stored material. Analyses of concrete wall cross sections from similar silos that contained K-65 residues at the Niagara Falls Storage site reveal that radon decay product radionuclides can be deposited within the concrete. In comparison to the quantity of material within the silos, the contaminated silo structures represent a minor source term. The inner layer of the concrete [approximately 2.54 cm (1 in.)] will be removed during remediation and addressed, if appropriate, as a component of Subunit A. Therefore, the remaining parts of silo structures are not likely to contain significant quantities of contaminants and are not included in the fate and transport modeling for the risk

assessment.

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Silo 4 was never employed for the storage of cold metal oxide residues and remains empty. Inspections completed on Silo 4 during the RI-related site investigations confirmed that no hazardous material was present within the silo. Silo 4 is not included in the conceptual model for the risk assessment as it is not contaminated with waste materials. Silo 4 will be dismantled as part of the remedial actions. The silo structure will be used as a test facility for the remediation of Subunits A and B.

D.3.1.2 Remedial Action Alternatives

As discussed in Section 4.0 of this FS Report, a number of remedial action alternatives have been identified and evaluated for each of the Operable Unit 4 subunits. Only those alternatives which are discussed in Section 4.0 are considered in this risk evaluation. Each of these alternatives is summarized in the sections that follow.

Alternatives Descriptions

With the exception of the no action alternative, Subunit A alternatives that remain after alternative development and screening include variations on treatment and disposal. All of the alternatives consider removing the waste materials from the silo and stabilizing by one of two methods. Alternatives 2A/Vit and 3A.1/Vit use vitrification to reduce the mobility and volume of the material prior to disposal. Alternatives 2A/Cem and 3A.1/Cem use cement stabilization to reduce the mobility of the contaminants.

Alternatives 2A/Vit and 2A/Cem consider on-property disposal of packaged, treated material. This disposal consists of a vault covered by a multi-layered cap with an intruder barrier. Additionally, to meet ARARs and to provide added protection, institutional controls are considered part of the alternatives. These controls are passive and primarily consist of DOE maintaining ownership of the facility and controlling access to the disposal area.

Alternatives 3A.1/Vit and 3A.1/Cem consider off-site disposal of the treated material at NTS. Treatment is necessary to meet the waste acceptance criteria of NTS. Included in the alternative is packaging and transporting the material to NTS. No material will remain at the FEMP site.

The alternatives for Subunit B contain the same components as those for Subunit A. They include 2B/Vit (vitrification and on-property disposal), 2B/Cem (cement stabilization and on-property disposal), 3B.1/Vit (vitrification and off-site disposal at NTS), 3B.1/Cem (cement stabilization and off-site disposal at NTS),

4B (removal and on-property disposal without stabilization), in addition to no action. Treatment of material in Subunit B is to provide added reliability to the alternatives but unlike Subunit A alternatives, is not required to meet NTS waste acceptance criteria.

All Subunit C alternatives (except for the no-action alternative) include demolition of the treatment facilities, four silos, tank, and piping and decontamination of grossly contaminated debris. They also include removal of surface soil which contains concentrations above proposed remediation levels (PRLs) for the expanded trespasser and removal of grossly contaminated soils beneath the silos. Clean soil is used as backfill to bring the surface to grade as necessary. The alternatives vary in the disposal location. Alternative 2C places contaminated debris and soil in an on-property disposal facility that uses a multilayer cap, Alternative 3C.1 takes the contaminated material and soil to NTS, and Alternative 3C.2 takes the contaminated material and soil to an off-site commercial facility located in an arid region.

D.3.2 POTENTIAL RECEPTORS, PATHWAYS, AND EXPOSURE PARAMETERS

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Exposure pathways describe the course a chemical or radiological contaminant takes from a source to a receptor. An exposure pathway generally consists of four elements:

1. A source and mechanism of contaminant release
2. A contaminant transport media/mechanism
3. A point of potential human contact
4. An exposure route and receptor

The Operable Unit 4 sources, release and transport mechanisms, exposure media/modes, and receptors have been evaluated in the sections that follow, relative to both short-term and long-term exposures. The various potential exposure pathways have been combined into conceptual site models that represent the realm of potential exposures considered in the assessments of short-term and long-term risks. Consistent with the EPA Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) and the Risk Assessment Work Plan Addendum, hypothetical receptors have been identified for each exposure scenario that ensures that RME to an individual in the remediation workforce or public are approximated. The resulting estimates of potential individual exposure are input to the subsequent assessment of potential health risks. Although contaminants potentially released during the implementation of Operable Unit 4 remediation alternatives may affect the broader population surrounding the FEMP, this assessment does not address collective risk to the population. Individual risk is an adequate measure for use in evaluating the effectiveness of remediation alternatives, and the RME receptor bounds the potential exposure by any individual, thereby providing adequate protection for the public.

The conceptual models also support identification of actions designed to eliminate or mitigate these pathways, as appropriate, through the use of treatment, containment, or site institutional control measures. Potential short-term exposures are discussed in Section D.3.2.1, while potential long-term exposures are discussed in Section D.3.2.2.

D.3.2.1 Short-Term Exposure

The remedial action alternatives involve a range of different work activities and varying degrees of short-term physical risk and potential exposure to Operable Unit 4 CPCs. The feasible remedial alternatives identified for the Operable Unit 4 subunits are listed in Table D.3-1, and the general categories of remedial work activities are identified for each alternative. The work activities include:

TABLE D.3-1

SUMMARY OF OPERABLE UNIT 4 SUBUNIT REMEDIAL ALTERNATIVES AND WORK ACTIVITIES

Alternative	Site Prep.	Partial Berm Removal	Construct Work Platform	Install RTS/Gas Treatment	Install Mining Device	Silos 1 and 2 Contents Removal	Silo 3 Contents Removal	Decant Tank Removal	Stabilize Material	Material Disposal	Silo Removal	Soil Removal
SUBUNIT A												
2A/Vit - Remove, Vitrify, On-Property Disposal	X	X	X	X	X	X		X	X	X		
2A/Cem - Remove, Cement, On-Property Disposal	X	X	X	X	X	X		X	X	X		
3A.1/Vit - Remove, Vitrify, Off-Property Disposal	X	X	X	X	X	X		X	X	X		
3A.1/Cem - Remove, Cement, Off-Property Disposal	X	X	X	X	X	X		X	X	X		
SUBUNIT B												
2B/Vit - Removal, Vitrification, On-Property Disposal	X		X	X	X		X		X	X		
2B/Cem - Removal, Cement, On-Property Disposal	X		X	X	X		X		X	X		
3B.1/Vit - Removal, Vitrification, Off-Property Disposal	X		X	X	X		X		X	X		
3B.1/Cem - Removal, Cement, Off-Property Disposal	X		X	X	X		X		X	X		
4B - Removal, On-Property Disposal	X		X	X	X		X			X		
SUBUNIT C												
2C - Demolition, Removal, and On-Property Disposal	X									X	X	X
3C.1 - Demolition, Removal, Off-Site Disposal (NTS)	X									X	X	X
3C-2 - Demolition, Removal, Off-Site Disposal (permitted commercial disposal site)	X									X	X	X

- Site Preparation: This will involve grading, excavating, and backfilling prior to the construction of the material processing facility. It also involves the installation of lighting, utilities, roads, fencing, etc.,.

- Partial Berm Removal: The berms around the K-65 Silos will be partially removed to enable the construction of the work platform.

- Construction of the Work Platform: The work platform will be used for the removal of material from the silos.

- Installation of Radon Treatment System (RTS): A RTS utilizing dehumidifiers, carbon absorbers, and high-efficiency particulate air (HEPA) filters will reduce the radon in the K-65 Silos domes void space during removal operations. The system will maintain the silo headspace under negative pressure to minimize the possibility of leakage. Workers will be on top of the dome while installing the RTS.

- Construction and Assembly of Mining Device: The K-65 Silos contents will be removed with a hydraulic mining device. The device, suspended from the work platform, will consist of a high-pressure water jetting system and a slurry pump to pump the slurried material from the silos to the material processing facility. Construction and assembly of the material removal device will take place in the area between Silos 3 and 4 (away from K-65 Silos); therefore, no direct radiation exposure is considered. Then the removal device will be moved into position and introduced into the silos through the manways during material removal.

- Silos 1 and 2 Contents Removal: The contents will be removed from the silos with the hydraulic mining device suspended from the work platform. The device will be introduced through the silo manways and will be remotely operated from a control station located approximately 15 meters (m) [50 feet (ft)] from the silo. As material is removed from the silo, the remaining berm material will be removed in layers to ensure that the force exerted on the silo walls by the silo contents is balanced by the force exerted by the berm. The material removal device will be rotated from manway to manway to remove the silos' contents in layers.

- Silo 3 Contents Removal: Silo 3 contents will be removed from the silo by a vacuum system with a cutter head device, which is suspended from the work platform and introduced into the silo through the manways.

- Decant Sump Tank Removal: After removal of the silo structures, the decant sump tank will be removed. The sludge from the decant tank will be processed with the silo waste materials.

- Soil Removal: Under Alternatives 2C and 3C, surface soil will be removed to cleanup levels specified by the alternative.

- Material Stabilization: The material from the K-65 Silos and from Silo 3 will be stabilized by the addition of cement, flyash, and blast furnace slag to produce a monolithic cement product, or by vitrification with the addition of soda ash and carbon to produce a monolithic glass product. Because the material processing facility will be equipped with a RTS, and because the material will be enclosed in pipes and tanks during the stabilization process, it has been decided that exposure to radon will not be quantified, but will be addressed qualitatively.

- Material Disposal: Some alternatives propose that the material be disposed of on site while others propose an off-site disposal. This involves the shipment of material from the Operable Unit 4

Study Area to the designated disposal facility.

- Silo Structure Removal: After removal of waste materials from the silos, an approximate 2.54-cm (1-in.) inner layer will be removed from the concrete walls of Silos 1, 2, and 3, and the remaining concrete structures (including Silo 4) will be disassembled.

As noted in Figure D.3-1, potential receptors during the remediation process include various workers, the trespassing child, and the off-property resident farmer. It is assumed that current land use is still in force (i.e., the FEMP site is under DOE control and access is restricted) and that there are no on-property residents. It should be noted, however, that there is no secondary containment mechanism for the silos contents if the silo dome(s) should collapse or be damaged by the work platform, or if the material removal systems should fail and discharge silo contents to the environment. A hypothetical dome failure event and the associated risk evaluation are presented in Attachment D.I of this appendix.

The trespassing child may be exposed to direct radiation and to surface and berm soil at certain points during the remediation process. Potential routes of exposure include inhalation of resuspended dust, ingestion of contaminated soil, and dermal contact with contaminated soil. These routes of exposure will be evaluated quantitatively, except for inhalation of radon, which will be evaluated qualitatively.

Workers on site during the remediation process include remediation workers directly involved in the landscape, construction, material removal, material processing, and other activities related to site cleanup. These workers would wear respirators and other protective clothing and equipment that would greatly reduce their exposure and risk. In addition, other support workers (non-remediation) such as security, clerical personnel, delivery people, regulatory officials, etc., would be present. These nonremediation support workers would not necessarily be wearing protective clothing and equipment at all times.

The non-remediation worker and the other unprotected workers on site may be exposed to surface and berm soil, particularly during the surface and berm soil removal process. Potential routes of exposure include inhalation of resuspended dust, ingestion of contaminated soil, dermal contact with contaminated soil, and direct radiation exposure. It is assumed that the remediation workers will wear protective clothing, use protective equipment, and follow all applicable Occupational Safety and Health Administration (OSHA) regulations. The OSHA regulations are designed to minimize inhalation, ingestion, and dermal exposure, precluding the need for quantitative assessment of these pathways for the protected remediation worker. The most significant exposure pathway for the unprotected nonremediation worker is inhalation of resuspended dust. The risk for this pathway is quantified.

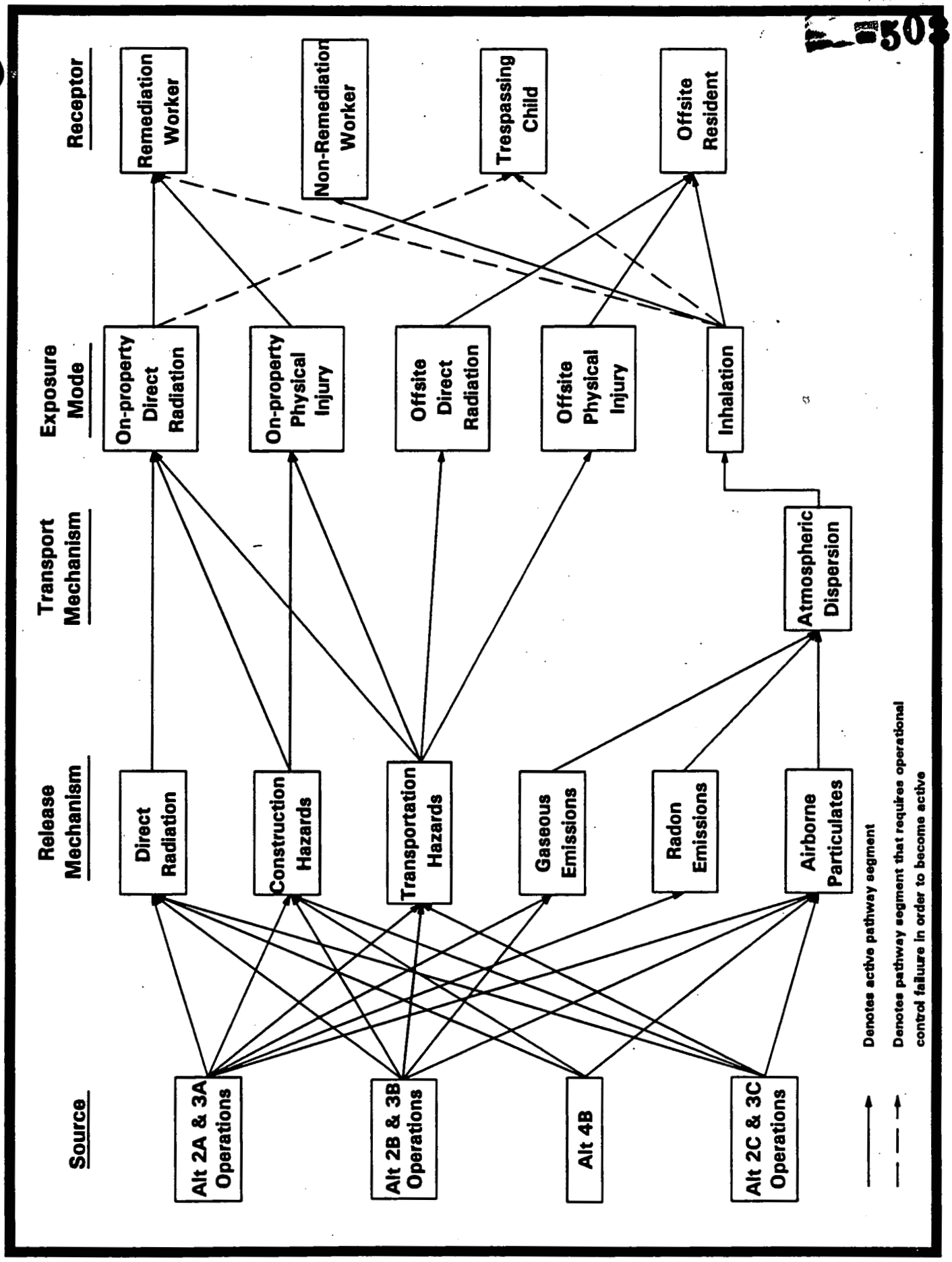

FIGURE D.3-1 SHORT-TERM RISK CONCEPTUAL SITE MODEL

The off-property resident farmer may also be exposed to surface and berm soil via inhalation of resuspended dust during the remediation process. However, based on an evaluation of the inhalation pathway for an on-site worker not wearing protective gear, which indicated potential ILCRs are below 10^{-6}, it was determined that an evaluation of the off-property resident farmer was not necessary.

As noted above, surface and berm soil is the source of potential exposure for the trespassing child, the workers, and the off-property resident farmer. The chemical COCs and their concentrations in soil and air from resuspended dust are presented in Table D.3-2, while the corresponding values for radionuclides are presented in Table D.3-3. These COCs were selected from the Baseline Risk Assessment list of CPCs and are the chemicals and radionuclides that had a risk greater than 10^{-6} or a HI of greater than 0.2. In addition, frequency of detection was taken into consideration in selecting these lists of COCs for evaluation in this assessment. The concentrations of the COCs in air are calculated from the equation on Page 6-35 of the Risk Assessment Work Plan Addendum:

$$C_a = (D_1)\,(C_s)\,(CF)$$

where:

C_a = COC concentration in air [milligram (mg)/cubic meter (m^3)]

D_1 = dust loading factor [6.0×10^{-4} gram (g) of soil/m^3 of air]

C_s = COC concentration in soil [microgram (μg)/g]

CF = conversion factor (10^{-3} mg/μg)

This equation models contaminant concentrations in air arising from construction activities. For purposes of estimating risks from these short-term exposures, it is assumed that the concentrations of the COCs in air do not vary, even though the mechanical process (construction) that resuspends the dust would only occur during working hours. It should be noted that resuspended dust refers to both volatiles and particulates in air. Although all resuspended particulates are conservatively assumed to be of optimum respirable size, some (unquantified) proportion of these particles would be too large to reach the lungs. These conservative assumptions will lead to an overestimation of the actual risk from inhalation of resuspended particulates. Exposure parameters for the trespassing child and unprotected nonremediation worker are presented in Table D.3-4. The data were taken from the latest version of the RI Report for Operable Unit 4.

TABLE D.3-2

NONRADIOLOGICAL CONTAMINANTS OF CONCERN IN SURFACE SOIL, BERM FILL, AND AIR AT OPERABLE UNIT 4[a]

Constituent of Potential Concern	Concentration in Soil (mg/kg)	Calculated Concentration in Air (mg/m^3)[b]
Antimony	28.7	1.72×10^{-5}
Arsenic	7.77	4.66×10^{-6}
Benzo(a)anthracene	4.7	2.82×10^{-6}
Benzo(a)pyrene	4.92	3.12×10^{-6}
Benzo(b)fluoranthene	9.777	5.82×10^{-6}
Benzo(g,h,i)perylene	5.3	3.18×10^{-6}
Cadmium	5.36	3.22×10^{-6}
Chromium[c]	20.4	1.22×10^{-5}
Chrysene	3.5	2.11×10^{-6}
Dibenzo(a,h)anthracene	0.900	5.40×10^{-7}
Indeno(1,2,3-cd)pyrene	4.2	2.52×10^{-6}
Methylene chloride	0.025	1.50×10^{-8}
Molybdenum[c]	5.88	3.53×10^{-6}
Nickel	30.8	1.85×10^{-5}
Silver[c]	9.81	5.89×10^{-6}
Thallium	0.71	4.27×10^{-7}
Vanadium	25.3	1.52×10^{-5}
Zinc	51.8	3.11×10^{-5}

[a]Taken from Table D.2-5 in Appendix D of the Final RI Report for Operable Unit 4 (November 1993).
[b]See text for description of derivation.
[c]Table D.2-5 in Appendix D of the Final RI Report for Operable Unit 4 (November 1993) presented two UCL on mean values for this chemical, one including data from outliers and one rejecting the outliers. The larger value (including data from outliers) was selected as the more conservative approach to risk assessment.

TABLE D.3-3

RADIOLOGICAL CONTAMINANTS OF CONCERN
IN SURFACE SOIL, BERM FILL, AND AIR
AT OPERABLE UNIT 4[a]

Isotope	Concentration In Soil (pCi/g)	Calculated Concentration In Air (pCi/m^3)[b]
Pb-210	4.45	2.67×10^{-3}
Ra-226	3.8	2.28×10^{-3}
Ra-228	1.3	7.80×10^{-4}
Sr-90	1.8	1.08×10^{-3}
Tc-99	3.6	2.16×10^{-3}
Th-228	1.3	7.80×10^{-4}
U-238	14.2	8.49×10^{-3}

[a]Taken from Table D.2-5 in Appendix D of the Final RI Report for Operable Unit 4, November 1993.
[b]See text for description of derivation.

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TABLE D.3-4

PARAMETERS USED TO ESTIMATE POTENTIAL SHORT-TERM EXPOSURE[a]

Pathway Parameters	Trespassing Child Age 7-18	Nonremediation Worker
Inhalation of VOCs, Fugitive Dust, and Radon		
Inhalation Rate (IR) (m^3/hr)	0.83[b]	0.83[b]
Exposure Time (ET) (hr/d)	4[d]	1[c]
Exposure Frequency (EF) (d/yr)	52[d]	250[c]
Exposure Duration (ED) (yr)	3[e]	3[e]
Body Weight (BW) (kg)	43	70
Averaging Time (AT)-Noncancer (d)[f]	1095	1095
Averaging Time (AT)-Cancer (d)[g]	25550	25550
Incidental Ingestion of Soil/Sediment		
Ingestion Rate (IR) (g/d)	0.1	NA
Fraction Ingested from Contaminated Source (FI)	0.25[h]	NA
Exposure Frequency (EF) (d/yr)	52	NA
Exposure Duration (ED) (yr)	3[e]	NA
Body Weight (BW) (kg)	43	NA
Averaging Time (AT)-Noncancer (d)[f]	1095	NA
Averaging Time (AT)-Cancer (d)[g]	25550	NA
Dermal Contact with Soil/Sediment		
Skin Surface Area Available for Contact (SA) (m^2)	0.42[i]	NA
Skin Adherence Factor (AF) (mg/cm^2)	1.0[j]	NA
Adsorption Factor (ABS) (unitless)	csv[k]	NA
Exposure Frequency (EF) (d/yr)	52[k]	NA
Exposure Duration (ED) (yr)	3[e]	NA
Body Weight (BW) (kg)	43	NA
Averaging Time (AT)-Noncancer (d)[f]	1095	NA
Averaging Time (AT)-Cancer (d)[g]	25550	NA

See Footnotes next page.

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[a]Parameter values obtained from the Risk Assessment Work Plan Addendum (DOE 1992) unless otherwise noted.
[b]Derived by dividing the default adult human inhalation rate of 20 m^3/day by 24 hours/day, and rounding to two significant figures (EPA 1989).
[c]Total time during which berm removal occurs (before and during waste removal) averaged over the entire three-year remediation period, EPA 1991.
[d]Specific guidance from EPA Region 5. Standard trespass scenario assumes 4 hr/d, 52 d/yr.
[e]Based on the total time for the remedial alternatives involving waste removal, rather than those involving in situ containment, as an upper-bound on exposure duration.
[f]Calculated as the product of ED (years) x 365 days/year.
[g]Averaging time for carcinogenicity calculated as the product of 70 years x 365 days/year.
[h]Assumes a small child spends 4 of 16 waking hours/day on site.
[i]From Dermal Exposure Assessment Principals and Applications, EPA/600/8-91/011B.
[j]Guidance from EPA (1992). AF from P8-17; EF from P8-6; ET and SA (adult) from P8-7 (or Table 10-1); and SA (child) from Section 8.4.
[k]csv = Chemical specific value.

D.3.2.2 Long-Term Exposure

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Figure D.3-2 depicts the conceptual model for long-term exposures following completion of Operable Unit 4 remedial alternatives. The conceptual model is developed to identify the realm of potential long-term exposure pathways associated with the Operable Unit 4 alternatives. It addresses potential risks from contaminants that may remain within the boundaries of Operable Unit 4, Operable Unit 4 materials disposed elsewhere within the FEMP boundaries, and Operable Unit 4 contaminants that may in the future migrate beyond the boundaries of Operable Unit 4. The remedial action alternatives discussed in Section D.3.1.2 are designed to eliminate or mitigate these pathways, as appropriate, through the use of treatment, containment, and/or site institutional control measures.

The two engineering measures, waste treatment and containment, eliminate or mitigate pathway segments at the source/release mechanism level. As shown in Figure D.3-2, the on-property disposal vaults' (Alternatives 2A, 2B, 4B, 2C) containment features serve to eliminate surface and subsurface release mechanisms, while stabilized waste forms mitigate leaching and airborne releases in the event of facility degradation. In the absence of disposal facility and/or waste form failures, there would be no risk to humans from materials disposed in these facilities.

While institutional control measures can mitigate release mechanisms (e.g., access controls to prevent containment system damage), they generally address exposure control at the exposure mode/receptor level. As shown in Figure D.3-2, land use restrictions and access controls included in the remedial alternatives would prevent exposure to certain media (e.g., perched water) and mitigate exposure to others (e.g., groundwater).

The conceptual model does not include potential risks for off-property disposal endpoints (Alternatives 3A, 3B, and 3C), nor does it consider no action alternative end points (Alternatives 0A, 0B, and 0C), which are the bases of the Baseline Risk Assessment as summarized in Section D.2.0. The conceptual model does not consider existing contamination in groundwater, surface water, sediment, or soil not within the boundaries of Operable Unit 4, nor does it consider impacts on flora and fauna. These concerns are within the scope of Operable Unit 5, as specified in the Risk Assessment Work Plan Addendum (DOE 1992).

D.3.2.2.1 Long-Term Release Mechanisms

The Baseline Risk Assessment evaluated all existing contaminant sources within Operable Unit 4. These

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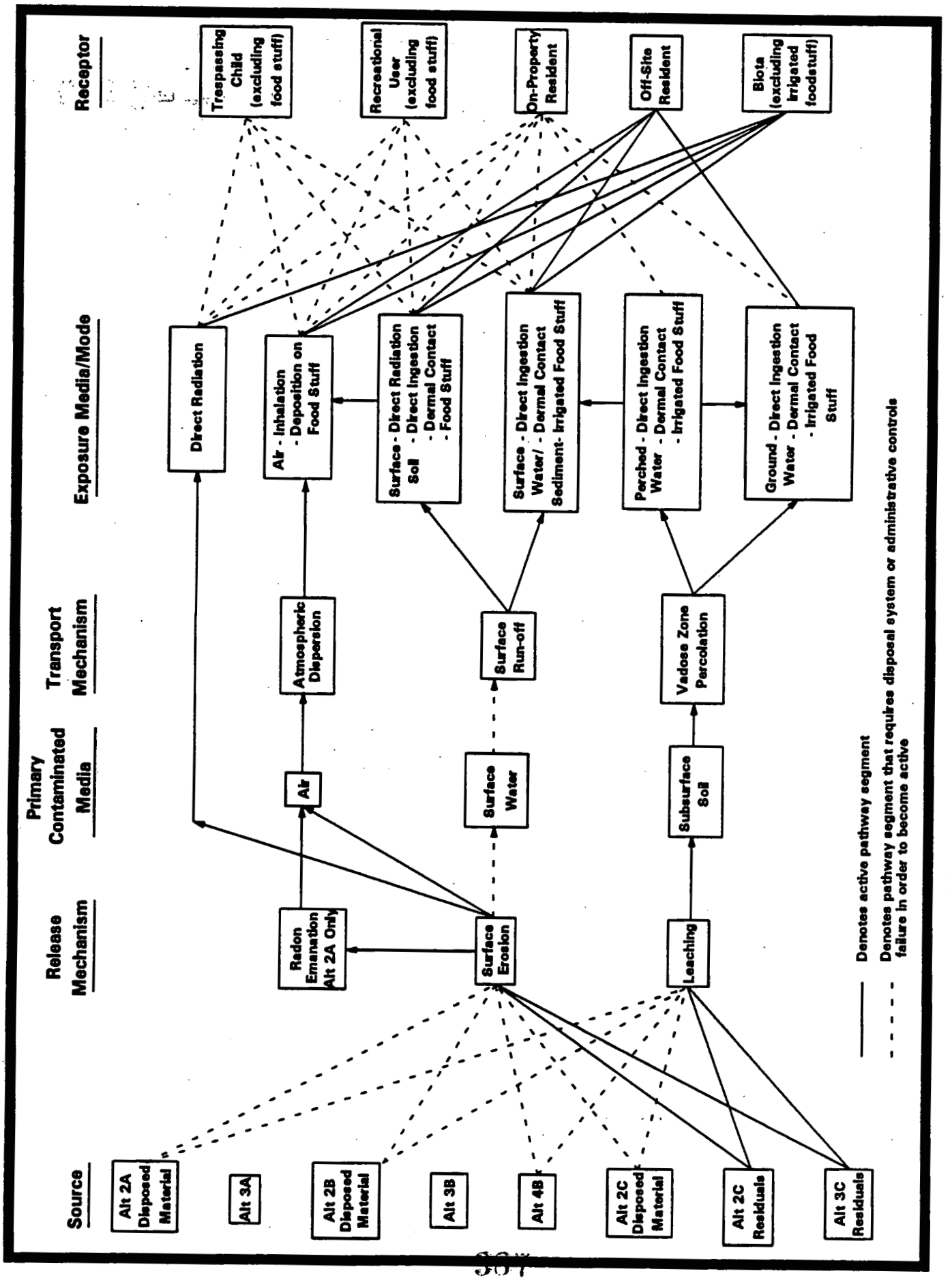

FIGURE D.3-2 LONG-TERM RISK CONCEPTUAL SITE MODEL

were the Silos 1 and 2 contents and decant tank sludge (Subunit A); Silo 3 contents (Subunit B); and the silo structures, berm soil, surface soil, and subsurface soil (Subunit C). However, as depicted in Figure D.3-2, the remedial action alternatives envisioned for Operable Unit 4 will remove all contaminant sources with the exception of residual surface and subsurface soils, and wastes disposed of in on-property disposal facilities.

The potential release mechanisms associated with these residual contamination sources include direct contact, penetrating radiation exposure, wind and water erosion, and water leaching. Although the disposal facilities are designed to maintain their full integrity for 1,000 years, for the purpose of this evaluation, the assumption has been made that the infiltration barriers of the disposal facility deteriorate and permit increased infiltration of water. However, it is reasonable to expect the disposal facilities to otherwise survive substantially intact over the long term, preventing direct contact with the wastes or surface erosion. The designs include several layers of cap material that collectively provide adequate thickness to prevent exposure of disposed material to wind erosion; the cap material also retards the diffusion of any radon that might emanate from the material sources and allows for decay of radon before release to the air. In addition, remedial alternatives that involve cement or vitrification stabilization of the primary radon sources (silo residues) would mitigate the potential for emanation of radon from these sources.

It is considered that the six inches of fill could be removed and the receptors could be exposed to the exposed soils. These existing soils will contain COCs at the PRL or existing COC concentrations.

Releases by surface water erosion are eliminated from the scope of the Operable Unit 4 conceptual model, again because on-property disposal facilities and in situ caps are designed to remain intact and prevent water erosion of material. In addition, the remedial alternatives that involve cement or vitrification stabilization would mitigate the potential for surface water erosion of disposed material.

D.3.2.2.2 Long-Term Transport and Exposure Pathways

Once released to the environment, COCs can travel by several transport pathways to reach media to which receptors may be exposed. The impact of Operable Unit 4 residual sources on perched groundwater in the sand lens beneath the silos (perched groundwater) and groundwater in the Great Miami Aquifer is included in the scope of the Operable Unit 4 conceptual model. However, existing contamination in groundwater is within the scope of Operable Unit 5.

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As indicated in the preceding sections, the potential sources of contaminant leaching to perched groundwater and the aquifer are the Operable Unit 4 surface and subsurface soils, and wastes disposed in the on-property disposal facility. Potential exposure pathways for contaminants in groundwater following transport include ingestion of drinking water, ingestion of fruits and vegetables irrigated with groundwater, ingestion of animal products from cattle raised on groundwater and feed crops irrigated with groundwater, dermal contact with groundwater while bathing, and inhalation of volatile organic compounds (VOCs) from use of groundwater in the home.

Potential exposure pathways for contaminants in air following resuspension and transport include inhalation of airborne contaminants and ingestion of farm-produced fruits, vegetables, meat, and milk. Direct access to Operable Unit 4 residual on-site subsurface soils results in the potential for inhalation of airborne contaminants, and ingestion of farm-produced fruits, vegetables, meat, and milk, as well as incidental ingestion of soil. Potential exposure pathways for the expanded trespasser include incidental ingestion, inhalation of resuspended particulates, dermal absorption, and direct radiation exposure.

D.3.2.2.3 Long-Term Exposure Receptor Scenarios

The Baseline Risk Assessment evaluated all existing contaminant sources within Operable Unit 4. These were the Silos 1 and 2 contents and decant tank sludge (Subunit A); Silo 3 contents (Subunit B); and the silo structures, berm soil, surface soil, and subsurface soil (Subunit C). The Baseline Risk Assessment evaluated potential exposures to a trespassing child, groundskeeper, and off-property surface water user receptors, in addition to on-property and off-property farmer receptors. Exposures to Operable Unit 4 COCs were evaluated under two current land use scenarios (with and without access controls) and a future land use scenario without access controls.

Two future land uses are identified for evaluation in the assessment of long-term risks and the development of PRGs. The first is Future Land Use Without Continued Federal Ownership, which is equivalent to the Baseline Risk Assessment scenario for future land use. In this scenario, the federal government deeds the land over for unrestricted private ownership. Given the surrounding land use, the most likely use is farming.

The second scenario is a Future Land Use with Continued Federal Ownership as an undeveloped government reserve. A government reserve is defined as land which remains under government ownership and control and for which no future development is intended. While active access controls are discontinued, the federal government will exercise its right to preclude site development with deed

restrictions. This land use scenario was not included in the Baseline Risk Assessment but was developed in the FS to facilitate evaluation of long-term risks with continued land use restrictions. In this government reserve scenario, the federal government owns the land, prohibits all development including grazing, and does not plan a specific land use. The land would be fenced and signs installed prohibiting trespassing and hunting.

Federal ownership and land use restrictions can be used to supplement engineering measures considered under the remediation alternatives to prevent or mitigate potential exposures to Operable Unit 4 COCs. Land use restrictions and access controls would prevent inadvertent intrusion into on-site disposal facilities and soils with residual concentrations of COCs. As specified in Ohio Administrative Code (OAC) 3734.02, hazardous and solid waste disposal facilities must include a protective covenant to restrict mining, drilling, and residential uses. Attachment D.II to this appendix discusses the transition from baseline to post-remediation exposure-receptor scenarios. The sections that follow provide summary descriptions of the land use/receptor combinations and their adaptation to the Operable Unit 4 long-term risk assessment.

Future Land Use With Continued Federal Ownership

Under this land use scenario, DOE retains federal ownership of the land. This proprietary right precludes members of the public from establishing residence on Operable Unit 4 or the on-property disposal vault. The potential receptor exposure scenarios include:

- Off-Property Resident Farmer - This scenario assumes that a farm family lives immediately adjacent to the FEMP property boundary and is exposed through the following pathways:
  - Ingestion of groundwater
  - Inhalation of fugitive dust, VOCs, and gases
  - Consumption of farm-produced foodstuffs including vegetables, meat, and milk
  - Dermal contact and inhalation while using groundwater in the home
- Expanded Trespasser - This scenario considers the risks to an adult and/or child that visits the site despite continued federal ownership. The activities of this receptor include hiking, roaming, and bird watching. Due to the nature of the restrictions, activities such as hunting, jogging, and biking are not considered. The trespasser is exposed through the following pathways:
  - Inhalation of fugitive dust, VOCs, and radon
  - Incidental ingestion of soil
  - Dermal contact with contaminants in soil
  - External radiation exposure from contaminated soil

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- Trespassing Child - This scenario considers the child that visits the site despite controlled federal ownership, and is exposed through the following pathways:

  - Inhalation of fugitive dust, VOCs, and radon
  - Incidental ingestion of soil
  - Dermal contact with contaminants in soil
  - External radiation exposure in contaminated soil

The expanded trespasser is an extension of the trespassing child by the addition of the adult life portion to the expanded trespasser. The child life portion of the expanded trespasser is exposed for two hours a day for 110 days while the trespassing child is exposed for four hours per day for 52 days per year. Both child receptors are exposed for 12 years.

Evaluation of the off-property farmer receptor for this land use scenario assumes that the on-property disposal vault (Alternatives 2A, 2B, 2C, and 4B) infiltration barriers are deteriorated to a point that allows infiltration of water and leaching of constituents.

Future Land Use Without Continued Federal Ownership

Under this land use scenario, there are neither access controls nor continued federal ownership. This scenario includes exposure routes that require development time such as establishing a home and farm operations on property. The receptor exposure scenarios include:

- RME On-Property Resident Farmer - This scenario assumes that a farmer resides on the property and conducts agricultural activities. Typical activities may include food and feed production, livestock production, and general farm work. The receptor is assumed to not intrude into the disposal facility and is exposed through the following pathways:

  - Inhalation of fugitive dust, VOCs, and gases
  - Ingestion of groundwater
  - Dermal contact and inhalation while using groundwater in the home
  - Consumption of foodstuff grown on the property, including vegetables, meat, and milk
  - Incidental ingestion of, external radiation from, and dermal contact with soil

Groundwater exposure pathways include ingestion of drinking water, inhalation of volatiles released from water during household use, dermal contact while bathing, ingestion of vegetables and fruits irrigated with groundwater, and ingestion of meat and milk from cattle drinking groundwater and receiving one-half of their daily ration from forages grown under irrigation with groundwater. The groundwater modeling

results for each remedial alternative are presented in Section D.3.2.2.4. Exposure parameters for the on- and off-property residents are presented in Table D.3-5. The derivation of exposure factor values was consistent with the approach described in the Operable Unit 4 RI.

Table D.3-6 presents a comparison of the Baseline Risk Assessment receptors considerations and the FS Risk Assessment. Two other receptors were considered in the Baseline Risk Assessment that were not considered in this FS Risk Assessment. They are the groundskeeper and the Great Miami River user. As noted in the table, no current land use scenarios with maintenance or access controls were considered in this FS Risk Assessment. The risks to the Great Miami River user were projected in the Baseline Risk Assessment to be less than 10^{-6}. Since the major source terms (silos and surface soils) will be removed by remediation, the risk to the river user will be less under all alternatives. Therefore, the risks to the Great Miami River user will continue to be less than 10^{-6}.

A Construction Intruder Receptor scenario was identified in the Risk Assessment Work Plan Addendum for considerations in the future land use scenario. This scenario involves exposures to workers building residences for the on-property farmer. This receptor was not quantitatively evaluated since it was not considered reasonable to have significant residential construction activity within the limited area of Operable Unit 4. In addition, the design of the on-property disposal vault is such that it would be unlikely that the structures would be breached.

The pathway involving inhalation of constituents released from groundwater used in the home was not quantitatively evaluated because groundwater fate and transport modeling results predicted that the only constituent to impact groundwater is uranium, which is not volatile.

D.3.2.2.4 Long-Term Fate and Transport Modeling

Fate and transport computer models were used to predict the potential movement of residual and disposed constituents from Operable Unit 4 source terms to receptor locations. The transport models provide the only means of predicting potential groundwater constituent concentrations at receptor locations in the future under assumed conditions. The four models used were:

- The geochemical model used to estimate leachate concentrations
- The hydrogeological evaluation of landfill performance (HELP) model used to estimate exfiltration rates
- The ODAST model to predict contaminant movement through the vadose zone

TABLE D.3-5

PARAMETERS USED TO ESTIMATE POTENTIAL LONG-TERM EXPOSURES[a]

Pathway Parameters	Trespassing Child Age 6-18	Expanded Trespasser Child Age 6-18	Expanded Trespasser Adult 18-50	RME On-Property Farmer Age 1-70	CT On-Property Resident Farmer Age 1-70	On-Property Resident Child Age 1-6	Off-Property Resident Farmer Age 1-70
Inhalation of Dusts, Volatiles, and Radon							
IR (m^3/hr)	0.83	0.83	0.83	0.83	0.83	0.5	0.83
ET Indoors (hr/d)	N/A	N/A	N/A	18.3	19.8	22	18.3
ET Outdoors (hr/d)	4	2	1	5.7	4.2	2	5.7
EF (d/yr)	52	110	40	350	275	350	350
ED (yr)	12	12	32	70	9	6	70
BW (kg)	43	43	70	70	70	15	70
AT-Noncancer (d)[f]	4380	4300	11680	25550	3285	2190	25550
AT-Cancer (d)[g]	25550	25550	25550	25550	25550	25550	25550
Ingestion of Drinking Water							
IR (ℓ/d)	N/A	N/A	N/A	2	1.4[b]	1.4[c]	2
FI (unitless)	N/A	N/A	N/A	1	1	1	1
EF (d/yr)	N/A	N/A	N/A	350[d]	275[b]	350[d]	350[d]
ED (yr)	N/A	N/A	N/A	70	9[e]	6	70
BW (kg)	N/A	N/A	N/A	70	70	15	70
AT-Noncancer (d)[f]	N/A	N/A	N/A	25550	3285	2190	25550
AT-Cancer (d)[g]	N/A	N/A	N/A	25550	25550	25550	25550

See footnotes at end of table.

TABLE D.3-5
(Continued)

Pathway Parameters	Trespassing Child Age 6-18	Expanded Trespasser Child Age 6-18	Expanded Trespasser Adult 18-50	RME On-Property Farmer Age 1-70	CT On-Property Resident Farmer Age 1-70	On-Property Resident Child Age 1-6	Off-Property Resident Farmer Age 1-70
Inhalation of Volatiles Released from Household Water Uses							
IR (m^3/hr)	N/A	N/A	N/A	0.63	0.63	0.63	0.63
ET (hr/d)	N/A	N/A	N/A	0.25[h]	0.17[h]	0.33[h]	0.25[h]
EF (d/yr)	N/A	N/A	N/A	350[d]	275[b]	350[d]	350[d]
ED (yr)	N/A	N/A	N/A	70	9[e]	6	70
BW (kg)	N/A	N/A	N/A	70	70	15	70
AT-Noncancer (d)[f]	N/A	N/A	N/A	25550	3285	2190	25550
AT-Cancer (d)[g]	N/A	N/A	N/A	25550	25550	25550	25550
Incidental Ingestion of Soil/Sediment							
IR (g/hr)	0.1	0.1	0.1	0.18	0.122	0.2	N/A
FI (unitless)	0.25	0.1	0.05	1	1	1	1
EF (d/yr)	52	110	40	350[d]	275[b]	350[d]	350[d]
ED (yr)	12	12	32	70	9[e]	6	70
BW (kg)	43	43	70	70	70	15	70
AT-Noncancer (d)[f]	4380	4380	11680	25550	3285	2190	25550
AT-Cancer (d)[g]	25550	25550	25550	25550	25550	25550	25550

See footnotes at end of table.

TABLE D.3-5
(Continued)

Pathway Parameters	Trespassing Child Age 6-18	Expanded Trespasser Child Age 6-18	Expanded Trespasser Adult 18-50	RME On-Property Farmer Age 1-70	CT On-Property Resident Farmer Age 1-70	On-Property Resident Child Age 1-6	Off-Property Resident Farmer Age 1-70
Dermal Contact While Bathing							
SA (m^2)	N/A	N/A	N/A	2.0[h]	2.0[h]	0.7[h]	2.0[h]
PC (cm/hr)	N/A	N/A	N/A	csv	csv	csv	csv
ET (hr/d)	N/A	N/A	N/A	0.25[h]	0.17[h]	0.33[h]	0.25[h]
EF (d/yr)	N/A	N/A	N/A	350[d]	275[b]	350[d]	350[d]
ED (yr)	N/A	N/A	N/A	70	9[e]	6	70
BW (kg)	N/A	N/A	N/A	70	70	15	70
AT-Noncancer (d)[f]	N/A	N/A	N/A	25550	3285	2190	25550
AT-Cancer (d)[g]	N/A	N/A	N/A	25550	25550	25550	25550
Dermal Contact With Soil/Sediment							
SA (m^2)	0.41	0.41	0.57	2.0[h]	2.0[h]	0.7[h]	2.0[h]
DA (cm/m^2)	1	1	1	csv	csv	csv	csv
ABS	cvs	cvs	cvs	cvs	cvs	cvs	0.25[h]
EF (d/yr)	52	110	40	350[d]	275[b]	350[d]	350[d]
ED (yr)	12	12	32	70	9[e]	6	70
BW (kg)	43	43	70	70	70	15	70
AT-Noncancer (d)[f]	4180	4180	11680	25550	3285	2190	25550
AT-Cancer (d)[g]	25550	25550	25550	25550	25550	25550	25550

See footnotes at end of table.

TABLE D.3-5
(Continued)

Pathway Parameters	Trespassing Child Age 6-18	Expanded Trespasser Child Age 6-18	Expanded Trespasser Adult 18-50	RME On-Property Farmer Age 1-70	CT On-Property Resident Farmer Age 1-70	On-Property Resident Child Age 1-6	Off-Property Resident Farmer Age 1-70
Inhalation of Dusts, Volatiles, and Radon							
DR (mrem/hr)	csv	csv	csv	csv	csv	csv	N/A
ET Indoors (hr/d)	N/A	N/A	N/A	18.3	19.8	22	N/A
ET Outdoors (hr/d)	4	2	1	5.7	4.2	2	N/A
EF (d/yr)	52	110	40	350	275	350	N/A
ED (yr)	12	12	32	70	9	6	N/A
BW (kg)	43	43	70	70	70	15	N/A
Ingestion of Vegetables and Fruit							
IR (g/d)	N/A	N/A	N/A	122	78[b]	101.5[i]	122
FI (unitless)	N/A	N/A	N/A	1	1	1	1
EF (d/yr)	N/A	N/A	N/A	350[d]	275[b]	350[d]	350[d]
ED (yr)	N/A	N/A	N/A	70	9[e]	6	70
BW (kg)	N/A	N/A	N/A	70	70	15	70
AT-Noncancer (d)[f]	N/A	N/A	N/A	25550	3285	2190	25550
AT-Cancer (d)[g]	N/A	N/A	N/A	25550	25550	25550	25550
Ingestion of Meat							
IR (g/d)	N/A	N/A	N/A	75	50[b]	29	75
FI (unitless)	N/A	N/A	N/A	1	1	1	1
EF (d/yr)	N/A	N/A	N/A	350[d]	275[b]	350[d]	350[d]
ED (yr)	N/A	N/A	N/A	70	9[e]	6	70

See footnotes at end of table.

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TABLE D.3-5
(Continued)

Pathway Parameters	Trespassing Child Age 6-18	Expanded Trespasser Child Age 6-18	Expanded Trespasser Adult 18-50	RME On-Property Farmer Age 1-70	CT On-Property Resident Farmer Age 1-70	On-Property Resident Child Age 1-6	Off-Property Resident Farmer Age 1-70
BW (kg)	N/A	N/A	N/A	70	70	15	70
AT-Noncnacer (d)[f]	N/A	N/A	N/A	25550	3285	2190	25550
AT-Cancer (d)[g]	N/A	N/A	N/A	25550	25550	25550	25550
Ingestion of Milk							
IR (L/d)	N/A	N/A	N/A	0.3	0.2[b]	0.9	0.3
FI (unitless)	N/A	N/A	N/A	1	1	1	1
EF (d/yr)	N/A	N/A	N/A	350[d]	275[b]	350[d]	350[d]
ED (yr)	N/A	N/A	N/A	70	9[e]	6	70
BW (kg)	N/A	N/A	N/A	70	70	15	70
AT-Noncancer(d)[f]	N/A	N/A	N/A	25550	3285	2190	25550
AT-Cancer(d)[g]	N/A	N/A	N/A	25550	25550	25550	25550

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[a]Parameter values obtained from Final RI Report for Operable Unit 4 (November 1993), Table D.3-12.
[b]Special guidance from EPA Region V.
[c]Drinking water consumption rate of 1.4 L/day from NRC (Nuclear Regulatory Commission), 1977, U.S. Nuclear Regulatory Commission Regulatory Guide 1.109; NCRP (National Council on Radiation Protection) Report No. 76.
[d]Guidance from EPA (1991[a]), OSWER Directive: 9285.7-01B.
[e]Guidance from EPA (1991[b]), Interim Final, OSWER Directive: 9285.6-03.
[f]Calculated as the product of ED (years) x 365 days/year.
[g]Averaging time for carcinogens calculated as the product of 70 years x 365 days/year.
[h]Guidance from EPA (1992), AF from p. 8-17; EF from p. 8-6; ET and SA (adult) from p.8-7 (or Table 10-1); and SA (child) from Section 8.4.
[i]Guidance from EPA (1989), Interim Final, p. 6-36.

See footnotes at end of table.

TABLE D.3-6

COMPARISON OF BASELINE RISK ASSESSMENT AND FS RISK ASSESSMENT RECEPTORS

Receptors	Baseline Risk Assessment	FS Risk Assessment	Comments
Groundskeeper	Yes	No	Not considered because no active maintenance is planned
Trespassing Child	Yes	Yes	In the FS, the trespassing child is exposed only to surface soils
Expanded Trespasser	No	Yes	Government reserve land use not considered in the Baseline Risk Assessment
RME Off-Property Resident Farmer	Yes	Yes	None
RME On-Property Resident Farmer	Yes	Yes	None
CT On-Property Resident Farmer	Yes	Yes	None
On-Property Resident Child	Yes	Yes	None
Great Miami River User	Yes	No	Not considered because the risk from the Baseline Risk Assessment was less than 10^{-6}

- The SWIFT III model used to predict contaminant movement through the Great Miami Aquifer

This section presents a brief description of the methodology used to quantitatively predict constituent concentrations. For a more complete description of the models and parameters used for the Operable Unit 4 modeling, please refer to Appendix E of the Final RI Report for Operable Unit 4.

Conceptual Groundwater Flow Model

Based on characteristics of the material underlying the on-property disposal vaults and Operable Unit 4 area, a conceptual model was developed for the pathway between the disposal areas and receptor locations. This conceptual model is summarized in the following sections. Since there are two separate disposal locations, the model was developed to account for the variable stratigraphies of the soils. The disposal locations are the Operable Unit 4 footprint for residual contaminated sub-surface soils, and the on-property disposal vaults area. Fluids and/or leachate entering from the disposal areas migrate first through the unsaturated glacial overburden, then through the unsaturated outwash deposits, and finally into the Great Miami Aquifer.

The disposal vault is designed to minimize the intrusion of water for a period of 1,000 years. However, for the purpose of this analysis, it is assumed that the impermeable barriers deteriorate after 100 years, allowing water to infiltrate and contact the disposed wastes at an increased rate. After this point, leaching of both treated waste (Alternatives 2A and 2B), untreated wastes (Alternative 4B), and untreated soils (Alternative 2C) was assumed to start and continue at a constant rate for the next 900 years.

Water flowing through the waste and the vadose zone dissolves materials, forming an aqueous solution (Leachate A). This solution percolates into and reacts with the soil matrix in the vadose zone as it moves toward the aquifer. These interactions determine what chemical species are present in the percolating water (Leachate B) and how fast they will move in the unsaturated zone. In this analysis, the composition of Leachate B and the speed at which individual constituents migrate are treated individually. In general, the heavy metals will precipitate out at this point through carbonate formation and do not migrate readily.

Contaminant transport in the vadose zone constitutes the bulk of the total migration of water and dissolved materials from waste (source) areas at the FEMP site to the Great Miami Aquifer. This occurs as surface water infiltrates from the surface and percolates through the source of contamination and its surrounding soil into the saturated zone. Downward movement of water, driven by the forces resulting from

gravitational potential, capillary pressure, and other components of total fluid potential, mobilize the contaminants for transport through the vadose zone. However, the most important parameters are the percolation rate and the soil partitioning coefficient (K_d). Many metals such as lead and radium have a very large K_d such that the migration rate through the vadose zone is minimal. The effect of K_d and the precipitation of metals from Leachate A is responsible for the fact that many metals are not transported through the vadose and into the aquifer.

The flow and contaminant transport process in the vadose zone is conceptualized from the hydrogeology of the site and in specific strata. As is discussed in the Final RI Report for Operable Unit 4, the geology of the FEMP site is dominated by glacial sediments. Well-sorted sand and gravel glacial outwash forms the regional Great Miami Aquifer. This aquifer is divided by a 0.3- to 6-m-thick (1- to 20-ft-thick) clay interbed at an approximate depth of 36.6 m (120 ft). The transport pathway considered for this analysis is the upper part of the Great Miami Aquifer above the clay interbed. The uppermost 6.1 to 7.6 m (20 to 25 ft) of the outwash deposits is unsaturated and forms model Layer 2 of the vadose zone conceptual flow model. An unweathered gray till interbedded with sand and gravel glaciofluvial stringers overlies the outwash deposits. The thickness of this unit (referred to as glacial overburden), which makes up model Layer 1, ranges between 4.6 and 7.6 m (15 and 25 ft) for disposal areas. However, this layer is not included in the vadose zone modeling because of numerous fractures present within this zone. All layer thicknesses were estimated based on geologic boring logs from subsurface investigations conducted across the site.

Prior to their simulation in the vadose zone, each COC concentration was compared to its 0.2 HI and 10^{-7} risk level screening. Since these source unit leachate concentrations represent the maximum concentration for each COC, the constituents whose concentrations were below the screening levels were eliminated from the modeling as being incapable of generating significant risk through the groundwater pathway. This reduced the number of simulated COCs by approximately 40 percent.

After the initial source unit leachate screening had been completed, the transport of the remaining COCs through the vadose zone was simulated using ODAST. The vadose zone modeling took into account both source depletion and retardation in its calculations. The results showed that many of the COCs did not transport through the vadose zone within 1,000 years. This was mostly due to high retardation factors for metals and radionuclide compounds when transporting through the glacial overburden. Only two constituents, molybdenum and uranium, had sufficiently low retardation values and large enough source mass to transport through the vadose zone within 1,000 years. These resulting vadose zone

concentrations were compared to the HI and risk screening levels prior to their mixing with groundwater in the Great Miami Aquifer. The result was that uranium was the only COC with a concentration above the screening levels and, therefore, was the only COC which had to be simulated in the saturated groundwater system. The vadose zone uranium concentrations were then converted to a source loading rate and uranium transport in the Great Miami Aquifer was simulated using the SWIFT III model. All of the fate and transport simulations for the alternatives in the Operable Unit 4 FS were conducted in the same manner. Screening of all COCs was done at two points: prior to transport as a pure leachate and following transport through the vadose zone. Uranium is the only constituent reported since it is the only COC that is able to pass the screening points to be simulated in the groundwater. All other COCs were at levels below the screening levels due to low source unit leachate concentrations or high vadose zone retardation factors. For this reason, uranium is the only COC that is utilized in the FEMP's risk assessment for the groundwater pathway.

The calibrated groundwater flow model for the FEMP site was used to simulate the solute transport of the compounds in the Great Miami Aquifer. Based on the amount of material entering the aquifer derived from the vadose zone modeling, aquifer loading periods were defined for each compound to reduce the amount of data entry required. In general, loading periods ranged from 10 to 200 years in length depending upon the specific compound. Thus, compounds with steady loading rates had long loading periods, while compounds with variable loading rates used short loading periods. This allowed the simulation of short loading "spikes" while at the same time minimizing data input and run times. A compound was simulated for a total of 1,000 years in the Great Miami Aquifer. Figure D.3-3 presents the conceptual process of groundwater transport modeling to obtain receptor exposure point concentrations for on- and off-property receptors. The conceptual model in Figure D.3-3 is tied into the conceptual model for long-term risk assessment (Figure D.3-2).

Groundwater Modeling Source Terms

Subunit A (Silos 1 and 2) and Subunit B (Silo 3) source terms are each modeled for a cement stabilization and a vitrification remedial alternative followed by on-property disposal (Alternatives 2A/Cem, 2A/Vit, 2B/Cem, and 2B/Vit). Although Alternative 4B includes the on-property disposal of untreated Silo 3 wastes, treatability studies (Appendix C of the Operable Unit 4 FS) indicate that leachate from untreated Silo 3 wastes is similar to that from treated waste forms, and the waste mass associated with Alternative 4B is bracketed by 2A/Cem (higher) and 2A/Vit (lower). As such, it was not necessary to separately model Alternative 4B. Finally, Subunit C source term is also modeled for an on-property disposal alternative (Alternative 2C), which includes contaminant contributions from the residual soil that would

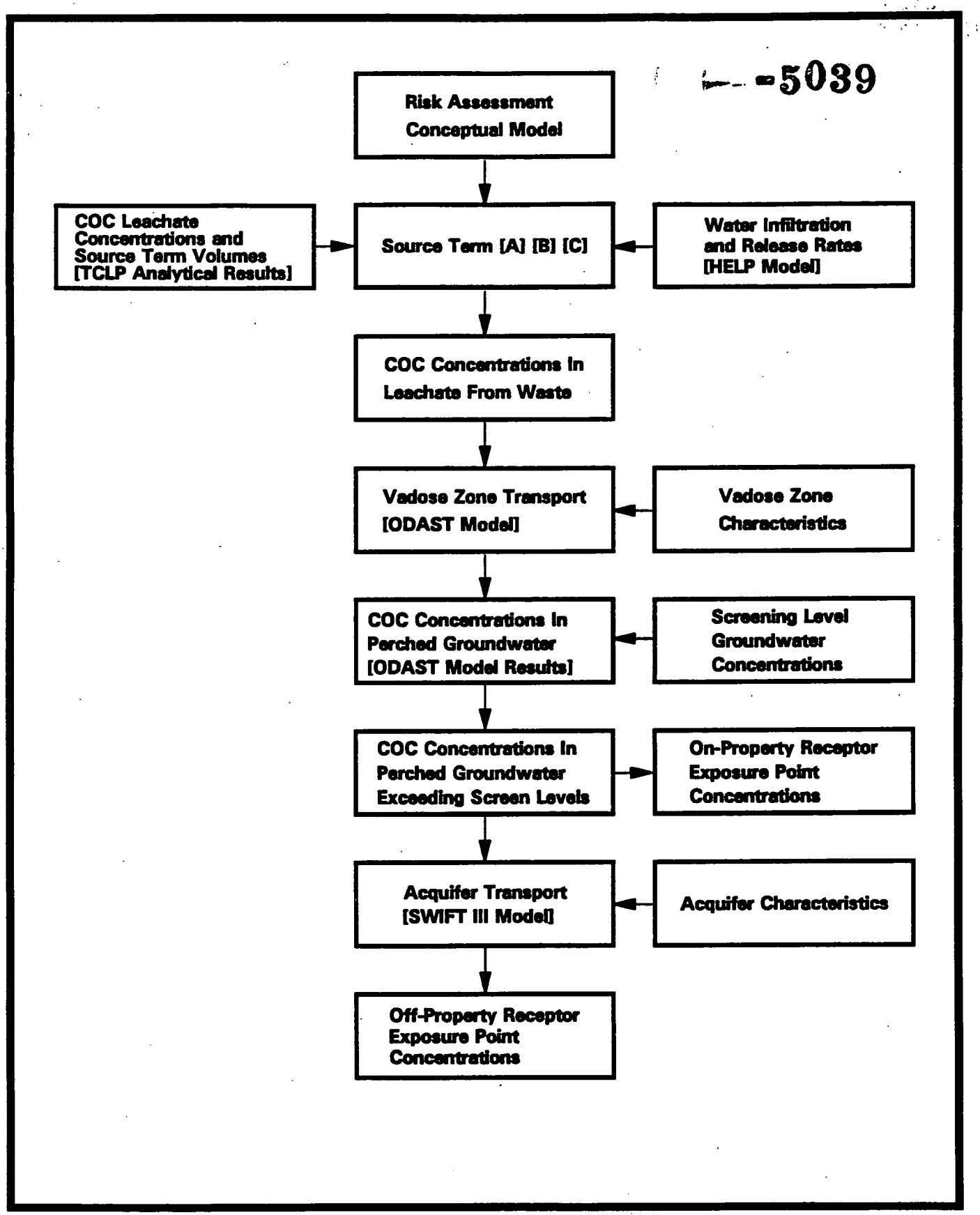

FIGURE D.3-3 GROUNDWATER TRANSPORT MODELING CONCEPTUAL MODEL

be left in place in the Operable Unit 4 Study Area (Alternatives 2C, 3C.1, 3C.2).

Table D.3-7 summarizes assumptions used to define groundwater modeling source terms for each of these remedial alternatives, including the methods of estimating constituent leachate concentrations from the disposed material. It is important to note an underlying difference in the leachate modeling approach between Alternatives 2A/2B and Alternative 2C. The leachate concentrations from the material for Alternatives 2A and 2B are estimated using Toxicity Characteristic Leaching Procedure (TCLP) sample analytical results of the treated and/or stabilized material. In contrast, the leachate concentration from the material for Alternatives 2C and 3C.1 residuals are estimated using geochemical modeling techniques. This results in higher relative estimates of contaminant leaching for Subunit C. In geochemical modeling, 30 percent of the uranium in the soil is assumed to be available for leaching, and the leaching coefficient was assumed to be 1.8 milliliter/gram (mL/g). A value of 30 percent availability bounds the range of results obtained in leaching experiments conducted on washed and unwashed soils contaminated with uranium. The average percent availability observed for soils with characteristics similar to Operable Unit 4 soils was 20.5 percent (maximum 21.4 percent). The leaching coefficient is based on the uranium K_d values provided in the Risk Assessment Work Plan Addendum. This geochemical modeling procedure is a conservative approach, which results in leachate concentrations elevated over TCLP results.

The groundwater transport modeling estimates water infiltration rates into and through the on-property disposal facility using the HELP model. Infiltration rates are modeled based on the assumption that the disposal facility deteriorates after 100 years, allowing water to infiltrate and percolate through the disposed material and out of the bottom of the disposal facility (exfiltration), potentially leaching constituents from the material and releasing them from the disposal facility. An exfiltration rate of 1.3 cm/year (yr) was calculated by the HELP model based on disposal facility design and FEMP rainfall data. A rate of 15.2 cm/yr (6 in./yr) was calculated for the soils left in place based on average rainfall (40.6 in./yr) corrected to account for evapotranspiration. Assumptions of this scenario include:

- the geomembrane water barrier has deteriorated and allows infiltration of water
- the quantity of water entering the HELP model system equals the quantity exiting the system

Groundwater Modeling in the Vadose Zone

The one-dimensional analytical model used to evaluate flow in the vadose zone is ODAST Version 2 (Javandel et al. 1984). The transport equation in ODAST is evaluated as a function of seepage velocity, dispersion coefficient, source decay, retardation factor, depletion time, and source rate. The K_d used for

TABLE D.3-7

SUMMARY OF LONG-TERM ON-PROPERTY SOURCE TERMS FOR OPERABLE UNIT 4 GROUNDWATER TRANSPORT MODELING

Remedial Alternative	Treatment Description	Waste Leachate Estimation	Water Exfiltration Rate (cm/yr)[a]	Waste Mass (lb)
2A	Cement, Disposal	TCLP, cemented waste	1.3	83,131,483
2A	Vitrify, disposal	TCLP, vitrified waste	1.3	29,573,316
2B	Cement, disposal	TCLP, cement waste	1.3	32,773,700
2B	Vitrify disposal	TCLP, vitrified waste	1.3	19,376,942
2C	Disposal	Geochemical Modeling	1.3	100,500,000
2C, 3C	Residuals, in place	Geochemical Modeling	15.2	15,000,000

[a]An exfiltration rate of 1.3 cm/year is used for all remedial alternatives involving disposal in the on-property vault disposal facility. An exfiltration rate of 15.2 cm/year is used for the residuals associated with Alternatives 2C and 3C.

uranium in the ODAST model was 1.8 mL/g which was obtained from the FEMP Risk Assessment Work Plan Addendum.

Hydrologic input data for ODAST included the flow rate, COC concentrations, layer thickness, and dispersibity value. The computer code was used for each of the two layers of the vadose zone. Transport through the bottom layer did not begin until the COC reached the bottom of the upper adjacent layer.

Output data from ODAST were in the form of mass loading rates at time increments of 20 years up to 1,000 years. The loading rates predicted to reach the Great Miami Aquifer at concentrations greater than the screening levels at the specified time are used as direct input into the SWIFT III model, which estimates the mass concentration in the Great Miami Aquifer. The only constituent which exceeded the screening levels was uranium. The screening levels were derived by calculating the concentration for each COC, which was equivalent to a 10^{-7} risk or a HQ of 0.2 via the drinking water exposure pathway. It was assumed that a 70 kilogram (kg) (154 pound) man would be drinking 2 liters [0.53 gallon (gal)] of water for 365 days a year for 70 years. Therefore, if the concentration of COCs would not be a cause for concern in the vadose zone, it would not be a cause for concern after it was diluted in the aquifer.

Groundwater Modeling in the Aquifer

The SWIFT III model is used to estimate aquifer concentrations of COCs for which the estimated ODAST loading concentrations exceeded the screening level concentrations. Steps in the development of the model for application to the FEMP site have included:

- Construction and calibration of a regional, two-dimensional, steady-state groundwater flow model
- Construction and calibration of a regional, three-dimensional, steady-state groundwater flow model
- Application of a local, two-dimensional, analytical solute transport model to help strategize the numerical solute transport model
- Construction of a local, two-dimensional, transient solute transport model
- Construction and calibration of a local, three-dimensional, transient solute transport model with uranium concentration data from the monitoring wells

The regional model covers an area of 74.3 km^2 (28.7 mi^2), including the FEMP site, the Southwest Ohio Water Company (SOWC) collector wells, and a portion of the Great Miami River. The regional model's

grid spacing varies between 786 m and 610 m (250 ft and 2,000 ft) and has its closest grid spacing in the area of the SOWC collector wells. It was calibrated against field data using steady-state flow assumptions, and calibration results were incorporated into the local area model.

The local model covers a smaller area than the regional model and uses tighter grid spacing, with grid cells 38 m (125 ft) on a side. The smaller grid was established to include the area of the existing uranium plume and extends from the northern part of the FEMP site to approximately 460 m (1500 ft) north of the Great Miami River. The grid size was selected based on the need to simulate a uranium dispersivity of 30 m (100 ft) longitudinally, which was the preferred value based on literature review (IT 1990). Using this dispersivity value, the grid size was selected to accommodate dispersivity values as low as 19 m (62.5 ft), or half the distance of the local grid area of 38 m (125 ft). The relationship between the local and regional models was established by imposing the steady-state flow field predicted by the regional model onto the local solute transport model.

The regional and local models each contain five layers. The uppermost two layers represent the upper and lower parts of the upper Great Miami Aquifer that underlies the area. The middle layer represents a clay interbed that is present in the immediate vicinity of the FEMP site, and the lowermost two layers represent the upper and lower parts of the Great Miami Aquifer. In regions where the clay interbed is not present, the middle layer has the same characteristics as the upper two layers. The layers extend laterally into bedrock to the edges of the buried valley that contains the aquifer. The number of aquifer cells in each layer was decreased with depth in the aquifer to simulate the narrowing bedrock valley. This was done using bedrock topography maps of the region and simulating the U-shaped buried valley which contains the Great Miami Aquifer.

Effects of pumping wells in the vicinity of the FEMP site are included in the SWIFT III model runs. A FEMP production well, three industrial wells located to the south of the FEMP site, and two large capacity collector wells owned by the SOWC are used. These wells are assumed to pump for the 1,000-year period. The groundwater concentrations were predicted using the SWIFT III model for a 1,000-year period with 100-year increments. A K_d of 1.4 mL/g for uranium was used for the SWIFT III model.

Modeling Results

Table D.3-8 presents the modeling results for both the ODAST and SWIFT III model runs for the uranium isotopes, which were the only contaminants which passed the screening test. The vadose zone uranium concentrations were used to calculate the risks for the on-property resident farmer and child.

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TABLE D.3-8

CONCENTRATIONS OF CONSTITUENTS OF CONCERN
ASSOCIATED WITH REMEDIAL ALTERNATIVES

Remedial Alternative				Constituents of Concern			
				Maximum Concentration in Vadose Zone		Maximum Off-Property Concentration in Aquifer	
Identification, Primary Source		Process	Constituent	pCi/L[a]	(mg/L)[b]	pCi/L[c]	(mg/L)[d]
2A	Silos 1 & 2 contents	Stabilization in cement	U-238	1.01×10^{0}	3.00×10^{-3}	NA[e]	NA
2A	Silos 1 & 2 contents	Stabilization by vitrification	U-238	$1.48 \times 10^{+1}$	4.41×10^{-2}	NA	NA
2B	Silo 3 contents	Stabilization in cement	U-238	2.0×10^{0}	6.00×10^{-3}	NA	NA
2B/4B[f]	Silo 3 contents	2B - Stabilization by vitrification, 4B - no treatment	U-238	9.7×10^{1}	2.87×10^{-1}	NA	NA
2C	Silos 1, 2 & 3 structures, surface and berm soil	Demolition, removal, on-property disposal	U-238	2.2×10^{-1}	6.5×10^{-4}	NA	NA
	Silos 1, 2 & 3 residuals	Residuals left in place within Operable Unit 4	U-234	8.78×10^{0}		6.56×10^{-2}	
			U-235	3.99×10^{-1}		2.9×10^{-3}	
			U-238	8.56×10^{0}		6.4×10^{-2}	
			Total Uranium		(2.57×10^{-2})		(1.92×10^{-4})
3C	Silos 1, 2, & 3 residuals	Residuals left in place within Operable Unit 4	U-234	8.78×10^{0}		6.56×10^{-2}	(1.92×10^{-4})
			U-235	3.99×10^{-1}		2.9×10^{-3}	
			U-238	8.56×10^{0}		6.4×10^{-2}	
			Total Uranium		(2.57×10^{-2})		

[a]Used to estimate risk to on-property residents.
[b]Vadose zone concentrations are produced from the ODAST model for total uranium.
[c]Used to estimate risk to off-property residents.
[d]Aquifer concentrations are produced from the SWIFT III model.
[e]Not analyzed because the predicted maximum concentration in the aquifer is less than the 10^{-7} risk screening level concentration.
[f]Treatability studies have determined that leachate from vitrified and untreated Silo 3 wastes are similar. As such, untreated waste (4B) was not separately modeled.

The maximum exposure off-property location was selected to be at the FEMP fenceline to the east of the Operable Unit 4 silos. The uranium isotope concentrations at this location were used to estimate risks for the off-property resident farmer.

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D.3.3 TOXICITY ASSESSMENT

This toxicity assessment presents information concerning the potential effects of exposure to the Operable Unit 4 COCs. The goal is to provide a quantitative estimate of the relationship between exposure and severity or probability of effect. The toxicity assessment contains a compilation of toxic and carcinogenic effects of COCs based on the detailed evaluations presented in the Baseline Risk Assessment. The toxicity data discussed in the sections that follow have been used, as applicable, in the assessment of human health risks from potential short-term and long-term exposures presented in Sections D.3.4 and D.3.5, respectively.

D.3.3.1 Cancer and Noncancer Toxicity Criteria

The risk of developing radiologically or chemically induced cancer is estimated by computing an ILCR, expressed as a probability. The chemical ILCR is calculated as the product of the average daily intake or dose, expressed as mg/kg-day, and the cancer slope factor (CSF), which is the risk per unit intake or dose, or the risk per mg/kg-day. This model implies linearity in the dose-response relationship over the entire dose range of concern. The radiological ILCR is calculated as the product of the radionuclide activity intake [picocurie (pCi)] and the CSF, which is the risk per unit activity intake, or the risk per pCi. In addition, cancer risks associated with external radiation are estimated for radionuclide COCs.

Cancer risks associated with multiple chemical and radionuclide exposures are assumed to be additive within the two classes of contaminants. However, due to differences in the methods used to derive the toxicity parameter values for the two classes of contaminants, cancer risks due to radionuclide and chemical exposures are not considered to be strictly comparable; therefore, radiological and chemical risks are not summed in the discussions which follow.

The risk of developing chemically induced noncancer effects is not expressed as a probability. Instead, a HQ is calculated as the ratio of the exposure dose, or intake, divided by a RfD, which is a hypothetical dose at which adverse effects are not expected to occur. A HQ equal to or greater than one indicates that the exposure dose exceeds the RfD, indicating that an adverse effect might be expected to occur. In the case of multiple chemical exposures, the potential for adverse noncancer effects is evaluated using HIs, which are defined as the sum of the HQs for the individual contaminant exposures.

The COCs in the surface and berm soil to which the potential receptors could be exposed during the remediation process include contaminants that may induce both carcinogenic and noncancer effects. Potential routes of exposure include inhalation, ingestion, and dermal contact. Table D.3-9 presents the

TABLE D.3-9

REFERENCE DOSES FOR NONCARCINOGENIC EFFECTS OF CONTAMINANTS OF CONCERN IN SURFACE AND BERM SOIL IN OPERABLE UNIT 4

Chemical	Oral Reference Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)[a]	Target Organ		Uncertainty Factor	
			Oral	Inhalation	Oral	Inhalation
Inorganics						
Antimony	0.0004[b]	ND[c]	Liver	ND	1000	ND
Arsenic	0.0003[b]	ND	Skin	ND	3	ND
Cadmium (food)	0.001[b]	ND	Kidney	Cancer (see Table D.4-2)	10	ND
Chromium (VI)	0.005[b]	ND	ND	ND	500	ND
Copper	ND	ND	ND	ND	ND	ND
Molybdenum	0.005[b]	ND	Liver	ND	30	ND
Nickel	0.02[b]	ND	ND	Cancer (see Table D.4-2)	300	ND
Silver	0.005[b]	ND	ND	ND	3	ND
Thallium	0.00006[b,a]	ND	Central nervous system	ND	3000	ND
Uranium	0.003[b]	ND	Kidney	ND	1000	ND
Vanadium	0.007[d]	ND	ND	ND	100	ND
Zinc	0.3[b]	ND	Blood	ND	3	ND
Semivolatiles						
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND
Chrysene	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND

See footnotes on next page.

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TABLE D.3-9
(Continued)

[a]Derived from inhalation RfC (see Section D.4.1.1).
[b]IRIS (EPA 1993[a]) current as of April 1993.
[c]ND - no data.
[d]EPA, Health Effects Assessment Summary Tables, (HEAST) Annual FY 92 including July and November Supplements (EPA 1992).
[e]EPA 1992[e], Memorandum from D. L. Forman, U. S. EPA Region VII, Philadelphia, Pennsylvania, "Subject: Cobalt Toxicity," dated March 12, 1992.
[f]EPA 1990c, Memorandum from Pei-Fung Hurst, ECAO, Cincinnati, Ohio, to R. Riccio, U.S. EPA Region III, Philadelphia, Pennsylvania, "Subject: Toxicity of Cobalt (Halby Chemical/Wilmington, Delaware)," dated October 9, 1990.
[g]Derived by analogy to thallium sulfate, adjusting for differences in molecular weight.
[h]EPA 1993c
[i]Based on anology to Aroclor - 1016.
[j]EPA, 1993e, Health Effects Assessment Summary Tables, (HEAST), March, 1993.
[k]EPA, 1993d, Memorandum from J. Dollarhide, ECAO to P. VanLeeuwen, Region V, 7/21/93.

RfD values for the nonradioactive COCs in surface and berm soil, taken directly from the November 1993 final version of the RI Report for Operable Unit 4. Because the remediation period is expected to take three years, subchronic RfD values were used when available. When subchronic values were not available, chronic RfDs were used. Their use provides a conservative evaluation of short-term remediation risks, since the long-term toxicity criteria are generally more stringent than the subchronic values. Table D.3-10 presents CSFs for the nonradioactive COCs in surface and berm soil; Table D.3-11 presents CSFs for radioactive COCs.

The inhalation pathway RfD values were derived from inhalation pathways Reference Concentrations (RFC) by multiplying the RFC values by the standard default daily adult inhalation rate of 20 m^3/day, as recommended by the EPA (1992). In the assessment of inhalation pathway risks, scenario-specific assumptions about daily inhalation pathway exposures were used. In evaluating the potential for adverse affects associated with cadmium exposure, the RfD derived for drinking water exposure was used for the groundwater pathway. In evaluating risks for all other ingestion pathways, the RfD derived for food exposures was used. Dermal contact RfDs and CSFs for COCs in surface and berm soil are presented in Table D.3-12.

Toxicity profiles for the radionuclides and nonradioactive COCs are presented in Section D.4 of the RI Report for Operable Unit 4 (DOE 1993).

D.3.3.2 Missing Toxicological Reference Values

A number of the nonradioactive COCs listed in Tables D.3-9 and D.3-10 do not have toxicological criterion values (e.g., cancer slope factors, oral references doses, or inhalation reference concentrations) which have been verified by EPA. After searching available sources for these values, a request was made to EPA, Region V, to supply the missing values. The EPA was unable to provide all of the needed values for each of the exposure routes covered. The potential toxic effects of the compounds which lack toxicological reference values for both cancer and noncancer endpoints for either oral, inhalation, or dermal exposures are addressed qualitatively below.

Of the 34 nonradioactive COCs identified in surface and berm soils, only four lack toxicological criterion values for oral, inhalation, or dermal exposure routes: acenapthylene, benzo(g,h,i)perylene, phenanthrene, and copper. Three of these compounds belong to a group of structurally related compounds known as Polyaromatic Hydrocarbons (PAHs). Acenapthylene, benzo(g,h,i)perylene, and phenanthrene are PAHs which are formed during the incomplete combustion of coal, oil, wood, and other

TABLE D.3-10

CANCER SLOPE FACTORS FOR CARCINOGENIC EFFECTS OF CONTAMINANTS OF CONCERN IN SURFACE AND BERM SOIL IN OPERABLE UNIT 4

Chemical	Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg/day)^{-1}$[a]	Tumor Site		Cancer Classification[b]	Reference
			Oral	Inhalation		
Inorganics						
Antimony	ND[c]	ND	ND	ND	D	d
Arsenic	1.75	15	skin	respiratory tract	A	e
Beryllium	4.3	8.4	gross tumors	lung	B2	e
Cadmium (food)	ND	6.3	ND	respiratory tract	B1	e
Chromium (VI)	ND	42	ND	lung	A	e
Copper	ND	ND	ND	ND	D	e
Molybdenum	ND	ND	ND	ND	D	d
Nickel	ND	0.84	ND	respiratory tract	A	e
Silver	ND	ND	ND	ND	D	e
Thallium compounds	ND	ND	ND	ND	ND	e
Uranium	ND	ND	ND	ND	ND	f
Vanadium	ND	ND	ND	ND	ND	d
Zinc	ND	ND	ND	ND	D	e
Semivolatiles						
Benzo(a)anthracene	7.3	6.1	ND	ND	B2	h
Benzo(a)pyrene	7.3	6.1	stomach	respiratory tract	B2	e, g
Benzo(b)fluoranthene	7.3	6.1	ND	ND	B2	h
Benzo(g,h,i)perylene	ND	ND	ND	ND	D	e
Chrysene	7.3	6.1	lymphoma, skin	ND	B2	h
Dibenzo(a,h)anthracene	7.3	6.1	ND	ND	B2	h
Indeno(1,2,3-cd)pyrene	7.3	6.1	ND	ND	B2	h

See footnotes on next page.

TABLE D.3-10
(Continued)

[a]Derived from inhalations unit risk (see Section D.4.1.2).
[b]Cancer weight-of-evidence Group A = human carcinogen; Group B1 and B2 = probable human carcinogen; Group C = possible human carcinogen; Group D - not classifiable as to carcinogenicity to humans; Group E = evidence of noncarcinogenicity to humans
[c]ND - no data
[d]EPA 1993a, "Drinking Water Regulations and Health Advisories"
[e]IRIS, 1993 (EPA 1993b) current as of April 1993
[f]The carcinogenicity of uranium is attributed to its radioactivity; see Section D.4.2.27 and Table D.4-3.
[g]EPA, Health Effects Assessment Summary Table (HEAST)(EPA 1992).
[h]The oral and inhalation cancer slope factors for benzo(a)pyrene are used for the other polyaromatic hydrocarbons assigned to cancer classification B2 (see the toxicological profile for polyaromatic hydrocarbons [Section D.4.217] for additional information)
[i]EPA 1992h, RATS (Risk Assessment Teleconference for Superfund) Meeting Notes, May 13, 1992.
[j]EPA, 1993d, Memorandum from J. Dollarhide ECAO to P. VanLeeuwen Region V, 7/21/93, including Attachments 1-6.

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TABLE D.3-11

CANCER SLOPE FACTORS FOR OPERABLE UNIT 4 RADIOACTIVE CONTAMINANTS OF POTENTIAL CONCERN[a]

Radionuclide	ICRP Lung Class[b]	Inhalation $(pCi)^{-1}$	GI Absorption Factor (f_1)	Ingestion $(pCi)^{-1}$	Penetrating External Exposure $(pCi \cdot yr/g)^{-1}$
U-238 + 2 dtrs	Y	5.2×10^{-8}	5.0×10^{-2}	2.8×10^{-11}	3.6×10^{-8}
U-234	Y	2.6×10^{-8}	5.0×10^{-2}	1.6×10^{-11}	3.0×10^{-11}
Ra-226 + 5 dtrs	W	3.0×10^{-9}	2.0×10^{-1}	1.2×10^{-10}	6.0×10^{-6}
Rn-222 + 4 dtrs	Gas	7.7×10^{-12}	1.0×10^{0}	1.7×10^{-12}	5.9×10^{-6}
Pb-210 + 2 dtrs	D	4.0×10^{-9}	2.0×10^{-1}	6.6×10^{-10}	1.6×10^{-10}
Ra-228 + 1 dtr	W	6.9×10^{-10}	2.0×10^{-1}	1.0×10^{-10}	2.9×10^{-6}
Th-228 + 7 dtrs	Y	7.8×10^{-8}	2.0×10^{-4}	5.5×10^{-11}	5.6×10^{-6}
Tc-99	W	8.3×10^{-12}	8.0×10^{-1}	1.3×10^{-12}	6.0×10^{-13}
Sr-90 + 1 dtr	D	6.2×10^{-11}	3.0×10^{-1}	3.6×10^{-11}	0.0×10^{0}

[a]EPA, Health Effects Assessment Summary Tables, Annual FY 1992 including the July 1992 and November 1992 supplements (EPA 1992).
[b]Classification recommended by the International Commission of Radiological Production (ICRP) for half-time for clearance from the lung: "Y" = years, "W" = weeks, "D" = days.

TABLE D.3-12

DERMAL REFERENCE DOSES AND CANCER SLOPE FACTORS FOR CHEMICAL CONTAMINANTS OF CONCERN IN OPERABLE UNIT 4

Chemical	Gastrointestinal Absorption Fraction	Dermal Reference Dose (mg/kg-day)	Dermal Slope Factor $(mg/kg\text{-}day)^{-1}$
Inorganics			
Antimony	0.15[a]	6.00×10^{-5}	ND[b]
Arsenic	0.95[c]	1.35×10^{-4}	4.00×10^{0}
Cadmium (food)	0.05[a]	5.00×10^{-5}	ND
Chromium	0.45[a]	2.50×10^{-4}	ND
Copper	0.6[c]	ND	ND
Molybdenum	0.38[a]	1.90×10^{-3}	ND
Nickel	0.05[c]	2.00×10^{-3}	ND
Silver	0.05[c]	ND[e]	ND
Thallium	1[a]	6.00×10^{-5}	ND
Uranium[d]	0.05[c]	1.50×10^{-4}	ND
Vanadium	0.05[c]	3.50×10^{-4}	ND
Zinc	0.25[c]	7.50×10^{-2}	ND
Semivolatiles			
Benzo(a)anthracene	0.43[a]	ND	ND
Benzo(a)pyrene	0.43[a]	ND	ND
Benzo(b)fluoranthene	0.43[a]	ND	ND
Benzo(g,h,i)perylene	0.43[a]	ND	ND
Chrysene	0.43[a]	ND	ND
Dibenzo(a,h)anthracene	0.43[a]	ND	ND
Indeno(1,2,3-cd)pyrene	0.43[a]	ND	ND

See footnotes on next page.

TABLE D.3-12
(Continued)

[a]See the Toxicity Profile for this chemical in Section D.4.2.
[b]ND - not derived
[c]EPA 1989a, "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), "EPA/540/1-89/002, pp. A-2 to A-3
[d]The carcinogenicity of uranium is due to its radioactivity rather than chemical toxicity; its cancer potency due to penetrating external radiation is presented in Table D.4-3.
[e]EPA 1993d, Memorandum from J. Dollarhide ECAO to P. VanLeeuwen Region V, 7/21/93, including Attachments 1-6.

organic substances. Only a few PAHs have been characterized with respect to their toxicities, and available information on PAHs shows a wide range of relative potencies with both cancer and noncancer endpoints. The COC list for surface and berm soils include a total of 12 PAHs, nine of which were addressed for oral and dermal exposures using the available toxicological information. The toxicity of the three remaining PAHs could not be quantitatively assessed. While the impact that this omission may have on the final outcome of the risk assessment cannot be assessed at this time, nine of the 12 COCs which are PAHs have been assessed quantitatively for two routes of exposure.

Besides the three PAHs discussed above, the only other COC which could not be quantitatively assessed for oral, inhalation, and dermal exposures was copper. Copper is an essential nutrient that is toxic to humans only at high doses, such as those which occur during industrial exposures. Copper may cause gastrointestinal irritation and anemia following oral exposures. EPA has established a Maximum Contaminant Level (MCL) in drinking water of 1.30 mg/liter (L). Inhalation exposures to metallic copper dust or fumes can produce a short-term illness known as metal fume fever, which is characterized by chills, fever, aching muscles, metallic or sweet taste, and/or upper respiratory tract irritation. Chronic exposures may result in anemia. Copper salts act as skin irritants upon dermal exposure, producing an itching eczema. The elimination of copper by vomiting and diarrhea will usually protect exposed individuals from the more serious systemic effects of copper exposure; therefore, the lack of toxicological reference values for copper is not expected to have a major impact on the final risk assessment for Operable Unit 4.

D.3.3.3 Inhalation Reference Concentrations

The toxicity of the remaining COCs was quantitatively assessed for oral and dermal exposures; however, 13 compounds remain for which inhalation reference values were unavailable: six metals, two VOCs, four semivolatile organic compounds (SVOCs), and one polychlorinated biphenyl (PCB) mixture.

The toxicological reference value needed to quantitatively assess risks due to inhalation exposures of noncarcinogenic compounds are known as RfCs. The method by which RfCs are derived for inhalation exposures parallels that for oral reference doses (RfDs), except that factors such as the dynamics of the respiratory system, diversity across species including airway diameter and branching effects, clearance rates, and differences in the physicochemical properties of contaminants must be considered. Given the complexity of the process by which inhalation RfCs are derived, it is not surprising that so few RfCs have been verified to date.

As one measure of the relative toxicities of these compounds, the Threshold Limit Value-Time Weighted Averages (TLV-TWAs) were cited when values could be found. The TLV-TWA is the time-weighted average airborne concentration of a substance to which a worker may be exposed during a 40 hour work week without adverse impacts. These values are not routinely used in CERCLA risk assessments because they are derived for evaluation of the effects of chemicals on healthy adult workers and may not be protective for children or other sensitive subgroups. They are used here in a strictly qualitative sense to give some indication of the relative toxicity of these compounds.

PAHs

Inhalation RfCs have not been developed for any of the PAHs, but there is currently a description of the inhalation carcinogenic effects of benzo(a)pyrene available on EPA's Integrated Risk Information System (IRIS) database. Lung cancer has been shown to be induced in humans by various mixtures containing PAHs. However, in these studies, exposures were performed using particulate matter carriers, and it is not known if systemic toxicity to the lung is dependent on the particulate matter carriers. Of the 12 COCs which are PAHs, six have been classified as probable human carcinogens: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, dibenzo(a, h)anthracene, and indeno(1,2,3-cd)pyrene. The inhalation toxicity of these carcinogenic PAH compounds was assessed using route-to-route extrapolation from the CSF for benzo(a)pyrene listed on IRIS. Chemicals of concern for the surface and berm soils, which are PAHs and are not known as cancer inducers, include: acenapthylene, anthracene, benzoperylene, fluoranthene, phenanthrene and pyrene. The inhalation toxicity (noncarconoganic) of these compounds cannot be quantitatively assessed at this time. However, it should be noted that the carcinogenic effects of chemicals generally override the noncarcinogenic effects. Therefore, the lack of RfC values for the PAHs is not thought to be a significant factor.

Metals

Antimony is used with lead alloys in storage battery grids, alloys, rubber, matches, ceramics, enamels, and paints. It is a common pollutant in urban air and has been used medicinally as a parasiticide, emetic, and expectorant. These medicinal uses have been largely phased out because of its relatively high toxicity. The toxic effects associated with acute oral exposure to antimony are similar to those of arsenic poisoning and includes vomiting, diarrhea, irregular respiration, lowered temperature, and collapse. Locally, antimony compounds irritate the skin and mucous membranes. The American Conference of Governmental and Industrial Hygienists has established a TLV-TWA of 0.5 mg/m^3 for antimony.

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Molybdenum is a nutritionally essential trace element. In plants, it is necessary for the bacterial fixing

of atmospheric nitrogen and as such, it is quite common in food. The human body contains approximately 9 mg of molybdenum, most of which is contained in the liver, kidney, fat, and blood. Symptoms of molybdenum poisoning include decreased copper levels in the blood, gastrointestinal irritation, and pain and swelling in the joints. Industrial exposures to high concentrations of molybdenum dust have been associated with "hard-metal lung disease." The TLV-TWA for molybdenum has been set at 5.0 mg/m^3.

The major effect of excessive absorption of silver is local or generalized impregnation of various tissues, the result of which is the production of a generalized grayish pigmentation of the skin and mucous membranes, a condition known as argyrosis. Silver can be absorbed from the lungs and gastrointestinal tract. There are no systemic charges or physical disabilities associated with argyrosis; however, the pigmentation is permanent. The TLV-TWA for silver is 0.01 mg/m^3.

Thallium is readily absorbed from the gastrointestinal and respiratory tracts and is widely distributed to the tissues of the body. It is used as a catalyst in some alloys and has been used medicinally as a depilatory, but its chief uses have been in rodenticides and insecticides. The major effects of thallium poisoning are on the nervous system, skin, and cardiovascular system. The TLV-TWA for thallium is 0.1 mg/m^3. However, this value bears the notation "skin," meaning that the compound may be taken in through cutaneous absorption, rather than or in addition to inhalation absorption.

Vanadium is used as a catalyst in the production of several materials, including sulfuric acid. It is used to harden steel, in the manufacturing of pigments, in photography, and in pesticides. Vanadium is a ubiquitous element common in many foods including milk, seafood, cereals, vegetables, and food oils. The average body burden of vanadium has been estimated at 30 mg, and a beneficial hematopoietic effect has been postulated but not proven. The toxic action of vanadium is largely to the respiratory tract. Following industrial exposures to vanadium dust, workers experience bronchitis, bronchopneumonia, and a discoloration of the tongue. In contrast to this low oral toxicity, the TLV-TWA for vanadium is 0.05 mg/m^3.

Zinc is an essential trace element necessary to enzymatic functions, protein synthesis, and carbohydrate metabolism. It is widely present in the environment and is found in water, air, and all living organisms. The average American daily intake of zinc is approximately 12.6 mg, most of which is consumed through foods. Inhalation of high concentrations of freshly formed zinc fumes in industrial settings has resulted in metal fume fever; however, only freshly formed material is potent, presumably due to flocculation in

air which prevents deep penetration into the lungs of "aged" particulates. Workers note that this effect appears most frequently on Mondays or after holidays and that in even the most severe cases, recovery is usually complete in 24 to 48 hours. The TLV-TWA for zinc is 5.0 mg/m^3.

Of the six metals which were not quantitatively assessed with respect to inhalation toxicity, molybdenum and zinc are nutritionally essential trace elements, and it has been postulated that vanadium may have beneficial biological effects as well. Of these metals, silver has the lowest TLV-TWA. However, the critical effect associated with the absorption of silver is pigmentation of the skin and mucous membranes, which is not accompanied by any serious toxicological effects. The concentrations in air calculated for these metals is, on average, three-four orders of magnitude lower than the associated TLV-TWA values. This would indicate that the lack of an inhalation RfC for these metals is likely to have only a slight effect on the overall risk estimate.

VOCs

Only two VOCs lacked the RfC values needed to quantitatively assess their contribution to risk for receptors exposed to Operable Unit 4 surface and berm soils through inhalation. Acetone is commonly used in laboratories because of its solvent properties and low toxicity. The principle effects associated with inhalation exposures to acetone include nasal effects, nausea, vomiting, and muscle weakness. Acetone is narcotic at high concentrations and may cause headaches or dizziness. The TLV-TWA for acetone is of 1780 mg/m^3.

Mixed xylenes are used in the manufacturing of resins, paints, and other chemicals as well as for a general solvent. Volunteers exposed to various concentrations of mixed xylenes in air reported eye irritation, dizziness or lightheadedness, and a loss of balance. The TLV-TWA for mixed xylenes is 434 mg/m^3. This value is intended to protect workers from sensory irritation and central nervous system effects.

Once again, comparison of the concentrations in air calculated for these two VOCs, with their TLV-TWA values, suggests that the lack of an inhalation RfC for these compounds is not likely to have a substantial effect on the overall risk estimate for surface and berm soils.

SVOCs

Benzoic acid is a common food preservative, which is readily absorbed by the gastrointestinal tract. Chronic feeding studies of benzoic acid conducted with rats and mice have shown few adverse effects.

Humans ingesting 1.75 g/day over 20 days reported irritation, discomfort, weakness, and malaise. The oral RfD for benzoic acid (4.0 mg/kg/day) is based on the human per capita daily dietary intake of 312 mg/day. Since inhalation exposures to benzoic acid are rare, there is insufficient data by which to determine a TLV-TWA or an inhalation RfC.

Bis(2-ethylhexyl)phthalate (BEHP) and di-n-butylphthalate are both members of a larger group of compounds known as phthalate esters. Phthalate esters are widely used as plasticizers and, as such, have become quite common in the environment. In general, phthalate esters have a very low order of both acute and chronic toxicity. Since inhalation exposure to phthalate esters are rare, a majority of the toxicological database involves oral, dermal, or intraperitoneal exposures. Consequently, there is insufficient information by which to establish a TLV-TWA or an inhalation RfC.

BEHP has been identified as a Class B2 carcinogen by the ingestion pathway, and EPA has derived an ingestion CSF for this compound. The carcinogenic activity of BEHP by inhalation has not been evaluated, but its oral CSF is relatively low compared to the carcinogenic metals or PAHs, for example. Thus, given its low volatility, it is not likely that the omission of BEHP from the inhalation risk assessment has resulted in a substantial underestimation of total cancer risks.

Like BEHP, Arochlor 1260 is as a Class B2 carcinogen by ingestion; the presumption of carcinogenicity has been extended to Arochlor 1254 in this assessment because it has a similar chemical composition to Arochlor 1260. Unlike BEHP, the ingestion CSF for Arochlor 1260 (and by extension for Arochlor 1254) is relatively high. Thus, it is less certain that PCB inhalation exposures would contribute negligibly to total site risks if they could be included.

Phenol is readily absorbed through the gastrointestinal tract, by inhalation, and following percutaneous injection. Signs of acute phenol toxicity include nervous system depression, collapse, coma, cardiac arrest, and death. Acutely toxic doses can also cause extensive necrosis at the site of exposure. While several well designed animal studies exist which assess the chronic oral and reproductive toxicity of phenol, the database for inhalation exposures is inadequate. Since phenol causes adverse effects at the point of exposure, route-to-route extrapolation from oral toxicity studies to derive an inhalation RfC is not recommended. Phenol lacks both a TLV-TWA and an inhalation RfC.

While the lack of toxicological reference values for phenol may result in a slight underestimate of risk for the inhalation pathway, benzoic acid, BEHP, and di-n-butylphthalate are of low volatility and,

typically, inhalation exposures are not significant. The lack of quantitative reference values for these compounds is not likely to have a substantial impact on the final risk estimate for Operable Unit 4 receptors.

PCBs

Compounds with relatively low vapor pressures or strong affinities to bind with organic constituents in soil may present very little risk from an inhalation standpoint because their residence time in air will be low. For example, the PCB, Arochlor 1254, does not currently have an inhalation RfC, and the TLV-TWA is 0.5 mg/m^3 based on dermal absorption through the skin. Arochlor 1254 has both a low vapor pressure and a strong tendency to bind to organics in soil. These physicochemical properties of Arochlor 1254 indicate that inhalation exposures to PCBs in soil are likely to be low and that the lack of an inhalation RfC for Arochlor 1254 is not likely to have a major impact on the final risk assessment for surface and berm soils.

The RfD and CSF values presented in this section were taken directly from the Baseline Risk Assessment. They are used, as applicable, in the subsequent assessment of human health risks from potential short-term and long-term exposures. The assessment of short-term exposures is discussed in Section D.3.4. The long-term exposures assessment is discussed in Section D.3.5.

D.3.4 ASSESSMENT OF RISKS FROM SHORT-TERM EXPOSURE

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The Operable Unit 4 short-term exposure conceptual model depicted the various remedial alternatives and the associated receptors and pathways. Some of the pathways are evaluated qualitatively; others are evaluated quantitatively.

D.3.4.1 Workers

Risk to remediation workers during various remedial activities involves:

- Construction - Accidental injuries and fatalities are predicted to occur during any remedial activity that involves construction. Construction activities associated with the Operable Unit 4 remedial alternatives are described in Section D.3.2.1. On-site disposal Alternatives 2A, 2B, 4B, and 2C include construction of the on-property disposal vault, while off-property disposal Alternatives 3A, 3B, and 3C utilize existing and future disposal capacity at the NTS or a permitted commercial facility. The following risk coefficients (compiled by the U.S. Department of Labor, as described in the Operable Unit 4 Work Plan Addendum) have been used:

  - injury/manhour 3.04×10^{-5}
  - death/manhour 5.00×10^{-7}

- Transportation - Accidental injuries and fatalities are predicted to occur during the shipment of material to the designated disposal facility and during the hauling of material in and out of Operable Unit 4. Trucks and/or trains would be used for material transportation. The risk coefficients presented below are used to evaluate nonradiological risks to truck drivers and rail crews. In addition, truck drivers are exposed to direct radiation while transporting the material. It should be noted that the risk coefficients for truck and rail transport are not strictly comparable, since far more waste is transported per mile of rail transport than per mile of truck transport.

	Truck	Rail
- injury/mile	4.1×10^{-8}	4.6×10^{-6}
- death/mile	2.1×10^{-9}	4.6×10^{-8}

- Direct Radiation - Exposure to gamma radiation can occur if the workers are in close proximity to the silo material, such as the top of the silo domes. The Microshield computer code written by Grove Engineering, Inc. as a personal computer version of the main frame code ISOSHLD (which was written by DOE in 1986, BNWL-2316), was used to calculate the exposure levels on top of the domes with the bentonite layers on top of the material. Although exposure to direct radiation is anticipated during Subunit C work

activities, it was not quantified here based on the fact that direct exposures are dominated by the silo wastes.

Based on a projected shielding between sources and workers, Microshield was also used to calculate the highest exposure rate inside the material processing facility at one meter distance from the tanks and pipes of the processing unit. It was projected that the exposure rate is 1.4 milli-roentgen equivalent man/hour (mrem/hr). It is assumed that workers inside the facility would spend 10 percent of their time (202 hrs) in close proximity to these pipes and tanks which are holding the material.

- Resuspended Dust - Dust will be resuspended during the berm removal activity. Because remediation workers will be wearing respiratory equipment, their exposure to resuspended dust will be greatly reduced and will not be quantified. However, nonremediation workers are not necessarily protected; therefore, their exposure to resuspended dust will be quantified.

- Radon - Exposure to radon emanating from the silos under normal operating conditions during remedial activities is not quantified in this assessment since radon release is drastically minimized by keeping the silo headspace under negative pressure, utilizing an RTS, and using a glove box during material removal. Also, most of the radon which would be generated inside the material processing facility during stabilization would be trapped by the RTS. The design of the treatment RTS will be such that radon levels on site for the nonremediation worker was estimated at 0.140 pCi/L, which represent an ILCR of 6.71×10^{-7}. The fenceline radon concentration for the off-site receptor was estimated to be 0.002 pCi/L, which represents an ILCR of 3.2×10^{-7}. Table D.3-13 is a summary of current radon concentrations at different locations. However, exposure to radon can be significant in case of an event such as equipment failure or silo dome collapse. Because a silo dome failure would result in the maximum release of radon (the entire silo headspace contents), the event has been analyzed in Attachment D.I of this appendix.

D.3.4.1.1 Protection of Workers During Remedial Actions

Protective measures would be employed to ensure the safety of workers during remedial actions. These measures involve wearing protective clothing and respiratory protection during excavation. Engineering measures such as the RTS would ensure that the gamma levels on top of the dome are reduced. Using glove boxes, and the fact that the silo headspace would be under negative pressure, would reduce the probability of radon escape from the silos. Other safety measures, such as the remote removal of the material using the work platform and then pumping the material through pipes to the material processing facility, would also reduce workers' exposure to the contaminated material.

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TABLE D.3-13

AVERAGE RADON CONCENTRATIONS IN AIR AFTER BENTONITE PLACEMENT IN K-65 SILOS[a]

On-Site Monitor Location	pCi/L
NW	0.99
SW	1.34
NE	1.19
SE	1.37
Background[b]	0.63

[a]This table, based on monitoring data recorded by the FEMP, presents results of the average of hourly real-time monitored concentrations at four locations near the K-65 exclusion fence line and at a remote (background) location. All data include background concentrations.
[b]DOE guideline concentrations for the general public is 3.0 pCi/L above background as listed in DOE Order 5400.5, February 1990.

D.3.4.1.2 Risk Evaluation of Short-Term Worker Exposures

In this section, the evaluation of risk to nonremediation workers and remediation workers is presented.

- Nonremediation Workers: As mentioned previously, the only pathway by which a nonremediation worker would be exposed to the contaminants inside Operable Unit 4 is by inhalation of resuspended dust from remedial activities. It was assumed that the nonremediation worker is inhaling the total suspended particulates, and all surface soils would produce resuspended particulates (that is, no cover, vegetative or otherwise). The risk estimates in Table D.3-14 assume that the worker would be exposed for one hour per day for 250 days per year for three years (see Table D.3-4). Three years is the estimated period of remediation. The total ILCR risk is 2.9×10^{-7}. The total committed effective dose equivalent (CEDE) for the three years is 2.3 mrem or 0.77 mrem/year. This is below the National Emissions Standards and Technology (NESHAP) dose limit of 10 mrem/yr. Table D.3-15 presents the ILCR and HI from exposure to chemicals in the resuspended dust. The ILCR was 2.5×10^{-10}. This value is below the CERCLA ILCR target of 10^{-6}.

- Remediation Worker: As mentioned earlier, remediation workers would be exposed to risk from direct radiation, construction, and transportation accidents. Table D.3-16 is a summary of construction risk and direct radiation risk during various remediation activities for those alternatives that involve the removal of silo materials. However, this table presents the risk to a single worker during a specific remedial activity. The number of man-hours presented in this table are the result of engineering estimates for the amount of time required to complete each remedial activity. Total risks that involve all workers and all activities will be presented in Section D.4.1. Tables D.3-17 and D.3-18 summarize the risks to a single worker during a specific activity for Alternatives 2C, 3C.1, and 3C.2 remedial actions. Because the alternatives designated by the letter "C" do not involve the material inside the silos, their risk tables do not show any risk from direct radiation. In fact, all of the "C" alternatives require that the material inside the silo be removed under some other alternative.

- Off-site Waste Disposal Transportation Worker: Many alternatives include transporting waste material to the Nevada Test Site (NTS) for disposal. This transportation would be a combination of rail and truck. For all alternatives except 3C.2, material would travel by exclusive use rail from the FEMP to Las Vegas, Nevada (a distance of 3562 km), then by truck from Las Vegas to the NTS (179 km). For Alternative 3C.2, the material would travel by rail to a permitted commercial disposal site. Since this material is radioactive, the truck driving crew is exposed to radiation during the drive. The RADTRAN IV computer code (Neuhauser and Kanipe 1992) was used to estimate the total dose equivalent delivered to drivers during the remediation. Through Sandia National Laboratory's

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TABLE D.3-14

ILCR TO NONREMEDIATION WORKER FROM EXPOSURE TO RADIONUCLIDES FROM INHALING RESUSPENDED DUST WHILE REMOVING SURFACE SOIL AND BERM MATERIAL AROUND SILOS 1 AND 2 IN OPERABLE UNIT 4

Isotope	SF	Cs (pCi/g)	Ca (pCi/m^3)	I (pCi)	Risk	C.E.D.E. (mrem)
Pb-210	4.0×10^{-9}	4.5	2.7×10^{-3}	1.68	6.7×10^{-9}	5.4×10^{-2}
Ra-226	3.0×10^{-9}	14.7	2.3×10^{-3}	1.43	4.3×10^{-9}	3.4×10^{-2}
Ra-228	6.0×10^{-9}	1.3	7.80×10^{-4}	0.48	2.9×10^{-9}	2.38×10^{-1}
Sr-90	6.2×10^{-11}	1.8	1.1×10^{-3}	0.68	4.2×10^{-11}	3.4×10^{-4}
Tc-99	8.3×10^{-12}	3.6	2.3×10^{-3}	1.4	1.1×10^{-11}	9.1×10^{-5}
Th-228	7.8×10^{-8}	1.3	7.8×10^{-4}	0.48	3.8×10^{-9}	3.0×10^{-2}
U-238	2.4×10^{-8}	14	8.4×10^{-3}	5.2	2.7×10^{-7}	$2.17 \times 10^{+0}$
				Total	**2.9×10^{-7}**	**$2.3 \times 10^{+0}$**

SF: Inhalation slope factor (Risk/pCi).

Cs: Concentration of isotope in berm soil (pCi/g), taken from the Final RI Report for Operable Unit 4, November 1993, Table D.3-4.

Ca: Concentration of isotope in resuspended dust (pCi/m^3).

I: Intake from inhaling the resuspended dust for one hour per day for 250 days per year for 3 years at an inhalation rate of 0.83 m^3/hr.

Risk: This is the risk of cancer incidence due to inhalation of resuspended dust for the duration of the remedial activities.

C.E.D.E.: This is the Committed Effective Dose Equivalent from exposure to radionuclides in the resuspended dust. The Dose Conversion Factors for Inhalation were obtained from the "EPA Federal Guidance Report No. 11". The highest inhalation class was used since the chemical forms of these isotopes are not known.

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TABLE D.3-15

ILCR AND HI FOR UNPROTECTED NONREMEDIATION WORKERS EXPOSED TO CHEMICALS FROM INHALATION OF RESUSPENDED DUST WHILE REMOVING SURFACE AND BERM MATRERIAL

Chemical[a]	ILCR	HQ
Arsenic	2.5E-11	ND[6]
Benzo(a)anthracene	6.1E-12	ND
Benzo(a)pyrene	6.7E-12	ND
Benzo(b)fluoranthene	1.2E-11	ND
Beryllium	1.5E-12	ND
Cadmium	7.1E-12	ND
Chromium	1.8E-10	ND
Chrysene	1.5E-12	ND
Dibenzo(a,h)anthracene	1.2E-12	ND
Indeno(1,2,3-cd)pyrene	5.7E-12	ND
TOTAL	**2.5×10^{-10}**	**ND**

[a]Chemicals of concern for the berm and other surface soils that did not have toxicity information for either carcinogenic or non-carcinogenic effects for this route were addressed qualitatively (see Section D.3.3) and are not listed below.
[b]ND = Not derived (ND) because there is no toxicity value for this route of exposure.

TABLE D.3-16

SHORT-TERM WORKER RISK ASSESSMENT OF THE MATERIAL REMOVAL ALTERNATIVES FOR OPERABLE UNIT 4

				Risk to Workers			
				Construction		Direct Radiation	
Activity	Remedial Alternative	Duration of Activity	Worker Hours per Year[a]	Injuries	Death	Dose (mrem)	Cancer Risk
Partial berm removal	2A, 3A.1	3 months	524	1.78×10^{-2}	2.62×10^{-4}		--
Construction of the gantry crane system	2A, 3A.1, 2B, 3B.1, 4B	3.5 months	626	2.1×10^{-2}	3.13×10^{-4}		--
Installation of RTS/Gas Treatment	2A, 3A.1, 2B, 3B.1, 4B	2 months	191(10)	6.5×10^{-3}	9.5×10^{-5}	35	4.4×10^{-6}
Installation of mining device	2A, 3A.1, 2B, 3B.1, 4B	2 months	369	1.25×10^{-2}	1.84×10^{-4}		--
Silo 1 material removal	2A, 3A.1	18 months	(18)	6.12×10^{-4}	9.0×10^{-6}	1350	1.68×10^{-4}
Silo 2 material removal	2A, 3A.1	16 months	(18)	6.12×10^{-4}	9.0×10^{-6}	1548	1.93×10^{-4}
Berm removal during silo material removal	2A, 3A.1	34 months	72	2.4×10^{-3}	3.6×10^{-5}		--
Silo 3 material removal	2B, 3B.1, 4B	12 months	126(12)	4.28×10^{-3}	6.3×10^{-5}	0.4	6.0×10^{-8}
Material stabilization	2A, 3A.1, 2B, 3B.1	34 months	(202)	--	--	293	3.7×10^{-5}

[a]The number in parentheses represents the hours which a worker will spend on top of the silo dome during which time he/she will be exposed to direct radiation. However, for material stabilization and extraction, the number of hours represent the time that a worker will spend in the vicinity (1 m) of the tanks and pipes carrying the material.

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TABLE D.3-17

RISK TO A WORKER DURING THE ACTIVITIES OF DEMOLISHING AND ON-SITE DISPOSAL OF SILO STRUCTURES AND SOILS (ALTERNATIVE 2C)

	Construction		Transportation	
Residual Activity	Injuries	Deaths	Injuries	Deaths
Silo Cleaning	1.40×10^{-3}	2.00×10^{-5}	--	--
Silo Demolition	3.92×10^{-2}	5.60×10^{-4}	--	--
Concrete Scabbling of Silos	2.38×10^{-2}	3.40×10^{-4}	--	--
Transporting of Clean Silo Rubble	2.24×10^{-2}	3.20×10^{-4}	3.66×10^{-4}	1.87×10^{-5}
Removing of Decant Tank	1.96×10^{-2}	2.80×10^{-4}	--	--
Backfilling with Clean Soil	3.08×10^{-3}	4.40×10^{-5}	1.68×10^{-4}	8.61×10^{-6}
Disposal Facility Construction	7.28×10^{-2}	1.04×10^{-3}		
Hauling Soil	--	--	1.07×10^{-3}	5.48×10^{-5}
Hauling Gravel	--	--	1.71×10^{-4}	8.76×10^{-6}
Security Construction	1.54×10^{-2}	2.20×10^{-4}	--	--
Monitoring Wells Installation	4.06×10^{-2}	5.80×10^{-4}	--	--

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TABLE D.3-18

RISK TO A WORKER DURING SILO STRUCTURE DEMOLITION AND OFF-SITE DISPOSAL (ALTERNATIVES 3C.1 and 3C.2)

	Construction		Transportation	
Residual Activity	Injuries	Deaths	Injuries	Deaths
Silo Cleaning	1.40×10^{-3}	2.00×10^{-5}	--	--
Silo Demolition	3.92×10^{-2}	5.60×10^{-4}	--	--
Concrete Scabbling of Silos	2.38×10^{-2}	3.40×10^{-4}	--	--
Transporting of Clean Silo Rubble	2.24×10^{-2}	3.20×10^{-4}	3.66×10^{-4}	1.87×10^{-5}
Removing of Decant Tank	1.96×10^{-2}	2.80×10^{-4}	--	--
Backfill with Clean Soil	3.08×10^{-3}	4.40×10^{-5}	1.68×10^{-4}	8.61×10^{-6}
Loading Waste Boxes	5.88×10^{-2}	8.40×10^{-4}	--	--

TRANSNET system, RADTRAN IV simulates the transportation route of the trucks, the length of time the drivers are exposed to radiation, and the cumulative dose equivalent delivered for the trip. There are no occupationally exposed individuals during the rail transport since no one is in close proximity to the waste packages. The alternatives call for packaging the material from Subunit A in metal boxes. Tables D.3-19 and D.3-20 present key input parameter values for the analysis. Table D.3-21 summarizes the cumulative dose equivalent for each alternative with off-site material disposal. There are nonradiological risks to the truck drivers and rail employees associated with transporting the material. These risks were developed based on the total truck and rail miles associated with each alternative and risk factors for injuries and fatalities from truck and rail incidents. The risk factors used are 4.6×10^{-6} injuries per train mile, 4.6×10^{-8} fatalities per train mile, 4.1×10^{-8} injuries per truck mile, and 2.1×10^{-9} fatalities per truck mile. These risks are also presented in Table D.3-21.

- Risks Associated with Waste Treatment Processes: Potential risk of industrial injuries and fatalities or radiation exposure associated with the treatment of wastes at on-site facilities (vitrification and cement stabilization) are not estimated quantitatively because no data are available that would support the development of quantitative risk estimates for these processes. At this stage in the evaluation of Operable Unit 4 remedial alternatives, it is reasonable to assume that the risks to workers during process operations will be comparable to those for cementation and vitrification.

D.3.4.2 Public

In this section, protection of members of the public and risk evaluations for an off-property resident and a trespassing child will be discussed.

D.3.4.2.1 Protection of the Public During Remedial Actions

The level of risk to the public during remedial actions is dependent on the remedial alternative. However, all of the proposed remedial alternatives effectively reduce risks to the public during the remedial actions under normal operating conditions. The nonremoval alternatives, for example, offer the maximum protection since they do not involve the removal of material from the silos, reducing the level of exposure to the public. Moreover, after the introduction of the first foot of structural grout on top of the bentonite layer, the release of radon gas from the silos is drastically reduced.

Those alternatives which involve the removal of the silo contents also effectively reduce risks to the public under normal remedial actions. The material will be slurried inside the silos and then pumped through pipes to the material processing facility, keeping a minimal level of risk to the public. The

TABLE D.3-19

INPUT PARAMETERS FOR OFF-PROPERTY WASTE TRANSPORTATION RISK ANALYSIS

PARAMETER	Alternative					
	3A.1/C	3A.1/V	3B.1/C	3B.1/V	3C.1	3C.2
No. of Rail Trips	60	10	20	5	81	81
No. of Truck Trips	3002	482	991	256	4041	0
Packages per Rail Car	25	25	25	25	25	25
Packages per Truck	5	5	5	5	5	NA[b]
No. of Packages	15009	2412	4957	1282	20206	20206
Weight of Original Waste[a], lbs	15,005,000	15,005,000	8,678,804	8,678,804	86,320,282	86,320,282
Weight of Original Waste[a]/Box, gms	453,379	2,821,214	793,996	3,070,076	1,973,358	1,937,358

[a]Original waste is the silo residues (for Subunits A and B) and soils (for Subunit C).
[b]Not Applicable.

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TABLE D.3-20

WASTE CHARACTERIZATION INPUT PARAMETERS FOR OFF-PROPERTY WASTE TRANSPORTATION RISK ANALYSIS

Concentration, pCi/g	Radionuclide Concentration in Original Waste		
	Subunit A	Subunit B	Subunit C
Ac-227	5,960	503	3.25
Pb-210	153,000	2,620	20.5
Po-210	242,000	NA	37.9
Ra-224	NA	290	1.03
Ra-226	385,000	2,970	39.2
Ra-228	NA	297	1.86
Th-228	645	686	1.85
Th-230	54,600	5,120	4.76
Th-232	424	682	5.81
Pa-231	2,350	487	9
U-234	961	1,480	8.71
U-235	73	95	2.07
U-238	912	1,500	7.36

NA = Not Applicable.

TABLE D.3-21

IMPACTS TO TRANSPORTATION WORKER DURING OFF-PROPERTY WASTE TRANSPORTATION

IMPACT	Alternative					
	3A.1/Cem	3A.1/Vit	3B.1/Cem	3B.1/Vit	3C.1	3C.2
Driver Cum. Dose Equiv. (mrem)	21	22	0.95	0.86	0.24	0
Truck Driver Injuries[a]	0.027	0.0044	0.0090	0.0023	0.037	0
Truck Driver Fatalities[a]	0.0014	0.00023	0.00040	0.00012	0.0019	0
Train Crew Injuries[a]	0.61	0.098	0.20	0.052	0.82	0.73
Train Crew Fatalities	0.0061	0.00098	0.0020	0.00052	0.0082	0.0073

[a] Nonradiological impacts.

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primary risk to the public during remediation is the risk associated with material transport. However, events during remediation, such as equipment failure, personnel error, or a silo dome collapse, are possible. A dome collapse could expose both the workers and the public to the radon present inside the silo headspace. This hypothetical event has been evaluated in Attachment D.I. The risks to workers from this event (at distances between 350 - 500 m) and to members of the public (500 - 5000 m) are presented in Table D.I.3-1.

D.3.4.2.2 Risk Evaluation to Members for the Public During Remediation

Off-Property Resident Farmer

- Exposure to Radon: Since the space inside the silos will be under negative pressure and a RTS will be utilized during remediation, exposure of the general public to radon gas during remediation is very low under normal operating conditions. Moreover, the equipment inside the material processing facility have been designed in such a manner that the radon level at the site boundary was estimated to be 0.002 pCi/L which represents an ILCR of 3.2×10^{-7}. The radon concentration at the Operable Unit 4 boundary is comparable to those of the background (Table D.3-12), suggesting that its concentration off site is even lower. Therefore, public exposure to radon under normal remedial activities will not be evaluated quantitatively. However, as mentioned earlier, exposure to radon due to dome failure is analyzed in Attachment D.I.

- Exposure to Resuspended Dust: Some remedial alternatives require the removal of berm material and soil around the silos. This can result in resuspended dust being inhaled by workers on site. If this dust is carried away by air to off-site locations, it can be inhaled by the general public. Quantitative results have shown that exposure of a worker to resuspended dust for one hour during berm removal will result in a radiation dose of 2.4×10^{-3} mrem and a cancer risk of 3.2×10^{-10} due to inhalation of radionuclides in the dust (Table D.3-13). This is an extremely low dose, and risk to workers is well below the NESHAP 10 mrem limit. Exposure to nonradioactive COCs in the surface and berm soils are associated with both cancer and noncancer effects (Table D.3-14). The estimated ILCR to the unprotected worker (wearing no respiratory protection) from inhalation of nonradioactive COCs in resuspended dust is 7.6×10^{-7}. The total HI is 3.0×10^{-8}. The risk from this pathway to the public is considerably less than the risk to the worker due to the following considerations:

  - The concentration of contaminants off site due to dust resuspended on site is very small due to settling, dilution, and dispersion.

- The frequency of exposure of an off-site resident is much lower than that of a worker due to changes in wind direction and the protection offered by spending a large part of the day indoors.

  If an off-site resident should inhale resuspended dust with on-site concentrations, the risk of cancer will be negligible. Therefore, no quantitative evaluation of risk to the public due to resuspended dust is needed.

- Off-Site Transportation of Wastes:

  - Exposure to Radiation: All alternatives except for 3C.2 include transporting waste material to the NTS for disposal. This transportation will be a combination of rail and truck. The material will travel by exclusive use rail from the FEMP to Las Vegas, Nevada (a distance of 3562 km), then by truck from Las Vegas to the NTS (179 km). Alternative 3C.2 includes the transport of material by rail from the FEMP to a permitted commercial disposal site. Since this material is radioactive, members of the public may be exposed to radiation during the transport. The RADTRAN IV computer code was used to evaluate potential risks to the public during the transportation. Through Sandia National Laboratory's TRANSNET system, RADTRAN IV simulates the transportation route of the trucks, the length of time members of the public are exposed to radiation, and the dose equivalent delivered for the trip. This exposure is to members of the public sharing the road with the truck, people living along the rail and truck route, and people encountering the truck at truck stops. The alternatives call for packaging the material from Subunit A in metal boxes. The radiological impacts for each alternative requiring off-site material disposal are summarized in Table D.3-22.

    RADTRAN IV also assesses the impacts from accidental releases of the radioactive material in the transport containers. The code assesses the total impacts for eight accident severity categories. It assesses collective radiological impacts to the public from direct radiation exposure from contamination on the ground, inhalation of contaminants in a plume and resuspended from the ground, direct radiation exposure from contaminants in a plume, and ingestion of food grown in the contaminated area. The impacts from a single truck and train accident are included in Table D.3-22.

TABLE D.3-22

IMPACTS TO THE PUBLIC DURING OFF-PROPERTY WASTE TRANSPORTATION

IMPACT	Alternative					
	3A.1/Cem	3A.1/Vit	3B.1/Cem	3B.1/Vit	3C.1	3C.2
Routine Transport						
RME Individual dose (mrem)	0.0034	0.0085	0.00015	0.00014	3.86×10^{-5}	1.93×10^{-5}
Risk -ILCR	4.31×10^{-10}	8.32×10^{-10}	1.89×10^{-11}	1.71×10^{-11}	4.82×10^{-12}	2.41×10^{-12}
Transportation Accidents						
Public dose from radioactive material releases following truck accident, (person - rem)	1.1×10^{-5}	1.9×10^{-5}	3.6×10^{-6}	3.8×10^{-6}	8.9×10^{-8}	0
Public dose from radioactive material releases following train accident, (person - rem)	0.019	0.026	0.0061	0.0053	0.00016	0.00022
Truck Associated Injuries[a]	0.080	0.013	0.026	0.0068	0.11	0
Truck Associated Fatalities[a]	0.0087	0.0014	0.0029	0.00074	0.012	0
Train Associated Injuries[a]	0.90	0.15	0.30	0.077	1.2	1.1
Train Associated Fatalities[a]	0.24	0.038	0.079	0.020	0.32	0.29

[a]Nonradiological impacts.

- Nonradiological Impacts: Along with exposure to small amounts of radiation, the population along the transportation route is at risk from accidents. The Risk Assessment Work Plan Addendum presents risk coefficients for members of the public. These coefficients are 1.3 x 10^{-6} fatalities per train mile traveled and 6.8 x 10^{-6} injuries per train mile traveled. The resulting estimates of injuries and fatalities for each alternative requiring off-site radioactive waste disposal are also summarized in Table D.3-22.

Trespassing Child

Short-term risks to a trespassing child were evaluated to address potential exposure to a member of the public during stages of remediation. During those times when access barriers are temporarily removed, a trespassing child is postulated to come on site and be exposed to radionuclides and chemicals via the following pathways:

- Direct radiation from contaminated soil
- Direct radiation from silo contents
- Inhalation of resuspended dust
- Dermal contact with soil
- Ingestion of soil

The ILCR for radionuclides and carcinogenic chemical COCs for each pathway are presented in Table D.3-23. Table D.3-24 presents the HI value for the non-carcinogenic effects for the chemical COCs. As noted in Table D.3-23, the risks of radiologically induced cancer from direct radiation, inhalation of resuspended dust, and ingestion of soil are each less than 1 x 10^{-6} and the total radiological ILCR is 3.8 x 10^{-7}. Chemically induced cancer risks total 2.8 x 10^{-7} yielding a total ILCR on 6.6 x 10^{-7}. The HIs from Table D.3-24 associated with inhalation of resuspended dust, dermal contact with soil, and ingestion of soil are each less than 1.0. The combined HI for all is also less than 1.0, suggesting that there is little potential for adverse noncancer effects. It should be noted that the trespassing child was assumed to be present at Operable Unit 4 for 52 days a year. Given the size of Operable Unit 4 and the nature of remediation and the access controls, it is not likely that the trespassing child would be present. Hence the estimated risk is a gross over-estimate.

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TABLE D.3-23

ILCR CALCULATIONS FOR THE TRESPASSING CHILD EXPOSED TO CHEMICALS AND RADIONUCLIDES IN SURFACE AND BERM SOILS

Chemical	Dermal Contact with Soil	Incidental Ingestion of Soil	Inhalation of Resuspended Dust	Sum of Chemical-Specific Risk Across Pathways
Arsenic	8.6×10^{-9}	4.8×10^{-8}	3.3×10^{-11}	5.7×10^{-8}
Benzo(a)anthracene	ND[a]	1.8×10^{-8}	8.1×10^{12}	1.8×10^{-8}
Benzo(a)pyrene	ND[a]	1.3×10^{-7}	9.0×10^{-12}	1.37×10^{-7}
Benzo(b)fluoranthene	ND[a]	3.1×10^{-8}	1.7×10^{-11}	3.1×10^{-8}
Cadmium	ND	ND	9.7×10^{-12}	9.7×10^{-12}
Chromium	ND	ND	2.4×10^{-10}	2.4×10^{-10}
Chrysene	ND[a]	4.0×10^{-10}	6.1×10^{-12}	4.0×10^{-10}
Dibenzo(a,h)anthracene	ND[a]	3.9×10^{-9}	1.6×10^{-12}	3.5×10^{-9}
Indeno(1,2,3-cd)pyrene	ND[a]	3.0×10^{-8}	7.3×10^{-12}	3.0×10^{-8}
TOTAL	**8.6×10^{-9}**	**2.8×10^{-7}**	**3.4×10^{-10}**	**2.8×10^{-7}**

Radionuclide	Direct Radiation	Incidental Ingestion of Soil	Inhalation of Resuspended Dust	Sum of Specific ILCR Across Pathways
Pb-210 + 2d	2.1×10^{-12}	1.2×10^{-8}	5.6×10^{-9}	1.7×10^{-8}
Ra-226 + 5d	6.5×10^{-8}	1.8×10^{-9}	3.6×10^{-9}	7.1×10^{-8}
Ra-228 + 1d	1.1×10^{-8}	5.1×10^{-10}	2.8×10^{-9}	1.4×10^{-8}
Sr-90 + 1d	N/A	2.5×10^{-10}	$3{,}5 \times 10^{-11}$	2.9×10^{-10}
Tc-99	6.2×10^{-15}	1.8×10^{-11}	9.3×10^{-12}	2.8×10^{-11}
Th-228 +7d	2.1×10^{-8}	2.8×10^{-10}	3.2×10^{-8}	5.3×10^{-8}
U-238	1.4×10^{-9}	1.5×10^{-9}	2.3×10^{-7}	2.3×10^{-7}
TOTAL	**9.8×10^{-8}**	**1.6×10^{-8}**	**2.7×10^{-7}**	**3.8×10^{-7}**

[a] Not derived because there is no toxicity value for this route of exposure.
Chemicals of concern for the berm and other surface soils that did not have toxicity information for either carcinogenic or non-carcinogenic effects for this route were addressed qualitatively (see Section D.3.3) and are not listed above.
N/A = Not Applicable.

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TABLE D.3-24

HAZARD QUOTIENTS FOR THE TRESPASSING CHILD EXPOSED TO CHEMICALS IN SURFACE AND BERM SOILS

Chemical	Dermal Contact with Soil	Incidental Ingestion of Soil	Inhalation of Resuspended Dust	Sum of Chemical-Specific HQ Values Across Pathways
Antimony	6.7×10^{-2}	5.9×10^{-3}	ND[a]	7.3×10^{-2}
Arsenic	3.8×10^{-4}	2.1×10^{-3}	ND	2.5×10^{-3}
Barium	1.7×10^{-4}	9.1×10^{-5}	3.6×10^{-6}	2.6×10^{-4}
Cadmium	1.5×10^{-2}	4.5×10^{-4}	ND	1.6×10^{-2}
Chromium	5.7×10^{-2}	3.4×10^{-4}	ND	5.7×10^{-2}
Molybdenum	4.3×10^{-2}	9.7×10^{-5}	ND	5.3×10^{-4}
Nickel	1.3×10^{-4}	1.3×10^{-4}	ND	1.6×10^{-3}
Silver	4.1×10^{-3}	8.1×10^{-4}	ND	4.9×10^{-3}
Thallium	1.6×10^{-3}	9.80×10^{-4}	ND	2.6×10^{-3}
Vanadium	4.0×10^{-5}	1.2×10^{-5}	ND	5.6×10^{-5}
Zinc	1.9×10^{-6}	4.1×10^{-7}	ND	2.85×10^{-6}
TOTAL	**1.4×10^{-1}**	**1.1×10^{-2}**	**3.6×10^{-6}**	**1.6×10^{-01}**

[a]Not derived because there is no toxicity value for this route of exposure.

D.3.5 ASSESSMENT OF RISKS FROM LONG-TERM EXPOSURES

Following completion of the Operable Unit 4 remedial alternatives, subsurface soils will be the only contaminant source remaining within the unit boundaries. All silo contents will have been removed by Alternatives 3A and 3B, which ship the Silos 1, 2 and 3 contents to an off-site disposal facility, while Alternatives 2A, 2B, and 4B result in their disposal in an on-property vault. Subunit C remedial alternatives will remove contaminated structures and the top 15 cm (6 in.) of Operable Unit 4 surface soils, while the subsurface soils will be left in place beneath 6 inches of clean backfill soil.

Potential risks to human health from long-term exposure to chemicals and radionuclides following implementation of remedial alternatives for Operable Unit 4 have been estimated using the methods described in the Risk Assessment Work Plan Addendum (DOE 1992) and in the Baseline Risk Assessment. The methods used to characterize long-term exposure risks are the same as those used in the Baseline Risk Assessment for the corresponding exposure pathway and receptor combinations. For the purpose of this assessment, an assumption has been made that on-site disposal vault barriers to water infiltration degrade after 100 years, allowing contaminants to leach into the groundwater. This is considered a conservative approach since these disposal structures are designed to prevent water infiltration for a period of at least 1,000 years. The residual subsurface soils are also subject to leaching in addition to surface release mechanisms.

Exposure pathway and receptor combinations, quantitatively evaluated in the long-term risk assessment, are defined in the discussion of the conceptual model in Section D.3.2.2. Exposure of the off-property resident farmer and expanded trespasser receptors addresses the scenario in which DOE retains federal ownership of the FEMP property; exposure of the on-property resident farmer addresses the scenario in which DOE does not retain federal ownership of the property, which is returned to farm use. As discussed in Section D.3.2, these hypothetical receptors have been identified for each exposure scenario to approximate the RME to a member of the public. The resulting estimates of individual risk are input to the subsequent evaluation of remedial alternative effectiveness. Although contaminants remaining after completion of Operable Unit 4 remediation may affect the broader population surrounding the FEMP, this assessment does not address collective risk to the population. Individual risk is an adequate measure for use in evaluating the effectiveness of remediation alternatives; the RME receptors bound the potential risk to any individual in the exposed population, thereby providing adequate protection of the public.

Exposure point concentrations in soil are based on the contaminant-specific proposed remediation levels discussed in Attachment D.II and existing soil concentrations from Table D.3.3. Exposure point

concentrations of uranium isotopes in groundwater (the only COCs which passed the vadose zone/aquifer screening process) for the long-term exposure risk evaluation are presented in Table D.3-7 for each remedial alternative and receptor location. Groundwater exposure point concentrations for the off-property resident receptor are estimated for each remedial alternative for which ODAST results exceed screening levels by modeling the leaching of constituents from disposed materials, through the vadose zone, into the aquifer, and through the aquifer off property. Groundwater exposure point concentrations for the on-property resident receptors are estimated for each remedial alternative by modeling the leaching of constituents from disposed material and through the vadose zone as an estimate of potential perched groundwater contamination on property.

D.3.5.1 Risk Characterization Results

As discussed in the conceptual model, quantitative risk characterization is performed for the following receptors:

- The RME on-property resident farmer
- The CT on-property resident farmer
- The on-property resident child
- The off-property resident farmer
- The trespassing child
- The expanded trespasser

Receptor exposures arise from 1) predicted contamination of groundwater following leaching from the Operable Unit 4 residual subsurface soils and the on-site disposal vault (assuming degradation of disposal vault infiltration barriers, 2) direct contact with residuals soils on site, 3) contact with resuspended and volatilized contaminants, and 4) ingestion of farm products. Receptor exposure routes include:

On Property:

- Inhalation of fugitive dust, VOCs, and gases
- Ingestion of groundwater
- Dermal contact and inhalation while using groundwater in the home
- Consumption of foodstuff grown on the property, including vegetables, meat, and milk
- Incidental ingestion of, external radiation from, and dermal contact with soil

Off Property:

- Ingestion of groundwater
- Inhalation of fugitive dust, VOCs, and gases
- Consumption of farm-produced foodstuffs including vegetables, meat, and milk
- Dermal contact and inhalation while using groundwater in the home

Groundwater fate and transport modeling results predict that groundwater concentrations of all COCs for on-property and off-property receptors are less than the radiological and chemical screening level concentrations, which correspond to $1x10^{-7}$ radiological risk and 0.2 HI, for on-property disposal of materials associated with the following remedial alternatives:

- 2A/Cem
- 2A/Vit
- 2B/Cem
- 2B/Vit
- 2C
- 4B

Thus, there is a high degree of assurance that potential exposures to those contaminants which were screened out would not lead to cancer risks above $1x10^{-6}$, which is the lower end of the CERCLA target risk range, or with HI values above 1.0.

Groundwater fate and transport modeling results predict that groundwater concentrations of uranium isotopes, for both the on-property and off-property resident farmer receptors, are greater than radiological and chemical screening level concentrations for residual contaminated subsurface soils associated with Alternative 2C. Table D.3-25 presents risk assessment results for the groundwater pathway. These results indicate the highest ILCR is estimated for the RME on-property resident farmer at 2.6×10^{-5}. Estimated risks for the other receptors are lower than the RME farmer by a factor of 10 or more, and the dominant pathway is drinking water ingestion in all cases. The water pathway is not applicable to the trespasser receptors.

The results presented in Table D.3-26 for the surface release pathways indicate that for Alternative 2C/residual soil, the greatest risk is estimated for the RME on-property resident farmer (1.7E-03), followed by the on-property resident child (2.5E-04), CT on-property resident farmer (1.4E-04), trespassing child (7.5E-06), off-property resident farmer (4.0E-06), and expanded trespasser (2.9E-06), respectively. In addition, for each pathway/receptor combination, the surface pathway exposures result in the greatest risk. The dominant contributors to risk are radium-226, thorium-228, and arsenic. As detailed in Attachment D.III, the dominant pathways for the on-property resident receptors are external radiation and ingestion of farm products. The dominant pathway for the off-property farmer is inhalation, while for the trespasser receptors, it is external radiation.

TABLE D.3-25

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ILCRs AND HQs FROM LONG-TERM EXPOSURES TO URANIUM 238 IN GROUNDWATER LEACHING AND TRANSPORT PATHWAYS

Receptors (a) >>>>>>>	On-property Resident Farmer RME	On-property Resident Farmer CT	On-property Resident Child	Off-property Resident Farmer	Trespassing Child	Expanded Trespasser
ILCR						
PATHWAYS						
Drinking Water Ingestion	1.9E-05	1.3E-06	1.1E-06	1.4E-07	NA	NA
Ingestion of Fruits and Veg.	7.2E-06	4.7E-07	6.0E-06	5.5E-08	NA	NA
Ingestion of Meat	5.1E-08	3.4E-09	2.0E-08	3.7E-10	NA	NA
Ingestion of Dairy Products	6.3E-07	4.3E-08	1.6E-07	4.8E-09	NA	NA
Total ILCR - All Pathways	**2.6E-05**	**1.8E-06**	**7.3E-06**	**1.9E-07**	**0.0E+00**	**0.0E+00**
HQ						
PATHWAYS						
Drinking Water Ingestion	2.4E-01	1.3E-01	7.7E-01	1.3E-03	NA	NA
Dermal Exposure While Bathing	1.2E-02	6.2E-03	2.6E-02	6.5E-05	NA	NA
Ingestion of Fruits and Veg.	7.3E-02	4.0E-02	2.9E-01	4.2E-04	NA	NA
Ingestion of Meat	6.4E-04	3.5E-04	1.1E-03	3.6E-06	NA	NA
Ingestion of Dairy Products	8.0E-03	4.2E-03	1.1E-01	4.3E-05	NA	NA
Total HI - All Pathways	**3.3E-01**	**1.8E-01**	**1.2E+00**	**1.8E-03**	**0.0E+00**	**0.0E+00**

(a) Additional receptors addressed in the Baseline Risk Assessment are the grounds keeper and off-property user of surface water.

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TABLE D.3-26

ILCRs AND HIs FROM LONG-TERM EXPOSURES TO RESIDUAL SUBSURFACE SOILS - SURFACE RELEASE AND TRANSPORT PATHWAYS

Receptors (a) >>>>>>>	On-property Resident Farmer	On-property Resident Farmer	On-property Resident	Off-property Resident Farmer	Trespassing Child	Expanded Trespasser
ILCR	RME	CT	Child			
RADIONUCLIDE						
Uranium-238 + 2 dtrs	5.4E-05	4.4E-06	3.0E-06	1.9E-06	5.9E-07	2.3E-07
Radium-226 + 5 dtrs	4.5E-04	4.3E-05	3.4E-05	1.1E-08	3.1E-06	1.0E-06
Lead-210 + 2 dtrs	1.1E-04	7.3E-06	1.1E-05	1.7E-08	4.7E-08	5.8E-08
Radium-228 + 1 dtr	1.6E-04	1.5E-05	1.2E-05	5.6E-09	1.1E-06	6.5E-07
Thorium-228 + 7 dtrs	3.0E-04	2.9E-05	2.2E-05	1.9E-07	2.1E-06	6.5E-07
Strontium + 1 dtr	1.4E-04	9.4E-06	2.6E-05	2.9E-08	1.1E-09	1.3E-09
Technetium-99	2.2E-04	1.5E-05	4.5E-05	8.6E-08	8.6E-11	9.3E-11
Total - Radionuclides	**1.4E-03**	**1.2E-04**	**1.5E-04**	**2.3E-06**	**6.8E-06**	**2.6E-06**
CHEMICAL						
Arsenic	2.6E-04	1.7E-05	8.3E-05	4.3E-07	3.1E-07	3.3E-07
Cadmium (food)	4.9E-07	3.7E-08	4.2E-08	3.8E-08	1.4E-08	2.3E-10
Chromium	1.2E-05	9.0E-07	1.0E-06	9.3E-07	3.5E-07	4.7E-09
Nickel	4.0E-07	3.0E-08	3.4E-08	3.1E-08	1.2E-08	1.5E-10
Total - Chemicals	**2.8E-04**	**1.8E-05**	**8.4E-05**	**1.4E-06**	**6.8E-07**	**3.4E-07**
Grand Total	**1.7E-03**	**1.4E-04**	**2.4E-04**	**3.7E-06**	**7.5E-06**	**2.9E-06**

HI						
CHEMICAL						
Antimony	5.3E+00	2.5E+00	2.1E+01	3.3E-03	7.2E-02	1.8E-01
Arsenic	5.0E-01	2.5E-01	1.8E+00	5.7E-04	2.1E-03	2.6E-03
Barium	5.4E-02	2.7E-02	3.2E-01	6.3E-04	1.6E-03	1.3E-03
Cadmium (food)	2.1E+00	1.1E+00	1.4E+01	1.0E-03	1.6E-02	3.5E-02
Chromium	1.5E-01	4.5E-02	6.3E-01	1.2E-04	1.2E-02	3.1E-03
Molybdenum	3.2E-01	1.7E-01	2.0E+00	1.6E-04	5.4E-04	1.1E-03
Nickel	2.2E-01	1.1E-01	1.0E+00	1.4E-04	1.5E-03	6.3E-04
Silver	3.8E+00	2.0E+00	4.8E+01	1.9E-03	1.6E-04	1.3E-02
Thallium	4.7E-01	2.4E-01	1.8E+00	5.8E-04	2.6E-03	3.9E-03
Uranium	3.4E-01	7.9E-02	1.2E+00	4.8E-03	3.4E-02	4.9E-02
Vanadium	4.3E-02	1.8E-02	1.5E-01	6.8E-05	1.3E-03	2.5E-03
Zinc	2.1E+00	1.1E+00	1.1E+01	1.0E-03	1.1E-04	8.6E-04
Hazard Index	**1.5E+01**	**7.6E+00**	**1.0E+02**	**1.4E-02**	**1.4E-01**	**2.9E-01**

(a) Additional receptors addressed in the Baseline Risk Assessment are the grounds keeper and off-property user of surface water.

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D.3.5.2 Noncarcinogenic Health Effects

As noted above, potential receptors addressed in this assessment are the RME on-property resident farmer, CT on-property resident farmer, on-property resident child, off-property resident farmer, trespassing child, and the expanded trespasser. Potential exposure to the Operable Unit 4 contaminants are evaluated for the leaching/groundwater and surface release pathways. For the leaching/groundwater pathway, uranium is the only contaminant modeled to reach the aquifer at concentrations greater than the screening level, and only for the Alternative 2C residual subsurface soils. As shown in Table D.3-25, the groundwater pathway HIs are estimated to be 0.33 for the RME on-property resident farmer, 1.2 for the on-property resident child, 0.17 for the CT on-property resident farmer, and 0.0018 for the off-property resident farmer. Exposure to groundwater is not an exposure pathway for the trespassing child and expanded trespasser. The dominant pathway in all cases is drinking water ingestion.

Potential HIs for exposures to contaminants released via surface pathways are presented in Table D.3-26. The HIs are estimated to be 15 for the RME on-property resident farmer, 100 for the on-property resident child, 7.6 for the CT on-property resident farmer, 0.014 for the off-property resident farmer, 0.14 for the trespassing child, and 0.29 for the on-property expanded trespasser. The predominant contributors to these HIs are antimony, cadmium, silver, and zinc. As detailed in Attachment D.III, the dominant pathway for on-property and off-property resident receptors is ingestion of farm products, while the dominant pathway for trespasser receptors is dermal contact.

D.4.0 SUMMARY OF RISK ASSESSMENT RESULTS

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Section D.4.1 presents a summary of short-term human health risks and Section D.4.2 presents a summary of long-term ILCRs and HIs. For details related to the development of these quantitative risk results, see Section D.3.0.

D.4.1 SHORT-TERM RISK ASSESSMENT SUMMARY

The Operable Unit 4 short-term risk assessment conceptual model shows the various remedial alternatives and the associated potential receptors and exposure pathways. Potential short-term risks that may be experienced by workers during remediation activities include the risk of physical injury or death during construction and transportation activities, including off-site transportation of wastes, direct radiation exposures during construction, waste treatment, or transportation, and potential nonremediation worker exposures to airborne radioactive and chemical contaminants during soil removal operations. On-site disposal Alternatives 2A, 2B, 4B, and 2C include construction of the on-property disposal vault, while off-property disposal Alternatives 3A, 3B, and 3C utilize existing and future disposal capacity at the NTS or a commercial facility. Potential short-term risks to workers are summarized in Table D.4-1.

Members of the public may also be subjected to short-term risks during remediation. Potential short-term risks to the public include the risks of physical injury and death during the course of waste transportation to the NTS, radiological exposure during waste transport, inhalation of radon gas released during waste removal and treatment operations, and potential exposure to a trespassing child postulated to intrude on site during the period of remediation. Potential short-term risks to the public are summarized in Table D.4-2.

TABLE D.4-1

SUMMARY OF SHORT-TERM RISKS TO WORKERS

	REMEDIATION WORKERS				NON-REMEDIATION WORKERS	
	CONSTRUCTION/ TRANSPORTATION		CONSTRUCTION/ TREATMENT	OFF-SITE WASTE TRANSPORTATION	INHALATION	
ALTERNATIVE	TOTAL INJURIES	TOTAL DEATHS	ILCR	ILCR	ILCR	HI
2A/VIT	7.7E+00	1.3E-01	4.0E-04	-	9.6E-07[a]	ND
2A/CEM	9.9E+00	1.5E-01	4.0E-04	-	9.6E-07[a]	ND
3A.1/VIT	2.0E+00	2.9E-02	4.0E-04	2.8E-06	9.6E-07[a]	ND
3A.1/CEM	1.8E+00	2.7E-02	4.0E-04	2.6E-06	9.6E-07[a]	ND
2B/VIT	4.5E+00	6.8E-02	4.1E-05	-	-	-
2B/CEM	5.1E+00	7.7E-02	4.1E-05	-	-	-
3B.1/VIT	1.3E+00	1.9E-02	4.1E-05	1.1E-07	-	-
3B.1/CEM	1.1E+00	1.7E-02	4.1E-05	1.2E-07	-	-
4B	4.5E+00	6.8E-02	4.5E-06	-	-	-
2C	4.5E+00	6.6E-02	-	-	2.9E-07[b]	ND
3C.1	1.4E+00	2.1E-02	-	3.0E-08	2.9E-07[b]	ND
3C.2	1.4E+00	2.1E-02	-	3.0E-08	2.9E-07[b]	ND

[a]Includes exposures from inhaling contaminants from berm, soil, and radon.
[b]Includes exposures from inhaling contaminants from berm and soil.

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TABLE D.4-2

SUMMARY OF SHORT-TERM RISKS TO THE PUBLIC

	OFF-SITE WASTE TRANSPORTATION			SITE BOUNDARY RADON	TRESPASSING CHILD*	
ALTERNATIVE	INJURIES	DEATHS	ILCR	ILCR	ILCR	HI
2A/VIT	-	-	-	3.2E-07	-	-
2A/CEM	-	-	-	3.2E-07	-	-
3A.1/VIT	1.6E-01	3.9E-2	8.3E-10	3.2E-07	-	-
3A.1/CEM	9.8E-01	2.5E-1	4.3E-10	3.2E-07	-	-
2B/VIT	-	-	-	-	-	-
2B/CEM	-	-	-	-	-	-
3B.1/VIT	8.0E-02	2.0E-02	1.7E-11	-	-	-
3B.1/CEM	3.3E-01	8.0E-02	1.9E-11	-	-	-
4B	-	-	-	-	-	-
2C	-	-	-	-	-	-
3C.1	1.3E+00	3.3E-01	4.8E-12	-	-	-
3C.2	1.1E+00	2.9E-01	2.4E-12	-	-	-

*Trespassing child only postulated to come on site during periods of relaxed access controls (e.g., relocating Paddys Run).

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D.4.2 LONG-TERM EXPOSURE RISK ASSESSMENT SUMMARY

Following completion of the Operable Unit 4 remedial alternatives, subsurface soils will be the only contaminant source remaining within the unit boundaries. All silo contents will have been removed: alternatives 3A and 3B ship the Silo 1, 2 and 3 contents to an off-site disposal facility, while alternatives 2A, 2B, and 4B result in their disposal in an on-property vault. Subunit C remedial alternatives will remove contaminated structures and the top 15 cm (6 inches) of Operable Unit 4 surface soils (Alt. 3C off-property disposal, Alt. 2C on-property), while the subsurface soils will be left in place beneath 6 inches of clean backfill soil. As a result, the potential sources of residual contaminants that could result in exposure of on-property or off-property receptors are 1) residual subsurface soils within the Operable Unit 4 area, and 2) the on-property vault (outside the Operable Unit 4 boundaries) containing disposed wastes.

The potential release mechanisms associated with the residual soil contamination include direct contact, penetrating radiation exposure, wind and water erosion, and water leaching. Although the disposal vault is designed to maintain its full integrity for 1000 years, for the purpose of this evaluation, the assumption has been made that the vault's infiltration barriers deteriorate and permit increased infiltration of water. However, it is still reasonable to expect the vault to otherwise survive substantially intact over the long-term, preventing direct contact with the wastes, or surface erosion.

Potential exposure pathways for contaminants in groundwater following transport include ingestion of drinking water, ingestion of fruits and vegetables irrigated with groundwater, ingestion of animal products from cattle raised on groundwater and feed crops irrigated with groundwater, dermal contact with groundwater while bathing, and inhalation of VOCs from use of groundwater in the home. Potential exposure pathways for contaminants in air following transport include inhalation of airborne contaminants, and ingestion of farm-produced fruits, vegetables, meat and milk, in addition to direct contact on site.

Potential ILCRs and HIs for the Operable Unit 4 remedial alternatives are summarized in Tables D.4-3 and D.4-4 respectively. As indicated in Table D.4-3, Alternative 2C/residuals is the only alternative for which ILCRs were estimated in excess of the 1E-07 screening level. The highest estimated residual risks were for the RME on-property resident farmer receptor with an ILCR of 1.7E-03. The CT on-property resident farmer and on-property resident child residual risks were estimated to be 1.4E-04 and 2.5E-04 respectively. Risks for the off-property resident farmer,

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TABLE D.4-3

ILCR FROM LONG-TERM EXPOSURES ASSOCIATED WITH IMPLEMENTATION OF OPERABLE UNIT 4 ALTERNATIVES[a]

Alternative	Contaminant Release/Transport Pathway		
	Ground Water[b]	Surface[c]	Total
2A/Cem	NA[e]	NA	0
2A/Vit	NA	NA	0
2B/Cem	NA	NA	0
2B/Vit	NA	NA	0
4B	NA	NA	0
2C/Waste	NA	NA	0
2C/Residual Soil			
RME On-Property Resident Farmer	2.6E-05	1.7E-03	1.7E-03
CT On-Property Resident Farmer	1.8E-06	1.4E-04	1.4E-03
On-Property Resident Child	7.3E-06	2.4E-04	2.5E-04
Off-Property Resident Farmer	1.9E-07	3.7E-06	3.9E-06
Trespassing Child	d	7.5E-06	7.5E-06
Expanded Trespasser	d	2.9E-06	2.9E-06

[a]Additional receptors addressed in the Baseline Risk Assessment include the grounds keeper and off-property user of river water. See Table D.3-6.
[b]Primary groundwater exposure pathways are drinking water and ingestion of irrigated farm products.
[c]Primary surface exposure pathways on-property are inhalation, direct ingestion of soil, and ingestion of contaminated farm products. Off-property pathways are inhalation and ingestion of farm products contaminated through airborne deposition but do not include direct soil ingestion, and the trespasser receptors do not ingest contaminated farm products.
[d]The trespasser receptor exposure pathways do not include exposure to groundwater.
[e]NA - Not analyzed because predicted concentrations in groundwater were less than the 10^{-7} risk screening level concentration.

TABLE D.4-4

HAZARD INDICES FROM LONG-TERM EXPOSURES ASSOCIATED WITH IMPLEMENTATION OF OPERABLE UNIT 4 ALTERNATIVES[a]

Alternative	Contaminant Release/Transport Pathway		
	Ground Water[b]	Surface[c]	Total
2A/Cem	NA[e]	NA	0
2A/Vit	NA	NA	0
2B/Cem	NA	NA	0
2B/Vit	NA	NA	0
4B	NA	NA	0
2C/Waste	NA	NA	0
2C/Residual Soil			
RME On-Property Resident Farmer	3.3E-01	1.5E+01	1.5E+01
CT On-Property Resident Farmer	1.7E-01	7.6E+00	7.8E+00
On-Property Resident Child	1.2E+00	1.0E+02	1.0E+02
Off-Property Resident Farmer	1.8E-03	1.4E-02	1.6E-02
Trespassing Child	d	1.4E-01	1.4E-01
Expanded Trespasser	d	2.9E-01	2.9E-01

[a]Additional receptors addressed in the Baseline Risk Assessment include the grounds keeper and off-property user of river water. See Table D.3-6.
[b]Primary groundwater exposure pathways are drinking water and ingestion of irrigated farm products.
[c]Primary surface exposure pathways on-property are inhalation, direct ingestion of soil, and ingestion of contaminated farm products. Off-property pathways are inhalation and ingestion of farm products contaminated through airborne deposition but do not include direct soil ingestion, and the trespasser receptors do not ingest contaminated farm products.
[d]The trespasser receptor exposure pathways do not include exposure to groundwater.
[e]NA - Not analyzed because predicted concentrations in groundwater were less than the 10^{-7} risk screening level concentration.

trespassing child, and expanded trespasser were 3.9E-06, 7.5E-06, and 2.9E-06 respectively.

As indicated in Table D.4-4, Alternative 2C/residuals was also the only alternative for which HIs were estimated in excess of the 0.2 screening level. The highest estimated HI was for the on-property resident child receptor with an HI 100. The CT on-property resident farmer and on-property resident child residual risks were estimated to be 15 and 7.8 respectively. HIs for the off-property resident farmer, trespassing child, and expanded trespasser were 0.016, 0.14, and 0.29 respectively.

The assessment of ILCR and HI from long-term exposures addresses potential future land uses and receptors, and relies on the results of theoretical model efforts. Interpretation of the risk assessment results must consider the conservatism that is inherent to the risk assessment methodology.

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D.5.0 UNCERTAINTIES

In relying on multiple assumptions and models, all risk assessments contain elements of uncertainty. The purpose of examining the uncertainty is to provide information relative to the accuracy of the risk estimates and thus aid in the formation of risk management decisions. For the major categories of uncertainty of particular relevance to the Feasibility Study/Risk Assessment (FS/RA), questions were asked to elucidate the degree of uncertainty in the risk evaluation:

- COCs Selection:
  Are all COCs correctly identified and their concentrations adequately quantified?

- Toxicological Information and Models:
  How good is the current information concerning the toxic properties and dose-response characteristics of the COCs?

- Exposure Pathways:
  Are all potential pathways for transporting contaminants from the site environmental media to the receptors identified?

- Receptor Characterization and Exposure Assumptions:
  Are future land use scenarios realistic, and are all potential receptors identified? Are exposure factors reasonable?

- Exposure Point Concentrations:
  Are the models for estimating COC transport from the site media to the receptor, and for estimating the contaminant exposures and intakes, realistic and reasonable?

The FS/Risk Assessment takes a different approach than the baseline risk assessment at the FEMP site. The FS/Risk Assessment estimates exposure point concentrations using models and assumptions to project site conditions during and following remedial actions. Baseline risk assessments generally use existing data to evaluate current risks. The results of the FS/Risk Assessment have much more inherent uncertainty with regard to exposure patterns, exposed populations, and exposure concentrations than do the results of the baseline risk assessments. One purpose of this uncertainty analysis is, therefore, to characterize sources of uncertainty which contributes most of the overall uncertainty in the FS/Risk Assessment.

D.5.1 COC SELECTION

A major concern in this FS/Risk Assessment is the reliability of COC identification, both in terms of ensuring that all COCs have been identified and that chemicals or radionuclides have been correctly identified as COCs. The accuracy of COC identification is directly related to the quality of COC

characterization data, including the information on contaminant identification, location, and concentrations. The characterization was controlled by the design of the sampling and analysis plan, which described the sampling locations and analytical protocols.

The source of chemical analytic data for the FS/Risk Assessment was the Operable Unit 4 RI/FS. The RI Report for Operable Unit 4 was prepared according to CERCLA guidelines, and the data were validated. Whenever possible, COC identification was based on data collected according to a CERCLA sampling plan.

As described in the Final RI Report for Operable Unit 4 (November 1993), the selection of COCs for Operable Unit 4 is subject to less uncertainty than for other operable units. This is because the primary contaminant source for Operable Unit 4 is the relatively isolated waste contained in Silos 1, 2, and 3. Uncertainty does exist, however, because the soil samples may not be representative of conditions at the surface. Samples of nonradioactive chemicals were taken over the depth range of zero to two feet during the waste pit runoff sampling program, and over the range of zero to five feet during the K-65 berm sampling program. The cumulative impact of these uncertainties on the results of the FS/Risk Assessment exposure and risk assessments is unclear. However, the uncertainties concerning the representativeness of the Operable Unit 4 soil data can be expected to have a small impact on the risk assessment compared to other uncertainties in the risk assessment process. This is because the levels of contamination in the soils are comparatively low and the likelihood of not detecting a contaminant which would contribute significantly to risks is also low.

Uncertainty is inherent in the K-65 silo sampling data due to the heterogeneity of the waste forms and the bias introduced in the sampling program. The program did not include random samples. In fact, it intentionally selected samples exhibiting the greatest radiological contamination from each boring zone, to ensure detection of any significant radionuclide concentrations. However, any uncertainty in the silo data will have no impact on the COC selection for the FS/Risk Assessment, as all of the silo contents will be removed during remediation.

In summary, it is unlikely that major COC contributors to Operable Unit 4 risk have been overlooked. This is because, despite the shortcomings of some of the chemical concentration data that have been gathered at the FEMP site, there is still a very large and comprehensive database of site contaminant data. The evaluation of these data have identified a large number of contaminants which are present on the site, and confirm the general contamination pattern as indicated by past site operations. There is a high degree

of certainty that the major contaminants (uranium and other radionuclides, nonradionuclide inorganics, and organics) which could credibly contribute to site risks have been identified.

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D.5.2 TOXICOLOGICAL INFORMATION AND MODELS

EPA-supplied RfDs and CSFs were used throughout the risk assessment. Toxicological constants were not derived anew for any of the COCs evaluated in the FS risk assessment. Because of this, the toxicological evaluations (upon which the FS risk assessment is based) contribute no more uncertainty than that present in comparable CERCLA documents. However, the level of uncertainty in the toxicologic data and models is still substantial. This uncertainty arises out of the application of guidelines recommended by the regulatory agencies, these sources of uncertainty are beyond the control of FEMP investigation personnel.

As described in the Final RI Report for Operable Unit 4 (November 1993), considerable uncertainty is associated with the qualitative (hazard assessment) and quantitative (dose-response) evaluations of Superfund risk assessments. The hazard assessment characterizes the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will induce adverse effects in humans. The hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using either the International Agency for Research on Cancer (IARC) (1987) or EPA (1986b) schemes. Positive results in animal cancer tests suggest humans may also manifest a carcinogenic response, but the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncarcinogenic effects, positive animal test results may suggest the nature of the human effects (i.e., the target tissues and type of effects) (EPA 1989g).

There are many sources of uncertainty in the dose-response evaluation for cancer (i.e., slope factor or unit risk calculations) and noncarcinogenic effects (i.e., RfD or RfC calculations). The three major sources are:

1. Interspecies extrapolations:

   - Animal-to-human extrapolation, commonly used in the absence of quantitative pharmacokinetics, dosimetric, or mechanistic data, is usually based on a consideration of interspecies differences in body weight, surface area, or basal metabolic rate.

2. Intraspecies or individual variation:

   - Most toxicity experiments are performed with animals that are very similar in age

and genotype so that intragroup biological variation is minimal. The human population of concern may reflect a great deal of heterogeneity, however, including unusual sensitivity to specific toxic effects or contaminants.

- Toxicity data from human occupational studies reflect a bias because only those individuals sufficiently healthy to attend work regularly and those not unusually sensitive to the COCs are likely to be occupationally exposed.

3. Key study and database quality:

- The quality of key studies (from which the quantitative data are derived) and the quality of the literature databases add to the uncertainty. For carcinogenic effects, the uncertainty associated with some quality factors (i.e., group size) is incorporated into the 95 percent upper bound estimate of the slope factor. For noncarcinogenic effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to reflect gaps in the database.

Another source of uncertainty in the quantitative risk estimation for carcinogenicity is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linear multi-stage model, which is used in almost all quantitative estimations of human risk from animal data, is based on the nonthreshold assumption of carcinogenesis. An large body of evidence, however, suggests that epigenetic carcinogens (carcinogens which do not induce mutations), as well as many genotoxic carcinogens may have a threshold dose level below which they are noncarcinogenic (Williams and Weisberger 1991). The linear multi-stage model is therefore generally regarded as being extremely conservative for many chemicals.

Adding to the conservativeness of the approach is the fact that the EPA-derived slope factors found in IRIS are set at the 95 percent UCL of the linear slope of the multi-stage model. Thus, risks evaluated using the slope factors may be overestimated. This consideration applies to both radiological and chemical estimates of carcinogenic risk. The slope factors derived by EPA for the evaluation of risks due to external exposure to radiation are of particular concern in this regard. As discussed in Section D.3.3, these values were derived using very conservative assumptions about exposure conditions and are likely to provide very conservative risk estimates.

The methods used to define RfD values for chemical contaminants also incorporate a large degree of conservatism. Sets of multiplicative Uncertainty Factors (UFs) are used to adjust the results of animal and human toxicologic studies to take into account the nature of the endpoint No Observed Adverse Effect Level (NOAEL) to Lowest Observed Adverse Effect Level (LOAEL) seen in the studies, differences in response to different dose schedules, the presence of especially sensitive populations, and the possible

differences between human and animal sensitivity to contaminant exposures. Each UF may take a value as high as ten; thus, RfD values typically are set between 100 and 1000 times lower than the lowest dose seen to cause any adverse effects in animal studies. If the human and animal responses to contaminant exposures are not as dissimilar as reflected in the UFs (or if humans are less, rather than more, sensitive to contaminants), it is possible that the use of RfDs greatly overstates the potential for adverse health effects in humans.

The level of uncertainty in the toxicologic data for different chemicals varies because information concerning some constituents and their associated health effects is comparatively scarce, while for others much more information is available from health effects studies. Also, different amounts of data may be available concerning the different types of effects for a given COC. For example, uranium (a key COC at Operable Unit 4) has been established as a chemical toxicant (mainly affecting the kidneys) based on human and animal studies. The RfD for uranium was based on the results of animal studies and was calculated by applying an uncertainty factor of 1000 to a LOAEL for nephrotoxicity in rabbits to provide a margin of safety for extrapolation to humans. The uncertainty factor consists of three factors of 10 each for: 1) estimation of a NOAEL from a LOAEL, 2) extrapolation from animals to humans, and 3) for the range of sensitivities among exposed humans.

There is even greater uncertainty regarding the carcinogenicity of uranium. As an alpha-particle emitter, uranium is also considered a carcinogen; however, epidemiological evidence of uranium-induced excess cancers is very difficult to obtain. This is largely because the human data available on the radiocarcinogenic effects of uranium exposure are for underground miners who were also simultaneously exposed to radon and radon progeny, which are also carcinogens. The studies of humans sometimes lack quantitative information concerning uranium exposure, including potential uranium exposure through previous employment, concurrent smoking patterns, or concurrent radon exposure levels, all of which are needed to definitively determine the risk attributable to uranium exposure. These facts weaken the power of the human studies to detect excess risk, if any, above natural risk. These uncertainties are not well known or easily quantified.

Uncertainties in the interpretation of toxicologic data also strangely affect the risk assessment results for inhalation exposures to metals. Hazard Index values associated with particulate inhalation exposures exceed one for several receptors at Operable Unit 4. Almost all of the HI values are contributed by exposures to cobalt and chromium. In the case of cobalt, exposure concentrations result in contaminant intakes which barely exceed the inhalation RfD values. The inhalation RfD for cobalt (3.0×10^{-7}

mg/kg/day) was derived using maximum values for all possible UFs, based on a single epidemiologic study of hard metal disease. It is extremely unlikely that humans are actually as sensitive to cobalt exposures as reflected in this RfD. The RfD value is almost certainly well below normal background inhalation exposures received by members of the general population, and the RfD value for cobalt makes it more than one thousand times more toxic than mercury by the inhalation pathway. Thus the predicated slight exceedence of the cobalt inhalation RfD for some populations must be interpreted very cautiously and probably does not reflect significant concerns over adverse effects.

Chemical speciation is also an issue in evaluating the inhalation pathway risk estimates for chromium exposures. In the risk characterization, it was assumed that all of the chromium present in soils and groundwater was hexavalent. This is almost certainly inconsistent with the prevailing redox and chemical conditions in environmental media at the FEMP site, and it is likely that only a small portion of the chromium present is actually hexavalent. This failure to adequately consider chromium specification results in a substantial overestimation of the risks associated with chromium exposures, since hexavalent chromium species are much more toxic than the trivalent species. In the case of noncarcinogenic health effects, trivalent chromium is estimated to be on the order of 50 times less toxic than hexavalent chromium. In addition, trivalent chromium species are not thought to have any carcinogenic activity in humans, whereas the hexavalent chromium compounds are regarded as potent human carcinogens. The assumption that all chromium is hexavalent probably has resulted in an overestimation of cancer risks and the potential for noncarcinogenic adverse effects associated with chromium exposures by one or two orders of magnitude.

D.5.3 EXPOSURE PATHWAYS

The major source of uncertainty in predicting future exposures associated with Operable Unit 4 is the future disposition of the property itself. Because it is not possible to accurately predict future land uses or the condition of the site, the most conservative (rather than the most likely) future conditions were evaluated as stipulated by the National Oil and Hazardous Substance Pollution Contingency Plan (NCP).

A restatement of the selected receptors is as follows:

- Trespassing child
- Expanded trespasser
- Off-property resident farmer
- On-property resident farmer

Receptors other than those selected for the FS/Risk Assessment may be exposed to FEMP COCs;

however, the use of the conservative exposure scenarios addressed in this report provides a high degree of assurance that no actual exposed population will receive greater exposures than those estimated in the FS/Risk Assessment.

All potential exposure pathways were carefully evaluated for each exposed receptor. All pathways which could be complete under either of the future land-use scenarios (with and without continued Federal control) were evaluated quantitatively for their potential to be associated with adverse health effects. Each specific receptor population was assumed to be expose through all pathways which might be complete under minimally plausible conditions. Thus there is a high degree of assurance that total exposures are not underestimated for any actual exposed populations.

D.5.4 RECEPTOR CHARACTERIZATION

The default exposure factor values for characterizing exposures to FEMP receptors were presented in the Risk Assessment Work Plan Addendum (June 1992). For this FS/Risk Assessment, receptor scenarios were selected to represent the highest potential exposures. The exposure factors in the risk assessment are based on surveys of physiological characteristics and behavioral profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To account for most of this distribution, this risk assessment follows the EPA's recommendation to use the 95th percentile values for most exposure factors. In addition, the exposure factors are consistent with EPA Region V guidance. The selection of exposure factor values in this manner introduces a conservative bias into the results.

D.5.4.1 Exposure Duration

For FEMP risk assessments, it was assumed the farming family would occupy the land for a full lifetime (70 years) exposure period. This is a conservative approach, but, at most, it overestimates the risk by a factor of three relative to representative current residential tenure in the area. It was also assumed that all workers would occupy their jobs for 25 years, a realistic estimate of exposure duration given the stability of the surrounding communities. The exposure duration for all individuals (within an age bracket) are also realistic, based on community stability.

D.5.4.2 Exposure Frequency

It was assumed the family would occupy the property for 350 days per year, a conservative but, realistic assumption especially for a farming family. Likewise, workers were assumed to work for 250 days a year, the normal number of annual workdays. What is more uncertain is the number of days a

trespassing child or expanded trespasser would be on the FEMP property. Assuming 110 days for the expanded trespasser child, 40 days for the expanded trespasser adult, and 52 days for the trespassing child is conservative but reasonable and only moderately affects the results of the risk assessment.

D.5.4.3 Exposure Time

The farming family was assumed to spend 24-hours a day on the property. This is a conservative assumption as it does not take into account school time, shopping time, work, and other activities. Estimates of the time a worker, trespassing child, or expanded trespasser would spend in contact with the media at the site are more certain. The exposure times chosen are realistic, but could underestimate the exposure. The direct contact and inhalation pathways are affected most.

D.5.4.4 Body Weight

The body weights used in this FS/Risk Assessment were derived from standard tables for United States body weight distributions. The values were selected from the distribution midpoints because of the uncertainty regarding those distributions. The actual variation for adults is likely to be less than a factor of two. Although children have a wide range of body weights, the uncertainty is, at most, a factor of two or three (plus or minus for a given age group).

D.5.4.5 Ingestion of Soil, Food, and Water

There has been considerable discussion in the scientific literature concerning the appropriate oral ingestion rate of soil and dust for adults and children. Current EPA guidance recommends 100 mg/day for adults, 200 mg/day for children under the age of six, and 50 mg/day for an industrial worker not engaged in construction work. Since the FEMP risk assessments also considered a farmer who would be exposed to great quantities of dust through farming activities, a value of 180 mg/day was used. These values are realistic as a multi-year average, but the soil ingestion rates could potentially be much higher for shorter-term exposures.

The consumption of drinking water was set to the EPA Region V default values, which are conservative estimates. Over multi-year exposures, these values are not likely to vary widely and may be overestimated by a factor of less than two. Most likely, the consumption of drinking water will be less than the default values.

The rate and type of food consumption vary highly from locality to locality and from individual to individual. The estimates of food consumption used in the FEMP risk assessments are national averages

and may not be appropriate for some of the individuals exposed to FEMP COCs. The values presented represent conservative estimates and are not likely to vary by more than a factor of two for the average individual. The greatest uncertainty is in the consumption of specific foods (e.g., vegetables) by children. The direction and magnitude of this uncertainty are unknown.

D.5.4.6 Dermal Exposure Factors

Four critical assumptions have been made relating to the assessment of dermal exposure to soils: 1) the amount of exposed skin surface area, 2) the quantity of soil adhering to the skin, 3) the length of time the soil adheres to the skin, and 4) the partitioning rate of the COC from the soil across the skin barrier. In addition, the intake of contaminants associated with dermal contact to water is controlled by the dermal permeability to specific water - borne contaminates. These factors vary widely among individual exposures and may contribute substantially to uncertainty in risk assessment by these pathways. In general, the assumptions used to estimate dermal absorption are consistent with the conservative default values defined in recent EPA guidance. The average extent of uncertainty in dermal exposure factors is quite large (and order of magnitude or more). In addition, the adjustment of toxicity values for use in the dermal pathway risk assessment, particularly in the case of inorganic contaminants, was performed using conservative assumptions about contaminant intake and likely contributes a further degree of conservatism to the characterization of dermal pathway risks.

D.5.4.7 Inhalation Exposure

Multiple breathing rates were used in estimating doses via inhalation. The rates are defined for different exposed groups, including small children, adults at home, and adults at work. Each of these receptors has a wide range of breathing rates, which depend upon the levels of activity. The extent of the range is a factor of three for any defined level of activity. The breathing rates chosen for this evaluation are at the upper end of the distribution but do not represent the maximum.

D.5.5 EXPOSURE POINT CONCENTRATIONS

The values used to represent exposure point concentrations were defined to provide conservative estimates of exposure, thus ensuring a conservative evaluation of the risk. All FS/Risk Assessment exposure point soil concentrations are projected or modeled values. The uncertainty of exposure point concentrations estimated by models depends on input parameters (diffusion coefficients, groundwater flow, air flow, etc.,), model characteristics, release mechanisms, and source terms. The FS/Risk Assessment input parameters, which were based on site information and professional judgment, were designed to be conservative. The input parameters and models were selected and employed assistant with the Risk

Assessment Work Plan Addendum.

D.5.5.1 Air Concentrations

The major contributors to uncertainty in this FS/Risk Assessment air modeling are the release estimates for particulate and gaseous (radon) emissions and the concentrations and extent of COCs in the surface soil. The components of uncertainty include:

- Wind speed and direction
- Climate conditions (temperature, moisture, atmospheric stability, etc.,)
- Release rates of particulates to the air from soils
- Volatilization rates
- Radon release rates

The uncertainties associated with variations in meteorologic and climatologic conditions are captured to a large degree in the air quality models used to evaluate contaminant transport. Six years of actual climatic data from the FEMP site provide a very large database upon which long-term air quality modeling can be based. The overall level of uncertainty associated with the meteorologic models is probably relatively low compared to the contribution of other factors.

The particulate COC concentrations depend on the rate of resuspension during remediation activities and the projected surface soil contaminations, soil characteristics, and the percentage of vegetative cover following remediation. The projected surface soil concentrations for the operable units and the remediated solid were fixed at the primary remediation goals (PRGs) even though this substantially over estimates the likely actual soil concentrations or continuant. Another factor which is uncertain is the extent of surface soil contamination for the areas outside Operable Units 1, 2, 3, and 4. It was assumed that all capped ares would remain intact for 1000 years, and no radon release would occur. Overall, the predicted air concentrations are realistic but conservative.

The methods used to combine the particulate generation and air quality models contribute significantly to the uncertainty in the inhalation pathway risk assessment. As discussed in Section Appendix K, K.6.0, the particulate emission rate was determined using the annual average meteorological conditions to determine the downwind annual average concentrations. In addition, the assumption was made that the particle size distribution of the FEMP soils was such that essentially all of the particulates released to the air would be inhalable. This approach is conservative in that it not only assumes unlimited erosion potential, but also does not properly consider the increased dispersion due to the higher wind speeds, which leads to higher emission rates. The latter is a result of the emission rate increasing exponentially (as the cube of the wind speed), while the dispersion varies linearly with wind speed.

While the bias of this approach is clearly in the conservative direction, the magnitude of the impact is not known. Additional modeling will be required to provide quantitation of the combined effect of varying wind velocities on particulate exposure concentrations.

D.5.5.2 Groundwater Concentrations

The need to predict groundwater concentrations for 1000 years into the future represents a major source of uncertainty in the FS/Risk Assessment. In evaluating future groundwater concentrations, the same models have been used (ODAST and SWIFT III) as were used in the baseline risk assessment. The level of uncertainty associated with the modeling is large, but cannot easily be estimated quantitatively.

To assure that groundwater exposure concentrations are estimated conservatively, the RME exposure locations were set at the locations of highest groundwater concentrations. In addition, the exposure concentration estimates were estimated based on the concentrations seen in the 70-year period with the highest modeled groundwater contaminant concentrations. This approach results in exposure and risk estimates which exceed the long-term (1000-year) average exposure concentrations (for uranium) by a factor of approximately seven.

Another component of uncertainty in the groundwater modeling is the K_d values of COCs in the aquifers and the source terms for release. The K_d uncertainty is of most importance when modeling over hundreds of years. The K_d can vary according to the pH of water, concentrations of other components (chloride, sulfate, etc.,) and soil characteristics (sand, clay, porosity, etc.,). The K_d values for this FS/Risk Assessment were based on values from the literature, as summarized in the Risk Assessment Work Plan Addendum. Additionally, uncertainty derives from a potential variation in the release mechanisms from the sources into the vadose zone. An important component in the release mechanism is the exfiltration rate (the rate at which the water moves through the source area). Engineering calculations were used to estimate this rate for the engineered area.

In Operable Unit 4, another major source of uncertainty in the estimation of groundwater concentrations is the uncertainty in the concentrations of COCs in residual soils left after remediation. These concentrations are not well-characterized and could well be less than the proposed remediation level values which are assumed in the leachate modeling. Thus the soil leachate concentration estimates which serve as inputs to the groundwater models may also be conservative.

A final source of uncertainty in the groundwater modeling results for Operable Unit 4 remedial

alternatives is the fact that different methods were used to estimate leachate concentrations for different alternatives. For alternatives involving disposal in the vault (Alternatives 2A and 2B), leachate concentrations were calculated based on actual leaching test results of the silo contents, while for in situ containment of contaminated soils after silo contents removal (Alternative 2C), leachate concentrations were estimated using a geochemical model. In addition, a much larger volume of contaminated material was assumed to be leached under alternative 2C than under Alternatives 2A and 2B. The combined effects of these different assumptions is to estimate the leachate concentration for alternative 2C much more conservatively than the leachate concentrations estimates developed for alternatives 2A and 2B. Comparisons of long-term residual risks due to groundwater exposures for these alternatives need to be evaluated with this factor in mind.

D.5.6 Risk Characterization

Throughout this risk assessment, potential health effects caused by the simultaneous exposure to multiple on-site COCs were assumed to be additive in nature. Uncertainties associated with summing cancer risks or HIs for multiple substances are of particular concern in the risk characterization step. The assumption of dose additivity ignores possible synergism or antagonisms among chemicals and assumes similarity in mechanisms of action metabolism. However, data to quantitatively assess chemical interactions are generally lacking. In the absence of adequate information on chemical interactions, EPA guidelines indicate that carcinogenic risks and noncancer HIs should be treated as an additive. These assumptions are made to help prevent an underestimations of cancer risk or potential noncancer health affects at a site (EPA 1986, 1989).

D.5.7 Uncertainties Associated with Short-Term Risk Estimates

Unlike the long-term assessment of post-remediation risks, the evaluation of short-term risks does not involve the need to predict the behavior of receptors or physical systems long into the future. Instead the major sources of uncertainty in the short-term risk assessment are associated with the predicting conditions during the period when remediation is actually occurring. In addition, the short-term risk evaluation of remedial alternatives involves not only estimation of risk associated with exposures to chemicals and radionuclides, but also risk associated with safety hazards during remediation. Risks associated with both on-site activities (excavation, waste, removal, treatment, construction) and off-site transportation wastes are considered. Risks are evaluated for remediation workers as well as for members of the general population. Thus both the sources and nature of the uncertainties associated with short-term risk estimates are different from those associated with long-term estimates.

D.5.7.1 Alternative Design and Implementation

One of the major sources of uncertainty in the assessment of short-term risks is the lack of detailed designs for the various alternatives. Without detailed remedial design, important conditions effecting exposure cannot be predicted with a high degree of certainty. These conditions include construction sequencing, durations of specific types of exposures, and the numbers of workers, working conditions, and hazards faced by specific remediation and nonremediation workers. In addition, specific work practices, engineering controls, and personal protective measures taken to reduce risks can only be approximated. together these factors constitute a major sources of uncertainty in the short-term risk assessment.

D.5.7.2 Receptors and Pathways

The short-term risk assessment addresses risk for there major receptor groups; remediation workers, trespassing children (during remediation) and the off-property resident farmer. Among these three populations the major routes of on-property and off-property exposure are addressed. These pathways include, for the worker and trespassing child, direct radiation from contaminated soil, particulate and radon inhalation, and dermal contact and ingestion of soils. The off-property farmer is assumed to be exposed through particulate and radon exposures. In addition, risks due to particulate and radon inhalation are evaluated for an on-site nonremediation worker and radiation risks are assessed for drivers and the general public along the routes of truck and train transport of wastes to an off-site disposal.

As in the case of the long-term risk evaluation, exposure pathways are included if there is even a small possibility of their being complete for a given alternative. Thus there is a high degree for assurance that

the total multipathway exposures are not underestimated for actual receptors.

All of the pathways associated with groundwater and surface water are excluded from the short-term risk analysis. This is because preliminary engineering evaluations of the various alternatives indicate that they will not contribute significantly to releases to these media. If more detailed analyses show that such releases might occur, then health risk could be associated with these pathways. However, additional control measurers could also be taken to reduce exposures.

D.5.7.3 Exposure Assumptions and Parameters

As was done for the long-term risk assessment assumption regarding worker and public exposure to radiation were defined conservatively, building on values presented in the Risk Assessment Work Plan Addendum, supplemented by guidance from Region V EPA. The physiologic variable either took the same values (body weight), or took values that were adjusted to reflect specific conditions of exposure (dermal surface area exposed, respiratory rates). Behavioral variables were defined appropriate to the duration of implementation of the specific remedial technologies involved in each alternative. Throughout, the "RME" philosophy was employed to insure that exposure variables reflected reasonable worst-case exposure conditions for each exposed population.

As in the case of any risk assessment for chemical or radiologic exposure, the combined degree of uncertainty associated with all of the exposure factors may contribute a substantial proportion of the uncertainty associated with the risk estimates for any given population. The magnitude for this uncertainty as applied to the short-term risk estimates cannot be estimated quantitatively, but may be greater than one order of magnitude. The most likely direction of the bias introduced into the short-term risk estimates by the methods used to estimate exposures would be in the direction of overestimation of risks, relative to those experienced by actual receptors.

D.5.7.4 Exposure Point Concentration Estimates

Unlike the long-term risk evaluation, the short-term risk evaluation takes as its inputs measured contaminant concentrations in wastes and contaminated soils. For some pathways, (dermal contact and ingestion) these concentrations sever directly as inputs to exposure estimation. For other pathways (particulate and radon inhalation) measured concentrations of contaminants serve as inputs to release and transport models. In either case, the RME concentration estimates (the 95th percentile estimate of the mean contaminant concentration) is used in exposure assessment. This approach, which is consistent with EPA guidance, introduces a small degree of conservatism into the risk estimates.

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The contaminant release and transport models used in the short-term exposure assessment add an additional degree of uncertainty to exposure and risk estimates. Among these models, the particulate release model is relatively generic and gives release estimates that are highly uncertain. In addition, several assumptions are made in evaluating particulate releases (unlimited erosion potential, all particulates are inhalable) that ad a degree of conservatism and uncertainty to the particulate exposure and risk estimates.

On the whole, uncertainties in exposure point concentrations, particularly those associated with particulate exposures, account for a substantial degree of uncertainty in the short-term risk estimates.

D.5.7.5 Toxicologic Model and Parameter Values

All of the toxicologic and parameter values used in the short-term risk assessment are the same as those used in the long-term risk assessment, except in the case of contaminants for which subchronic RfD values were available. If subchronic toxicity values were available, they were used in place of chronic RfD values. The same risk characterization model were also used in the short-term risk analysis as were used in the long-term assessment. Thus most of the sources of uncertainty which were associated with the long-term risk evaluation (see section D.5.2) also act in a similar degree on the short-term risk estimates.

Additional sources of uncertainty also are present which effect the short-term risk estimates. However, as noted above, non-cancer toxicologic parameter values (subchronic RfDs) were not available for all of the COCs. Use of the chronic toxicity values in these cases probably overstates the potential for adverse effects unless very short-term (acute effects occur thorough a different mechanism which is not adequately account for by the exposure and risk characterization models used. On the whole, it is likely that a greater degree of uncertainty is associated with the short-term hazard index values that is associated with the long term values.

In addition, the cancer risk estimates associated with short-term exposure to chemical and radionuclide COCs must also be interpreted cautiously. The models and parameter values used to evaluate these risks generally assume, to one degree or another, that exposures will be relatively constant over a significant fraction of the lifespan. The applicability of the same models and parameter values to short-term, sporadic exposures to carcinogens is highly questionable. There is no way to evaluate the potential uncertainty associated with the short-term cancer risk estimation models, although it is probably greater than that associated with the long-term risk estimates.

D.5.7.6 Uncertainties Associated with Health and Safety Risk Estimates

Unlike the long-term risk assessment, the short-term risk evaluation addresses health and safety risks, as well as the risks from chemical and radiation exposure. The models and methods used to assess these risks possess their own specific limitations and uncertainties. One major source of uncertainty associated with these models is the inability, discussed above, to adequately describe the specific sequence of operations associated with a given remedial alternative in enough detail to clearly define potential health and safety hazards for specific occupational receptors. As a result, throughout this analysis very simple approximations have been used to evaluate risk to broadly defined categories of receptors, such as "remediation workers," "drivers," etc. More detailed identification of specific working populations facing specific types of risk are not possible.

One example of this difficulty is seen in the assumptions made regarding excavation methods for contaminated soils in those remedial alternatives where this activity occurs. For purpose of the cost evaluation of alternatives, it was assumed that normal excavation methods without special dust control measures would be used. In the actual case, it is likely that extensive dust suppression measures will be employed to reduce the particulate generation rate far below levels associated with normal excavation. Thus, potential risks for this activity may have been overestimated.

Another example of the uncertainty in the estimation of short-term risks is the assumptions made regarding off site transport routes for wastes. In evaluating safety risks (and radiation exposures) associated with these activities, it is assumed that transport would be over the shortest route between the FEMP site and the disposal site, and that no intermode transfers would occur during transport. In fact, transport routes might vary substantially from the shortest possible route, depending on the state and local restrictions and other factors which could affect the exact route chosen. In addition, it is possible that the most feasible route might involve multiple loading and unloading cycles or transfer between trucks and trains. These loading and unloading cycles might actually contribute far more risk than the actual transport itself, but thee is currently no good way to factor this into the risk estimates for waste transportation. In addition, the packaging system to be used in transporting the waste has not yet been fully defined. The current analysis assumes the absence of secondary shielding that could reduce both the routine radiation exposures and the likelihood of waste release during accidents.

A final factor which contributes in an important way to the uncertainty in the long-term occupational risk estimates for the various remedial alternatives is the nonspecific nature of the risk coefficients used to estimate the number of injuries and deaths associated with construction activities and waste transportation.

As noted previously, the risk coefficients for construction workers are extremely generic; they were derived from U. S. Department of Labor Statistics concerning the average rates of fatalities in construction throughout the United States. These values have two major weaknesses as predictors of injuries and death during remediation activities at the FEMP site. First, since they are based on aggregate statistics, they do not distinguish between specific jobs and activities according to the degree of hazard. Thus, using these values to assess risks associated with remediation requires the assumption that all remedial workers at the site face the same level of risk, regardless of what are undoubtedly substantial differences in the actual levels of risk associated with specific alternatives and activities. The aggregate estimates of accidental injuries and deaths developed for the various remedial alternatives do not thus reflect actual differences in the level of hazard, but rather reflect only differences in the number of labor hours required to implement the alternative. In addition to their inability to predict risks for specific groups of workers or activities, the risk coefficients may also not provide a reliable estimate of the aggregate risks for all the workers. Since the risk coefficients were not derived for hazardous waste remediation activities, even the average experience of all remediation workers at the site may not be adequately reflected in the coefficients.

The same general limitations also apply to the risk coefficients for waste transport. They are highly generic, and do not necessarily reflect the most likely actual experience during waste transport. In addition, the use of coefficients which are denominated on a constant injuries or deaths per-mile basis also does not reflect differences in risk as a function of the specific route taken or risk associated with loading/unloading and intermodal transfers.

On the whole, it is not possible to estimate the level of uncertainty associated with the occupational and transportation risk estimates. A much more detailed evaluation of the hazards associated with specific remedial activities will be required before any reliable comparison across alternatives can be conducted with regard to short-term health and safety hazards.

ATTACHMENT D.I

RISK ASSESSMENT FOR HYPOTHETICAL FAILURE OF FEMP OPERABLE UNIT 4 K-65 SILOS DOMES

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D.I.1.0 INTRODUCTION

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D.I.1.1 OBJECTIVES

This assessment is prepared in support of the Operable Unit 4 Feasibility Study (FS) Report Appendix D, Public Health and Occupational Risk Consideration.

The objectives of this assessment are to:

- Evaluate the potential significance of a hypothetical K-65 Silos dome failure event that might release radon during remedial activities
- Provide additional information to supplement assessments of risks incurred during remediation activities in the FS (the short-term risk assessment)

D.I.1.2 OVERVIEW

An assessment of the K-65 Silos structural integrity conservatively estimated the probability of spontaneous dome failure within five years as 18 and 17 percent for Silos 1 and 2, respectively (Eckert 1990).

The potential human health risks associated with a hypothetical dome failure event are assessed in this attachment to the Appendix D risk assessment because remediation activities at the K-65 Silos could affect dome integrity.

D.I.1.2.1 Scope

Remediation alternatives at the silos include the removal of the silo contents for further treatment, storage, and disposal at the FEMP site or an off-site location. This assessment is specific to a hypothetical dome failure event postulated to occur during the material removal operations under consideration. Exposures that are incidental to routine remedial activities, as conducted according to health and safety plans, are addressed in the short-term risk assessment (Section D.3.4) and will not be reconsidered here.

The material removal technologies considered in Section 4.0 of this FS Report include: (1) mechanical, (2) hydraulic, and (3) pneumatic removal options. Each of these options will be conducted according to procedures designed to minimize impact on dome integrity. For the purposes of this assessment, none of these removal technologies are assumed to be any more or less capable of

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impacting dome integrity. Refinement of this assumption can only be provided by detailed safety reviews and probabilistic risk analyses.

Risks from collapse of the Silo 3 dome and wall were addressed in the Remedial Investigation (RI) Report for Operable Unit 4 Baseline Risk Assessment and will not be recalculated here.

Dome failure initiated by a tornado has been evaluated (Eckert 1990). Risks associated with release of all solid material in Silo 3 and approximately 8.5 percent of wet solids in Silos 1 and 2 were estimated to be small as a result of the low yearly probability of a tornado at the Operable Unit 4 site. Because the occurrence of a tornado is not associated with any remedial action operation and has been estimated to be low, this scenario will not be reconsidered here.

D.I.1.2.2 Conditional Risk

Because the probability of a dome failure during remediation is not known, risks associated with the hypothetical event are assessed by assuming the event occurs. As such, it is a conditional risk that is associated only with the material release and does not consider the probability of the event, or potential sequences of events that could lead to such a release.

The conditional cancer risk is, therefore, the maximum risk for a dome failure event. When individual dome failure probabilities for each engineering operation become known, they can be applied to the conditional cancer risk, resulting in reduced estimates of the cancer risk from dome failure that are specific to each engineering alternative. For example, if the conditional cancer risk to an individual located 5 km (3.1 mi) from the release is 1×10^{-4}, and the probability of a specific engineering alternative to cause dome failure is 1×10^{-2}, then the cancer risk to that individual from dome failure caused by that alternative is 1×10^{-6}. Other engineering alternatives can be treated in the same way to compare their relative contributions to cancer risk from dome failure.

D.I.1.3 COMPARISONS WITH SHORT-TERM RISK ASSESSMENT METHODOLOGY

The dome failure assessment is performed using the same methodology used in the short-term risk assessment (Section D.3.4), with appropriate modifications in scope for the dome failure risk assessment.

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The following modifications were made:

- The source term is limited to radon gas. It is assumed that collapse of the dome would not release solids from the wet material in the silo.

  - Justification:
    The K-65 Silos material is a dense, wet slurry (See Section D.I.2.1).

  - Impact:
    Limiting the source term to a gas more accurately reflects potential exposures off site.

- Radon was added to the gas-phase source term. It was assumed that the accident occurs after the bentonite layer is removed, allowing radon emanation to occur without bentonite retardation.

  - Justification:
    The bentonite layer would be removed early in the remediation operation.

  - Impact:
    Using the higher concentration will more accurately reflect expected conditions in the silos during most of material removal operations.

- Vapor-phase organic constituents of concern (COC) were not included in the source term.

  - Justification:
    There is no quantitative information on the headspace composition of vapor-phase organic compounds. Measurements of K-65 headspace radon concentrations were made by the FEMP in 1987 and 1991 to evaluate the effectiveness of the bentonite layer to reduce radon concentrations (IT 1993). No measurements of organic vapors were made. As a result, an organic-vapor source term similar to the radon source term cannot be estimated.

  - Impact:
    This risk assessment continues earlier emphasis of focusing on radon as the most important gas-phase constituent of concern (Eckert 1990; IT 1993).

- Airborne concentrations of constituents released upon collapse of the dome are calculated using the PUFF air dispersion model [U.S. Environmental Protection (EPA), 1982].

  - Justification:
    The PUFF model was developed by the EPA to estimate concentrations downwind of an instantaneous release.

  - Impact:
    Calculated hourly average concentrations at various distances from the release will be used to estimate risks to hypothetical receptors exposed by this scenario.

- Risks to all adults located at the FEMP site are assessed, in addition to the off-site resident.

  - Justification:
    Employees located at the site, but who are not involved in remediation activities, will not have the benefit of respiratory protection. Risks to protected remediation workers are assessed in the short-term risk assessment.

  - Impact:
    Addition of all on-site employees address a specific feature of the dome failure accident scenarios.

D.I.2.0 IDENTIFICATION OF CONSTITUENTS OF CONCERN -5039

Radon gas in the K-65 Silos was identified as a potential constituent of concern for the Operable Unit 4 RI Baseline Risk Assessment.

As previously noted, the release of nonvolatile materials after dome failure is not considered due to the wet slurry nature of the material.

D.I.3.0 EXPOSURE ASSESSMENT

Exposures to individuals were assessed using methodology described in the RI Report for Operable Unit 4 Baseline Risk Assessment.

D.I.3.1 CONCEPTUAL MODEL OF EXPOSURE

A conceptual model for the hypothetical dome failure event risk assessment was developed to evaluate the potential health risks. The model (Figure D.I.3-1) considers one of the several pathways included in the short-term risk assessment (Section D.3.2.1). The model addresses collapse of a K-65 silo dome as the primary release mechanism, leading to emission of radon gas for transport in air, and resulting in potential inhalation exposure of receptors both on and off site.

D.I.3.1.1 Source Terms

Descriptive and historical information regarding the silos at the Operable Unit 4 site is given in Section 3.0 of the RI Report for Operable Unit 4. The silos contain residues generated from refinement of high grade uranium ore. Silo 1 contains 3280 cubic meters (m^3) [117,873 cubic feet (ft^3)] of residues and 360 m^3 (12,924 ft^3) of bentonite clay covering the material to retard radon emanation. Silo 2 contains 2840 m^3 (101,956 ft^3) of residues and 310 m^3 (11,129 ft^3) of bentonite clay. The contents are a wet mixture of clay, silt, and sand size particles. The water content has been estimated at 30.5 to 74.7 percent, with a specific gravity ranging from 2.79 to 3.08.

At the time of the hypothetical dome failure, it is assumed that the bentonite layer has been removed and that the radon concentration in the silo domes has returned to levels measured before bentonite addition. The source term was estimated using the radon concentration measured in Silos 1 and 2 headspace gas and the total volume of the silos. The radon inventory was estimated to be 80 curies (Ci) (Ladrach 1993).

D.I.3.1.2 Release Mechanisms

Silo dome failure is assumed to instantaneously release the entire volume of gas-phase radon. It is assumed that control measures will take place immediately such that continued releases will not occur.

D.I.3.1.3 Transport and Exposure Pathways

Airborne transport of the radon represents a potential inhalation pathway for exposure.

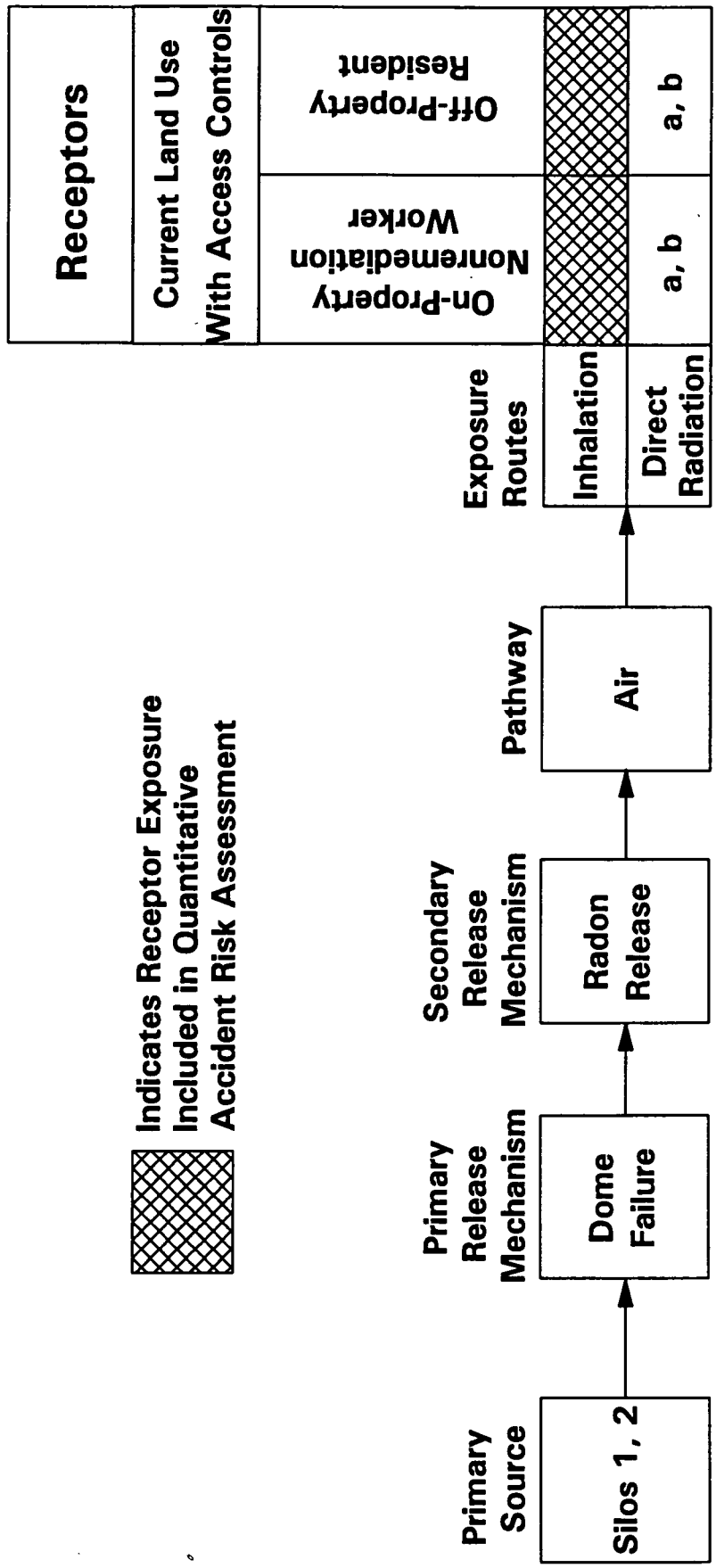

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FIGURE D.I.3-1 OPERABLE UNIT 4 CONCEPTUAL MODEL FOR DOME FAILURE ACCIDENT RISK ASSESSMENT

D.I.3.1.4 Receptors and Land Use Scenarios

The land use scenario considered is similar to the "current land use scenario with access control" described in the baseline and short-term risk assessments.

Because remediation will be done under current access controls, on-property receptors will include employees on site, including those not involved in remediation activities. Radon dispersion beyond the site perimeter represents a pathway to receptors off site, identified as the off-site resident (Figure D.I.3-1).

Potential exposures were quantified for non-remediation site workers, and the public. Remediation worker exposures were not quantified because their exposures will be mitigated by respiratory protection required during the remedial activities. The closest point of exposure for a non-remediation worker or member of the public is 350 m (1155 ft).

D.I.3.2 QUANTIFICATION OF INTAKE

Methodology from the RI Report for Operable Unit 4 Baseline Risk Assessment report was used with appropriate modifications specific to the hypothetical dome failure event.

D.I.3.2.1 Exposure Point Concentrations

Dispersion of the radon was estimated using the PUFF model (EPA 1982; Claggett 1993), which provides an estimate of the hourly average concentration at distances downwind of the release point. Assumptions used in the PUFF model include an arbitrary unit emission of one Ci, such that results obtained from the model were in units of Ci/m^3 in air per Ci released. It was assumed that the instantaneous radon release occurred at ground level (a worst-case assumption). The initial size of the PUFF was based on the horizontal and vertical dimensions of the silos. Worst-case meteorological conditions of a low wind speed [1 (m/s) (3.3 ft/s)] and a stable atmosphere were assumed. Thus, the maximum hourly average concentration of radon at 350 m (1155 ft) from a one Ci release is predicted to be 2.58×10^{-6} Ci/m^3 (Table D.I.3-1), and 2.06×10^{8} pCi/m^3 for a release of 80 Ci of radon.

D.I.3.2.2 Estimation of Radon Intake

Inhalation is assumed to be the primary pathway of exposure for radon release by this scenario. Intake was calculated using the following equation (EPA 1989):

TABLE D.I.3-1

LIFETIME CANCER RISK FROM A ONE-HOUR EXPOSURE FOLLOWING RELEASE OF 80 Ci OF RADON CAUSED BY K-65 SILO DOME FAILURE

Distance Downwind (meters)	Radon Concentration per Curie (Ci) Released C unit (Ci/m^3)	Exposure Concentration C_a (pCi/m^3)	Radon Inhalation Intake (pCi)	Lifetime Cancer Risk (per hour)
350	2.58×10^{-6}	2.06×10^{8}	1.71×10^{8}	1.32×10^{-3}
375	2.52×10^{-6}	2.02×10^{8}	1.67×10^{8}	1.29×10^{-3}
400	2.46×10^{-6}	1.97×10^{8}	1.63×10^{8}	1.26×10^{-3}
500	2.23×10^{-6}	1.78×10^{8}	1.48×10^{8}	1.14×10^{-3}
600	2.02×10^{-6}	1.62×10^{8}	1.34×10^{8}	1.03×10^{-3}
700	1.83×10^{-6}	1.46×10^{8}	1.22×10^{8}	9.36×10^{-4}
800	1.67×10^{-6}	1.34×10^{8}	1.11×10^{8}	8.54×10^{-4}
900	1.52×10^{-6}	1.22×10^{8}	1.01×10^{8}	7.77×10^{-4}
1000	1.40×10^{-6}	1.12×10^{8}	9.30×10^{7}	7.16×10^{-4}
1100	1.29×10^{-6}	1.03×10^{8}	8.57×10^{7}	6.60×10^{-4}
1200	1.19×10^{-6}	9.52×10^{7}	7.90×10^{7}	6.08×10^{-4}
1300	1.10×10^{-6}	8.80×10^{7}	7.30×10^{7}	5.62×10^{-4}
1400	1.02×10^{-6}	8.16×10^{7}	6.77×10^{7}	5.22×10^{-4}
1500	9.52×10^{-7}	7.62×10^{7}	6.32×10^{7}	4.87×10^{-4}
1600	8.90×10^{-7}	7.12×10^{7}	5.91×10^{7}	4.55×10^{-4}
1700	8.34×10^{-7}	6.67×10^{7}	5.54×10^{7}	4.26×10^{-4}
1800	7.83×10^{-7}	6.26×10^{7}	5.20×10^{7}	4.00×10^{-4}
1900	7.38×10^{-7}	5.90×10^{7}	4.90×10^{7}	3.77×10^{-4}
2000	6.96×10^{-7}	5.57×10^{7}	4.62×10^{7}	3.56×10^{-4}
2100	6.58×10^{-7}	5.26×10^{7}	4.37×10^{7}	3.36×10^{-4}
2200	6.24×10^{-7}	4.99×10^{7}	4.14×10^{7}	3.19×10^{-4}
2300	5.92×10^{-7}	4.74×10^{7}	3.93×10^{7}	3.03×10^{-4}
2400	5.63×10^{-7}	4.50×10^{7}	3.74×10^{7}	2.88×10^{-4}
2500	5.36×10^{-7}	4.29×10^{7}	3.56×10^{7}	2.74×10^{-4}
2600	5.11×10^{-7}	4.09×10^{7}	3.39×10^{7}	2.61×10^{-4}
2700	4.88×10^{-7}	3.90×10^{7}	3.24×10^{7}	2.50×10^{-4}

TABLE D.I.3-1
(Continued)

Distance Downwind (meters)	Radon Concentration per Curie (Ci) Released C unit (Ci/m^3)	Exposure Concentration C_a (pCi/m^3)	Radon Inhalation Intake (pCi)	Lifetime Cancer Risk (per hour)
2800	4.67×10^{-7}	3.74×10^{7}	3.10×10^{7}	2.39×10^{-4}
2900	4.47×10^{-7}	3.58×10^{7}	2.97×10^{7}	2.29×10^{-4}
3000	4.29×10^{-7}	3.43×10^{7}	2.85×10^{7}	2.19×10^{-4}
3500	3.52×10^{-7}	2.82×10^{7}	2.34×10^{7}	1.80×10^{-4}
4000	2.96×10^{-7}	2.37×10^{7}	1.97×10^{7}	1.51×10^{-4}
4500	2.53×10^{-7}	2.02×10^{7}	1.68×10^{7}	1.29×10^{-4}
5000	2.20×10^{-7}	1.76×10^{7}	1.46×10^{7}	1.12×10^{-4}

$$\text{Intae (pCi)} = \text{Ca} \times \text{IR} \times \text{ED} \quad (1)$$

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where:

Ca = exposure point concentration in air (pCi/m^3)

IR = inhalation rate (m^3/hr)

ED = exposure duration (hr)

Exposure point concentrations (Ca), calculated by the PUFF model are shown in Table D.I.3-1. The inhalation rate was assumed to be 0.83 m^3/hr for all receptors, as described in Table D.3-4 of the short-term risk assessment (Section D.3.2). The exposure duration was assumed to be one hour to correspond to the concentration units of the PUFF model output.

The radon inhalation intake for the one hour exposure was estimated to range from 1.71 x 10^8 pCi at 350 m (1155 ft) from the release to 1.46 x 10^7 pCi at 5 km (3.1 mi) from the release (Table D.I.3-1).

D.I.4.0 TOXICITY ASSESSMENT

The toxicity of Radon (Rn) -222 is described in detail in the baseline risk assessment of the RI Report for Operable Unit 4. Briefly, Rn-222 is generated as a daughter from Radium (Ra) -226 decay, and emanates from the silo material into the void volume of the silos.

Inhalation of radon and its daughters subjects the respiratory system to alpha radiation. Although radon and its daughters also emit gamma radiation, the external whole-body radiation dose from gamma radiation has been reported to be 9×10^{-6} rad/year/pCi/m^3, and is considered to be negligible relative to the alpha radiation dose absorbed during inhalation exposure [National Council of Radiation Protection (NCRP) 1984].

Epidemiological studies of uranium miners exposed to radon have indicated excess lung cancer mortality (Harley 1986). Radon and its decay products have been identified as a human carcinogen [International Agency for Research on Cancer (IARC 1988)].

D.I.5.0 RISK CHARACTERIZATION

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Incremental lifetime cancer risks (ILCRs) were characterized using the methods described in the RI Report for Operable Unit 4 Baseline Risk Assessment.

The ILCR was calculated according to the following equation, using the cancer slope factor (CSF) for Rn-222 in equilibrium with four daughters [EPA 1992]:

$$ILCR = Intake\ (pCi) * CSF\ (risk/pCi)$$

where:

$$CSF = 7.7 \times 10^{-12}\ risk/pCi$$

D.I.5.1 CARCINOGENIC RISK OF RADON

The estimated ILCR for hypothetical receptors are shown in Table D.I.3-1. The risks range from approximately 1×10^{-3} to 1×10^{-4} for receptors located at 350 m (1155 ft) and five km [3.1 miles (mi)] from the release, respectively. The major factors that determine the magnitude of these risk estimates are the magnitude of the source term and the proximity of the receptor to the source.

D.I.5.2 KEY RECEPTORS

The key receptors are those located nearest to the point of release, and who do not have respiratory protection. The primary characteristic of the receptor is his or her proximity to the release point.

It is assumed that remediation workers at the site have operating respiratory protection. However, it can be postulated that a remediation worker might lose respiratory protection following the dome collapse. In such an event, the inhalation rate parameter (IR) used to estimate radon intake might be changed to 2.5 m^3/hr (Table D.3.2-2, Section D.3). Such a change in breathing parameters would increase the estimated ILCR by a factor of 3. While non-remediation workers and members of the public would not be aware of the dome collapse, remediation workers would. As such, the remediation workers would, by procedure, immediately evacuate the area, further reducing their exposure potential.

D.I.5.3 COMPARISON OF RISKS

The ILCRs estimated for this accident scenario can be compared to risks calculated in the RI Baseline Risk Assessment, with certain qualifications. The values reported in Table D.I.3-1 are ILCRs, which

were estimated assuming a one-hr exposure to a radon cloud released upon dome failure. As such, it is assumed that the exposure would occur once in a lifetime. Risks estimated in the RI Baseline Risk Assessment for dome failure at Silos 1, 2, and 3 represent risks from chronic exposure to a larger inventory of radionuclides from all exposure pathways, including inhalation, ingestion, dermal contact, and whole-body gamma radiation exposure. Thus, these risks should only be compared with caution. In the RI Baseline Risk Assessment, the ILCR to an off-property resident farmer resulting from a dome failure at Silos 1, 2, and 3 was estimated to be 3×10^{-7} from radon plus daughters (Table D.5-13). The estimated ILCR to a receptor located 5 km [3.1 mi] from radon release following hypothetical silo dome failure is 1×10^{-4} (Table D.I.3-1).

The estimated ILCR to employees without respiratory protection can be compared to risks to remediation workers during routine material removal operations (Table D.3-16, Section D.3.4). For material removal operations, risks to workers range from 2.1×10^{-2} for injuries due to construction of the work platform to 6.12×10^{-4} for injuries related to K-65 Silos material removal activities. Risks from direct radiation during material removal are estimated at approximately 1.68×10^{-4} and 1.93×10^{-4} for removal of Silos 1 and 2 material, respectively. These direct radiation risks are less than the risk estimated for an unprotected worker located 350 m (1155 ft) from an accidental radon release (1×10^{-3}, Table D.I.3-1).

D.I.6.0 UNCERTAINTY CHARACTERIZATION

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Uncertainties in this risk assessment are related to the source term, the air dispersion model, and the application of the CSF.

D.I.6.1 SOURCE TERM

Source term estimates were made under the assumption that the radon concentration in the silos was at levels measured before the addition of the bentonite layer. Further, the hypothetical event was assumed to occur near the end of material removal operations such that the entire volume of the silos contained radon at these concentrations. That is, it was assumed that prior removal of material did not remove Ra-226, the parent radionuclide of Rn-222. This is a conservative assumption that would overestimate the radon inventory for release and the estimated lifetime cancer risks. The assumption is reasonable, however, because it is known that Ra-226 is concentrated in the lower levels of K-65 Silos waste.

D.I.6.2 MODEL APPLICABILITY

Use of the PUFF air dispersion model is appropriate for this hypothetical event in which a release would occur instantaneously. Because it is impossible to forecast the most likely meteorological conditions that would occur in the event of a hypothetical dome failure and release, the worst case was assumed. Assuming a stable atmosphere assures that maximum radon concentrations are not underestimated.

D.I.6.3 CANCER SLOPE FACTOR

Use of the cancer slope factor (CSF) specified in Health Effects Assessment Summary Tables (HEAST) (EPA 1992) to estimate lifetime cancer risks from a one-hour inhalation exposure represents a source of uncertainty. The CSF for radon was developed using epidemiological data from uranium miners exposed by chronic inhalation over a period of years that represented a significant fraction of a lifetime. Results of these epidemiological studies are commonly used to estimate lifetime cancer risks for other populations that might be chronically exposed to radon [NCRP 1984; Nuclear Regulatory Commission (NRC) 1988; EPA 1992].

The exposure scenario specific to this risk assessment is an acute exposure expected to last from approximately an hour to a few hours, once in a lifetime. As a result, the exposure duration

represents a small fraction of a lifetime. In the absence of epidemiological data from short-duration radon exposures, the impact of this uncertainty on the estimated lifetime cancer risks is unknown.

D.I.7.0 SUMMARY

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Risks associated with a K-65 Silos hypothetical dome failure were assessed in support of the FEMP FS Report for Operable Unit 4.

It was assumed that dome failure occurs at a time in material removal operations that would instantaneously release 80 Ci of radon. Dispersion of the radon cloud was estimated using the EPA PUFF model to estimate airborne radon concentrations at increasing distances from the release point. Estimated exposure point concentrations ranged from 2.06×10^8 pCi/m^3 at 350 m (1155 ft) from the silos to 1.76×10^7 pCi/m^3 at 5 km (3.1 mi).

Methodologies used in the RI Baseline Risk Assessment were used in this risk assessment.

D.I.7.1 EXPOSURE ASSESSMENT

Estimated radon intake ranged from 1.71×10^8 pCi for individuals located at the nearest point of exposure for non-remediation workers [350 m (1155 ft)] to 1.46×10^7 pCi for individuals located 5 km (3.1 mi) from the silos. Risks were not estimated for remediation workers located closer than 350 m because they will be using respiratory protection.

D.I.7.2 RISK CHARACTERIZATION

Estimated lifetime cancer risks ranged from 1×10^{-3} for individuals located 350 m (1155 ft) from the silos to 1×10^{-4} at 5 km (3.1 mi).

D.I.7.3 RISK COMPARISON

Estimated ILCRs to hypothetical receptors located 5 km (3.1 mi) from the K-65 Silos, and who might be exposed for one hr to a radon cloud following an accidental release, were higher in magnitude than risks estimated for an off-site resident farmer in the RI Report for Operable Unit 4 baseline risk assessment. However, the risk levels calculated for the hypothetical dome failure event are conditional risks that do not account for the fractional probability of occurrence for this event. Incorporating the probability of occurrence, which is technology-specific and not known at this time, would reduce the magnitude of these risks.

Estimated ILCRs to non-remediation workers without respiratory protection and who might be located as close as 350 m (1155 ft) from the release are an order of magnitude greater than risks from direct radiation associated with routine remediation activities (Section D.3.4).

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ATTACHMENT D.II

DEVELOPMENT OF PRGs AND PRLs FOR OPERABLE UNIT 4

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D.II DEVELOPMENT OF PRGs AND PRLs FOR OPERABLE UNIT 4

1.0 INTRODUCTION

This Attachment discusses the process used in developing Operable Unit 4 Preliminary Remediation Goals (PRGs), and Proposed Remediation Levels (PRLs). PRGs are receptor, contaminant and medium specific concentration levels that would result in remedial risks below target levels. There are multiple sources of PRGs:

- Risk-based PRGs are contaminant concentration levels that are derived using risk assessment procedures evaluating health risks from site-specific exposure conditions and land use scenarios.

- PRGs based on applicable or relevant and appropriate requirements (ARARs) are medium-specific contaminant concentrations taken directly from an ARAR (e.g., MCL), or derived on the basis of site-specific exposure pathways to comply with an ARAR [e.g., National Emissions Standards for Hazardous Air Pollutants (NESHAPS) 10 mrem dose limit].

- Technology and cost-based PRGs are medium-specific contaminant concentrations that represent attainable levels based on current technology (e.g., minimum detectable levels). They are used to modify the ARARs and risk-based PRGs to develop PRLs.

PRLs are the final subset of medium-specific contaminant concentrations developed from the range of risk-based, ARAR-based, and technology-based PRGs. An important component of the selection process is the determination of future land use for the site and the controlling receptor on whom the PRLs would be based to ensure protection of all other receptors. PRLs also account for background concentrations of Operable Unit 4 contaminants. The PRG/PRL development process is depicted in Figure 1.

A specific objective of this attachment is to discuss the development of PRLs for Operable Unit 4 which are based on a new land use/receptor/exposure scenario developed in the Site Wide Characterization Report. As discussed in Section 2.0 of this FS, the scenario entitled, "Future Land Use with Continued Federal Ownership", was not originally addressed in the Baseline Risk Assessment. The risk-based PRGs developed on the basis of this scenario require continued federal ownership of the site in order to ensure protection of public health. The reasonable maximum exposure (RME) receptor for this scenario is a expanded trespasser.

2.0 PRELIMINARY REMEDIATION GOALS

In the early stages of the RI/FS, as discussed in the Site-Wide Characterization Report (SWCR) (DOE 1993b), PRGs are used as action goals to determine if constituents in the environment need to be further addressed (see Figure D.II.1). However, PRGs are not action levels for remediation, although PRG's help establish the contaminants of concern, the media that need to be addressed and the feasible remedial options. PRGs are based on compliance with ARARs and the protection of human health and the environment. However, ARARs do not exist for all contaminants of concern. Moreover, ARAR-based PRGs may be less stringent than PRGs based on a 10^{-6} to 10^{-4} risk range and, therefore, do not necessarily meet the "protectiveness of human health" objective as required for Superfund sites. Therefore, both ARAR-based and risk-based PRGs have been developed for the FEMP site as follows:

- For individual chemical toxicants, a Hazard Index (HI) = 0.2 for the sum of all pathways.
- For chemical and radiological carcinogens, an Incremental Lifetime Cancer Risk (ILCR) = 10^{-6}, 10^{-5}, and 10^{-4}.
- For radionuclides, dose limit ARARs and to be considered (TBC) requirements.
- Pertinent ARARs for all contaminants.

Certain media associated with Operable Unit 4, such as groundwater, are outside the scope of remedial actions being considered under the FS. PRGs are presented for groundwater in Section 2 of the FS, but are not discussed further in this Attachment. PRGs are not presented for waste material contained in the silos because this material is heavily contaminated and would never be suitable for release. Table D.II-1 summarizes the relevant media and provides the rationale for development of PRGs or cleanup criteria for these media.

The following sections identify the basis for the PRGs presented herein. Furthermore, they address the ARARs, TBCs, risk ranges, and HQs for radiological and chemical constituents in surface soil and groundwater used to develop the PRGs.

Potential health effects that may result from exposures to radioactive and chemical contaminants are divided into two categories: carcinogenic and noncarcinogenic. For carcinogens, EPA has identified [in the National Oil and Hazardous Substance Pollution Contingency Plan (NCP)] a target range for

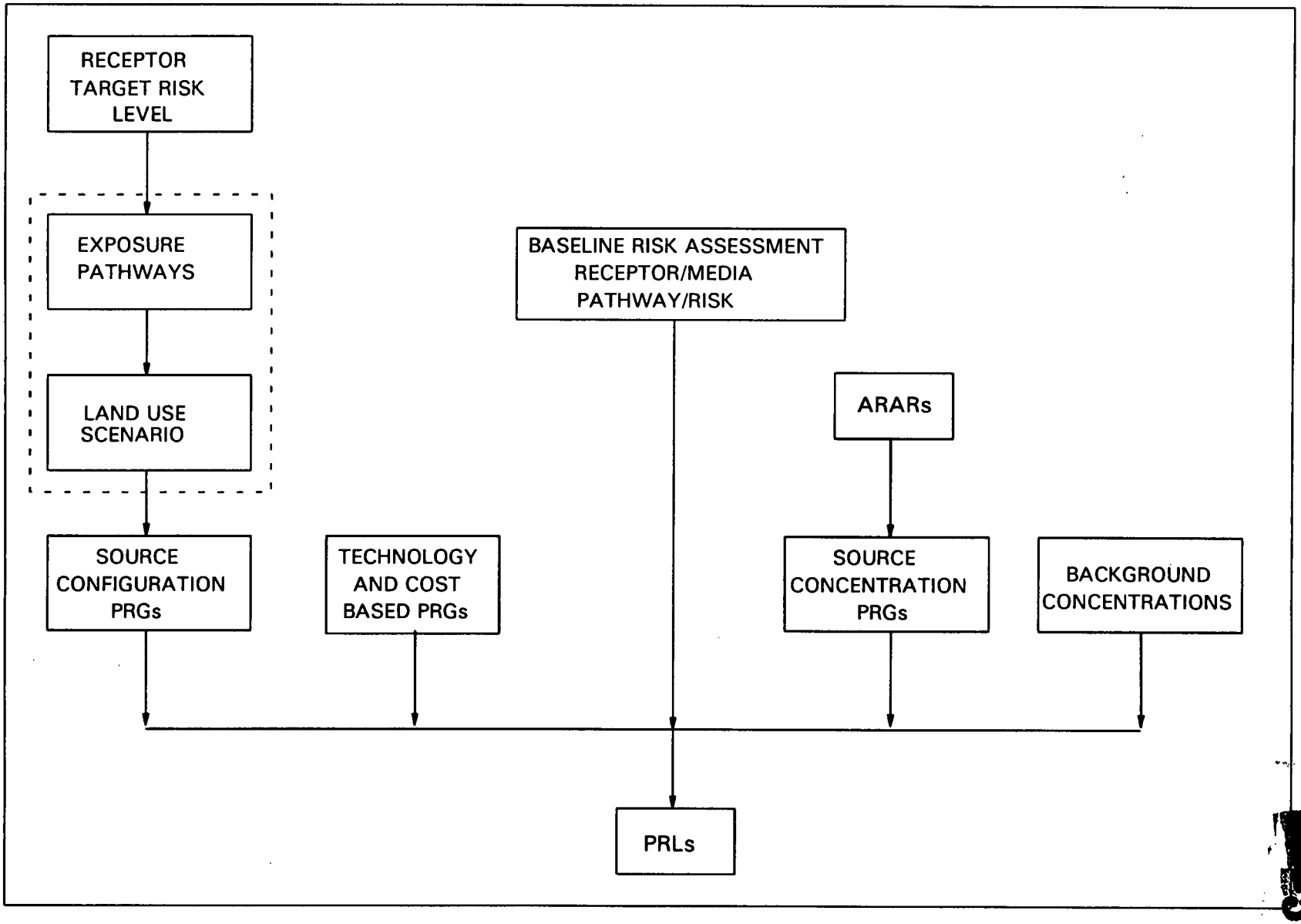

FIGURE D.II-1
PRG/PRL DEVELOPMENT PROCESS

TABLE D.II-1

DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS OPERABLE UNIT 4

Medium	Source of Preliminary Remediation Goals	Comments
Waste Material	Preliminary remediation goals are not relevant for waste material such as that contained in Silos 1, 2, and 3 because this material is heavily contaminated and would not be considered releasable. Residual material remaining after the potential removal of silo contained wastes would be addressed as part of structural materials and soil.	Exposure mitigation measures (e.g., containment, treatment, removal and disposal) would be considered as part of this FS.
Structural Material and Equipment	Radiological release criteria were previously developed for structural building material and equipment with superficial contamination. These criteria were adopted from guidelines established by the U.S. Nuclear Regulatory Commission (NRC) guidance and incorporated into DOE Order 5400.5. Therefore, no new radiological release criteria (or preliminary remediation goals) for structural material and equipment would be developed as part of this FS.	Radiological release criteria have not been established by the DOE or the NRC for material with volumetric contamination, such as concrete. Protocol for demonstrating construction materials such as concrete are not contaminated would be provided in Remedial Design/Remedial Action Work Plan.
Soil	Regulatory-based chemical and radiological cleanup criteria are not available for most contaminants of concern in soil. FEMP site soil cleanup criteria would be developed as part of Operable Unit 5, which includes remediation of site-wide soils. Soil PRGs developed as part of this FS would be subject to modification on the basis of additional information developed through Operable Unit 5.	No comments.
Residual Water	Regulatory-based cleanup criteria are not available for all constituents of concern existing in residual liquids or that may be transported from OU4 sources. Residual liquids would be directed through existing plant wastewater treatment systems. Discharges would be consistent with existing NPDES permit requirements and commitments defined under the South Groundwater Contamination Plume Removal Action. PRGs were therefore not derived for residual water within Operable Unit 4.	No comments.

TABLE D.II-1
(Continued)

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Medium	Source of Preliminary Remediation Goals	Comments
Groundwater	Regulatory-based chemical and radiological cleanup criteria are not available for all contaminants of concern in groundwater. Final FEMP site groundwater cleanup criteria would be developed as part of OU5 which includes remediation of site-wide groundwater. The chemical and radiological PRGs in this FS represent the concentration of a particular constituent of concern in groundwater presenting a specific ILCR or HI. These concentrations could occur in groundwater as a result of migration from residuals within OU4 or stabilized source materials. These PRGs are established to provide a relative performance measure for groundwater protection that a given alternative must attain to be protective of human health and the environment.	Decisions regarding remediation of groundwater would be addressed by DOE as a part of FEMP site OU5. Separation of final groundwater cleanup decisions from those considered under OU4 allow further characterization of groundwater and consideration of remedial action for site groundwater as a whole.

ILCRs of 10^{-6} to 10^{-4} to limit the possibility that an individual would develop cancer due to exposures to residual contaminants at a National Priorities List (NPL) site [40 Code of Federal Regulations (CFR) § 300]. As part of the cleanup goals at NPL sites, EPA strives to manage ILCRs within the target range described above, with the 10^{-6} risk serving as the point of departure.

For noncarcinogens, EPA guidance provides protection to individuals from health effect other than cancer by proposing that potential intakes or dermal exposures to a toxic chemical are maintained below the reference dose. The ratio of actual or potential dose to the reference dose, referred to as the HQ, is maintained at less than one to provide protection. Exposures to more than one contaminant can result in multiple HQs. The sum of these HQs equals the HI, which must also be maintained at less than one to provide protection. For sites where the total estimated ILCR for each receptor is less than 10^{-4} and the HI is less than one, action is usually not warranted.

Although risk management decisions are generally made at the upper end of the target range (10^{-4}), EPA does not consider 10^{-4} to be a discrete limit. Risks above that level may be considered acceptable based on site specific conditions (EPA 1991). Also, risks below 10^{-4} such as 10^{-5} may be considered as the target risk. The acceptable risk management decision may be based on factors other than results of the site specific risk assessment such as the conservative assumptions applied to estimate risks from possible exposure at the site, consideration of the toxicity information available on the major contaminants, and other health-based guidance available for certain constituents.

These considerations were incorporated into the development of PRGs for Operable Unit 4. The following general principles for carcinogenic and noncarcinogenic contaminants were applied to identify general risk-based objectives for remedial actions:

- Exposures to radionuclides should be reduced to levels as low as reasonably achievable (ALARA) as limited by the presence of naturally occurring radionuclides in the soil and groundwater.

- Exposures to carcinogenic chemicals should not result in an ILCR of more than 10^{-6} to 10^{-4} as limited by the presence of naturally occurring chemicals in soil and groundwater.

- Exposures to noncarcinogenic constituents should not result in significant adverse health effects, indicated by a HI greater than 1.0, as limited by the presence of naturally occurring chemicals in the soil and groundwater.

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- Exposures of biota should be limited to levels that are not associated with significant adverse ecological effects as limited by the presence of naturally occurring radionuclides and chemicals in the soil and groundwater or are determined by site screening criteria.

The methods and assumptions used to estimate carcinogenic and noncarcinogenic effects from exposures to site constituents are described in the Final Remedial Investigation (RI) Report for Operable Unit 4 (DOE 1993a) and are also described in Appendix D of the FS for Operable Unit 4. The discussions presented in the remainder of this section are based on those detailed analyses.

In developing risk-based PRGs, target risk levels are established for carcinogens; target HQs and HIs are established for noncarcinogens. Once established, these target risk levels are used in calculating the PRGs. Toxicity data used to develop PRGs are cancer slope factors and reference doses from the Integrated Risk Information System (IRIS) database (EPA 1992a) and Health Effects Assessment Summary Tables (EPA 1992b).

One goal of the NCP is to control total site-wide risks such that the sum of all risks does not exceed 10^{-4}. The default target risk of 10^{-6} is suggested by the EPA (1991) as the point of departure. In keeping with the NCP, PRGs were calculated for the 10^{-6}, 10^{-5}, and 10^{-4} risk levels using 10^{-6} as the target risk to yield a cumulative site-wide risk that does not exceed 10^{-4}.

EPA guidance provides that the cumulative site HI should be unity or less. However, EPA guidance is unavailable on apportioning allowable levels among the range of constituents in various environmental media. The most relevant guidance is provided by the Office of Drinking Water which, in calculating maximum contaminant level goals (MCLGs), uses a relative source contribution (RSC) factor of 0.2 to account for other sources of exposure (EPA 1989). Because it is not known what additional sources are contributing to total exposure, this default RSC would be examined on a site-specific basis.

2.1 DEVELOPMENT OF RISK-BASED PRG

2.1.1 LAND USE SCENARIOS

Each Superfund site has a spectrum of current and future potential land uses. The land use scenario describes the potential use of the land, exposure pathways, and receptors. The most common land

use scenarios are industrial, commercial, residential, and farming. Typical receptors are the industrial worker, commercial worker, residents, and farmers, respectively. Due to its unique past land use (uranium metal processing, government owned) and location (rural surrounded by farm land), the current and future land uses for the FEMP site are different from other Superfund sites. Table D.II-2 presents the spectrum of land uses and the potential receptors considered at possible risk when comparing the Baseline Risk Assessment baseline conditions to the amended conditions as described under the FS alternatives.

It should be noted that certain land use scenarios from the Baseline Risk Assessment are not appropriate for evaluating land uses for the FS. After remedial actions are complete, DOE would have removed all structures from the FEMP site with no plans for any operational missions.

Two viable future land uses were identified for evaluation in the assessment of long-term risks and development of PRGs. The first scenario is future land use without continued federal ownership, which is equivalent to the Baseline Risk Assessment scenario for future land use without access controls. In this scenario, the federal government deeds the land over for unrestricted private ownership. Given that the FEMP site is located within an agricultural community, the most likely land use is farming.

The second scenario is a future land use with continued federal ownership as an undeveloped government reserve. A government reserve is defined as land which remains under government ownership and control, with no future development. While active access controls are discontinued, the federal government would exercise it's right to preclude site development with deed restrictions. This land use scenario was not included in the Baseline Risk Assessment, but was developed in the Part III of the SWCR and Operable Unit 4 FS to facilitate evaluation of long-term risks with continued land use restrictions. In this reserve scenario, the federal government owns the land and prohibits all development including grazing and does not plan a specific land use. A potential receptor evaluated relative to this land use is the expanded trespasser. The expanded trespasser is developed to approximate the potential upper bound residual risks consistent with restriction on use of land. This scenario then, typifies the maximum exposures possible given institutional controls.

The receptors for the two land uses are as follows:

TABLE D.II-2
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
OPERABLE UNIT 4
RISK ASSESSMENT LAND USE SCENARIOS

OU4 Report	Land Use Description	Ownership	Access	Use	RECEPTORS					
					Grounds -Keeper	Trespassing Child	Expanded Trespasser	Off-Property Farm	On-Property Farm	River User
RI	Current land use with access controls	Federal	Limited	Industrial		X		X		X
	Current land use without access controls	Private	Unlimited	Industrial	X	X		X		X
	Future land use	Private	Unlimited	Farm				X	X	X
FS	Future land use with federal ownership	Federal	Unlimited	Govern-ment reserve			X	X		
	Future land use without federal ownership	Private	Unlimited	Farm				X	X	

Future Land Use Without Continued Federal Ownership

The FEMP site is owned by private individuals with unrestricted use. The principal land use is for farming. The receptors are:

- On-Property Farmer — A farm family who is living on the FEMP property, growing crops, and raising dairy cows.
- Off-Property Farmer — A family living and actively farming adjacent to the FEMP site boundary. Exposure to contaminants transported by air and groundwater.

Future Land Use With Continued Federal Ownership

The FEMP site is owned by the federal government which controls land use but does not actively restrict access. The land is fenced, posted, and not used for any purpose. The receptors are:

- Expanded Trespasser — Occasional visits to the property for hiking, roaming, and bird watching by a youth and/or adults. Activities such as jogging, biking or ball playing will not be feasible due to the undeveloped nature of the land.
- Off-Property Farmer — A family living and actively farming adjacent to the FEMP site boundary. Exposure to contaminants transported by air and groundwater.

It should be noted that the trespassing child of the Baseline Risk Assessment is a sub set of the expanded trespasser.

2.1.2 SOURCES, RECEPTORS, AND EXPOSURE PARAMETERS

The baseline risk assessment evaluated all existing contaminant sources within Operable Unit 4. These sources were the contents of Silos 1 and 2, and decant sump tank sludge (subunit A); the contents of Silo 3 (subunit B); and, the silo structures, berm soil, surface and subsurface soils (subunit C). Exposure/transport media considered in the Baseline Risk Assessment included surface and berm soil, silo contents, air and airborne particulates, surface water, perched water, and groundwater. Following completion of the remedial action alternatives envisioned for Operable Unit 4, all sources would have been removed with the exception of the new clean surface soil and the existing subsurface soils. The remedial measures include removal of the top 6 inches of contaminated soil from the Operable Unit 4 and backfilled to grade with clean soil, although the risk calculations were based on residual contamination in place and no credit was taken for the clean till cover.

Exposed receptors considered in the Baseline Risk Assessment included a trespassing child, a groundskeeper, and an off-property surface water user and the on-property, and off-property farmers. The FS assessment of risks following remediation examined the same on-property and off-property farmer receptors using the same pathway assumptions and exposure parameter values presented in the Baseline Risk Assessment. The expanded trespasser is similar to, but more restrictive than, the trespassing child in the Baseline Risk Assessment and is unique to the post-remediation risk assessment. This receptor is developed to facilitate examination of potential risks with continued land use restrictions.

The equations for evaluating the expanded trespasser exposure are modified versions of the equations employed in the Baseline Risk Assessment for the future land use without federal ownership. The parameters used for exposure are consistent with information from Butler County Department of Recreation. An expanded trespasser receptor considered for PRG development is an individual who plays on the property during childhood but uses it less frequently for non-intrusive recreational activities during adulthood.

It is assumed that the child is exposed to the site two hours/day for 110 days/year over a period of six years (ages 7 to 12). The child is present from April through October for 3 days a week for 30 weeks; an additional 20 days were added to allow for other visits. The adult visits the site one hour/day for 40 days/year over a period of 32 years (one day a week for 30 weeks, plus 10 days). To evaluate cancer risk, both the child and adult exposure periods were evaluated. The expanded trespasser is assumed to be exposed to soil contaminants via the oral ingestion, dermal contact, inhalation of dusts, and external radiation pathways. The exposure parameters were the same for the trespassing child and adult farmer with one exception. The incidental ingestion rate is assumed to be 100 mg/day.

2.1.3 DETERMINATION OF PRGs

The determination of PRGs for soil is presented in Sections 2.2.2.3 of this FS. Soil PRGs are derived from the OU4-Baseline Risk Assessment data and are presented in Tables 2-5, 2-6, and 2-7 for the on-property farmer, expanded trespasser, and off-property farmer, respectively.
Risks for individual pathways were summed to derive the PRG considering all potential routes of exposure. The on-property resident farmer is assumed to live on the residual soils within Operable

Unit 4 and is exposed to COCs by incidental ingestion, dermal contact, consumption of meat, milk, and produce, and direct radiation.

Dust resuspension and transport modeling was performed in the RI Report for Operable Unit 4 to examine exposure point concentrations both on property and off property as a result of baseline conditions with Operable Unit 4. These modeling results were used to calculate resuspension factors and ultimately soil concentration PRGs. The on- and off-property farmers are assumed to then consume the crops, eat meat from cows grazing on the forage, and drink milk from cows grazing on the forage.

The passive expanded trespasser is assumed to be exposed to Operable Unit 4 soil via incidental ingestion, inhalation of particulates, dermal contact, and external radiation.

2.2 Development of ARAR/TBC Soil Based PRGs

Chemical-specific ARARs were examined to identify PRGs for Operable Unit 4 COCs. These ARARs included non-zero MCLGs and Maximum Contaminant Levels (MCLs) for drinking water. Other considerations, including available guidance and health advisories, were examined to identify PRGs (or TBC- based PRGs). TBC guidance that were examined included DOE orders, ecological benchmark criteria, and drinking water health advisories. ARAR/TBC-based PRGs are presented in Tables 2-5 through 2-7 for soils and Table 2-8 for groundwater.

The EPA has promulgated standards for Ra-226 and Ra-228 in soil at uranium and thorium mill tailings sites (40 CFR § 192 Subpart B). In brief, these radionuclides are not to exceed background concentrations by more than 5 pCi/g in the top 15 cm (6 in) of soil or 15 pCi/g in each 15 cm (6 in) layer beneath the surface, averaged over an area of 100 m^2 (1100 ft^2). Because the FEMP site is not a mill tailings site, these standards do not specifically apply. However, the requirements are considered relevant and appropriate because waste material at the site is similar to mill tailings.

The EPA has identified standards for airborne emissions of radionuclides other than Rn-222 which limit exposures such that a member of the public would not exceed an effective dose equivalent of 10 mrem/year (40 CFR § 61 Subpart H). The USEPA has also identified annual dose limits of 25 mrem/year to the whole body, 75 mrem/year to the thyroid and 25 mrem/year to any other organ for exposures associated with management of uranium and thorium by-product material.

As a general standard for radiological exposures, DOE requires compliance with all federal requirements limiting doses from specific exposure modes. DOE Order 5400.5 establishes requirements for nonspecific radiological exposures from DOE facilities. This order requires that the committed effective dose equivalent to a member of the public not exceed 100 mrem/year above background from all nonoccupational exposure routes and that these exposures be reduced to ALARA levels. With this order, DOE defines the ALARA process for reducing residual exposures and risks to levels as low as reasonably achievable below applicable standards considering technical, economic, and social constraints as appropriate. DOE Order 5400.5 is comparable to the requirements of 10 CFR § 20 for the exposure of the public to radioactive materials.

These radiological dose standards and requirements are considered as applicable, relevant and appropriate, or TBCs to remediation efforts at the FEMP site. Current dose estimates for the site perimeter are within the specified limits.

EPA has identified two different guidelines for establishing a residual level for lead in soil in a residential setting. These guidelines are considered TBCs. The first is an interim guidance that considers the natural presence of lead in soil and recommends a cleanup level of 500 to 1000 mg/kg, as determined by site-specific conditions (EPA 1992a). The second is draft guidance in the form of an uptake/biokinetic model that can be applied to site-specific data to estimate lead levels in blood for children, the most sensitive population. A blood lead level of 10 μg/L or less is EPA's preferred level. This model yields a health-based level of 450 mg/kg for lead in surface soil.

A standard for cleanup of soil following a spill of material containing more than 50 mg/kg polychlorinated biphenyls (PCBs) is identified in the Toxic Substances Control Act. The standard

indicates that soil in areas of unrestricted access at which a spill occurs can be decontaminated to 10 mg/kg by weight by excavating at least 25 centimeters (10 inches) of soil and backfilling with material containing less than 1 mg/kg PCBs. Because PCB contamination in soil would have resulted from spills of material that occurred long before the effective date of these standards, they do not specifically apply; however, they are considered relevant and appropriate. In conclusion, wherever guidelines provide direction, applicable or relevant and appropriate and/or to be considered requirements are incorporated into the development of remedial goals.

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3.0 PROPOSED REMEDIAL LEVELS

Operable Unit 5 contains the majority of site-wide soils to be addressed for remediation and is, therefore, currently evaluating the technologies and alternatives potentially applicable to soils. To avoid the selection of final cleanup based upon a volume of soil which represents less than one percent of the total site-wide volume, the proposed final goals reflect preliminary technology considerations and a future land use consistent with the SWCR and the CRARE. Input from the public, and technical information derived from Operable Unit 5 will be considered prior to establishing proposed final remediation levels for the Record of Decision (ROD).

The approach used in this development of proposed remediation levels (PRLs) was a tiered approach. The initial PRGs presented in the SWCR were re-evaluated in the FS. The baseline risk assessment results were used to select COCs, receptors, and land use scenarios. The baseline risk assessment receptors are related to the FS receptors establishing a link to develop PRLs.

The PRLs are developed from the risk-based PRGs for the three receptors, and the ARAR/TBC PRGs. PRLs are actual soil concentrations and were derived as the PRG (incremental risk) concentrations plus background. In addition, cost benefit analysis and technology considerations can be used to modify a PRG to develop a PRL. Soil PRLs will be the only PRLs developed for Operable Unit 4 since groundwater PRLs will be developed as part of Operable Unit 5. The three receptors presented in Table D.II-3 encompass the two future land use scenarios. The expanded trespasser and the off-property farmer are the receptors for the government reserve land use (future land use continued federal ownership). The off-property farmer and the on-property farmer are the receptors for the farming land use (future land use without continued federal ownership).

3.1 BASIS OF PROPOSED REMEDIATION LEVELS

A review of the PRGS presented in Tables 2-5, 2-6, and 2-7 plus the background containment concentrations indicates that Ra-226 and Pb-210 would be the controlling contaminants for the Operable Unit 4 soils. U-238 has been established as one of the primary contaminants on a site wide basis. The 10^{-6} risk based PRGS are abstracted for the three receptors are presented in Table D.II-3 in descending order. In addition, the other receptors evaluated in the baseline risk assessment are

TABLE D.II-3

COMPARISON OF PRGS BASED ON A 10^{-6} RISK

Receptor	Evaluation of Receptor		Pb-210 + 2 progeny (pCi/g)	Ra-226 + 5 progeny (pCi/g)	U-238 + 2 progeny (pCi/g)
	Baseline Risk Assessment	FS Risk Assessment			
Miami River Water User	Yes	No	N/A	N/A	N/A
Off-property Farmer	Yes	Yes	6200	13000	1100
Trespassing Child	Yes	Yes	97	14	920
Groundskeeper	Yes	No	ND	ND	ND
Expanded Trespasser	No	Yes	77	0.37	59
CT On-property Farmer	Yes	Yes	ND	ND	ND
On-property Farmer	Yes	Yes	0.91	0.004	0.55
Background[a]			1.3	1.5	1.2
Surface Soil[a]			4.5	88	37
Subsurface Soil[a]			10	206	53

[a]Upper 95th percentile value from the Final Remedial Investigation Report for Operable Unit 4, November 1993.
N/A = Not Applicable - Baseline risk less than 10^{-6}.
ND = Not Determined - Vertical postion indicates relative risk levels.

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identified to this table. PRGs for the trespassing child were also calculated as this receptor represents the least conservative receptor for on-property soil exposure. PRGs for the groundskeeper, Central Tendency (CT) on-property farmer, and on-property resident child also were not calculated either because the receptor was not considered in either future land use (groundskeeper) or because they were between other receptors.

The PRGs for soils presented in Table D.II-3 indicate that the on-property farmer is the critical receptor for soil contamination. This is consistent with the Baseline Risk Assessment results, which indicate that the highest risks are to the on-property farmer followed by the trespassing child and the off-property farmer, in descending order. Accordingly, the PRGs range in magnitude from the off-property farmer, trespassing child, expanded trespasser, and to the on-property farmer.

PRGs representing 10^{-6} risk under the future land use without continued federal ownership residential farmer scenario differ from the ARARs-based PRG for Ra-226 of 5 pCi/g by several orders of magnitude. Moreover, the 10^{-6} risk-based PRGs for U-238 and Ra-226 are 2.6 and 36 times less than background, respectively.

For organics, most PRGs for soils based on the 10^{-6} risk level are well below the contract required quantitation limits (CRQLs) established by EPA. In fact, the 10^{-6} risk-based PRG for the on-property farmer is less than background levels for arsenic. To date, the CRQLs have been used for the site characterization study at the FEMP site.

Since PRGs are incremental above background concentrations, this implies that background concentrations could be a determining factor in the development of proposed PRLs for the soils. However, the current information concerning soil washing strongly suggests that background concentrations are not achievable for uranium isotopes. Treatability data for the other radionuclides and the heavy metals is not available, but information from other Superfund sites suggest that background concentrations would not be achievable for these contaminants through remedial treatment technologies. The most likely remedial alternative for Operable Unit 4 soils is excavation and disposal. Current estimates indicate that excavation to approximately 15 meters (45 feet) would be

necessary to assure clean up to background levels. Since it is likely that PRGs for the on-property farmer are not achievable using treatment technologies or will be cost prohibitive, the future land use scenario as a government reserve was therefore adopted as the most reasonable land use scenario as the basis for developing PRLs.

An additional consideration supporting continued federal ownership of the site following remediation is OAC 3734.02, which specifies that hazardous and solid waste disposal facilities must include a protective covenant to restrict mining, drilling, and residential uses. The site boundaries would likely be relocated to release as much uncontaminated land as possible while adequately enclosing the disposal cells and waste areas. As a government reserve, the reduced area would remain government owned with no land development, and no continued maintenance would be performed. The reduced area of the site would be fenced with posted signs prohibiting use.

It is anticipated that to attain the referenced PRLs, a minimum 15 cm (6 inches) of soils would be removed from the entire Operable Unit 4 area. Deeper excavations may also be required to remove identified "hot spots." Following excavation, the excavation areas would be backfilled with clean soils and seeded. The following steps were followed in developing PRLs for Operable Unit 4:

Step 1. The soil concentration representing the PRG for the 10^{-6} risk level for the expanded trespasser from Table D.II-3 was adopted as the PRL.

Step 2. Pertinent ARARs were identified for each COC. If the ARAR concentration level for a COC was less than the value PRG above, the ARAR level was adopted as the PRL.

Step 3. In the event the PRL from the first two steps was less than the 95 percentile of the background soil data set, the PRL was considered indistinguishable from background. That is, any soil concentrations at or below background concentrations would be considered acceptable as a conclusion for remedial actions. The selected PRG concentration was then added to the background concentration for a specific COC to calculate the PRL.

Step 4. The PRL was compared to the 95th percentile of the observed surface and subsurface soil concentrations, which includes the maximum detected values as reported in the Final RI Report for Operable Unit 4 (November 1993), including non-validated data sets such as Characterization Investigation Study on-site gamma spectrometry analysis. The frequency of detection of the

COCs in the soils was also considered in this evaluation. If the PRL was greater than the maximum observed concentrations or it was infrequently detected, consideration was given to eliminating the need to propose remediation levels for those COCs.

The ILCR or HI to the expanded trespasser and the on-property farmer was then calculated for the PRLs or for the residual soil concentrations to demonstrate effectiveness for the expanded trespasser and to display the residual to the on-property farmer if the land was to be deeded for private use.

3.2 PRESENTATION OF PROPOSED REMEDIATION LEVELS

Table D.II-4 presents the radionuclide PRLs and the chemical PRLs. All HIs were less than 0.2, so carcinogenic risks would drive the cleanup levels. The radionuclides Sr-90 and Tc-99 were present at concentrations below the surface and subsurface soil background concentrations; hence, no remediation is required for these COCs. The proposed PRLs for Ra-226 and Th-228 are approximately at background, and the proposed PRL for Ra-228 is approximately twice background. The last four columns of Table D.II-4 present the potential HI and ILCR values to the expanded trespasser and the on-property farmer for the government reserve land use.

The risk calculations were performed using the equations presented in the Baseline Risk Assessment for the on-property farmer. The expanded trespasser risks were calculated by ratioing the on-property farmer and expanded trespasser PRGs in Table D.II-4. These on-property risk calculations encompass all pathways of exposure as presented in the RI, that is, exposure through incidental ingestion, direct radiation dermal contact, inhalation of dust, vegetable consumption, meat consumption, and dairy consumption.

It should be noted that the trespassing child receptor would have a potential risk below that of the expanded trespasser, based on the decreased frequency of exposure and the higher PRGs presented in Table D.II-3. The Baseline Risk Assessment reported a radiological ILCR for the trespassing child from the unremediated soils and berms (current source term) to be 1×10^{-5}. The comparison of current source term to surface soils is not exact since the current source term includes both the surface soils and berm material. The FS risk assessment estimated a radiological ILCR for the trespassing child to

TABLE D.II-4
PROPOSED REMEDIATION LEVELS IN SOILS

Constituent of Concern	Expanded Trespasser HI = 0.2 PRG mg/kg	Expanded Trespasser 10^{-6} ILCR PRG mg/kg	Background (95th percentile) mg/kg	ARAR Target	Max. Detected Soil Concentration, mg/kg		Proposed Remediation Levels mg/kg	HI to Receptors from Proposed Remediation Levels		Risk to Receptors from Proposed Remediation Level	
					Surface	Sub surface		Expanded Trespasser	On-Property Farmer	Expanded Trespasser[a]	On-Property Farmer[b]
Radionuclides (pCi/g)											
Pb-210 +2 progeny	N/A	77	1.33	NA	4.5	101	78	N/A	N/A	$1x10^{-6}$	$2.0x10^{-3}$
Ra-226 +5 progeny	N/A	0.37	1.45	5 (top 6 inch soil) 15 (below 6 inch)	88	206	2	N/A	N/A	$1.0x10^{-6}$	$3.8x10^{-4}$
Ra-228 +1 progeny	N/A	0.77	1.19	NA	0.48	1.24	2	N/A	N/A	$2.0x10^{-6}$	$2.4x10^{-4}$
Sr-90 +1 progeny	N/A	1420	ND	NA	1.8	0.8	NR	N/A	N/A	$<1x10^{-6}$	$6.3x10^{-5}$
Tc-99	N/A	38700	ND	NA	3.6	3.6	NR	N/A	N/A	$<1x10^{-6}$	$2.2x10^{-4}$
Th-228	N/A	0.4	1.43	NA	2.9	1.3	2	N/A	N/A	$2x10^{-6}$	$4.7x10^{-4}$
U-238 +2 progeny	N/A	59	1.22	NA	37	53	60	N/A	N/A	$1x10^{-6}$	$2.1x10^{-4}$
Chemical (mg/kg)											
Antimony	31	N/A	7.7	NA	32	32	NR	0.2	6.1	N/A	N/A
Arsenic	510	23	8.45	NA	10	12	NR	N/A	N/A	$<1x10^{-6}$	$1.3x10^{-3}$
Barium	>10000	N/A	91.3	NA	112	142	NR	<.1	0.10	N/A	N/A
Cadmium	26	N/A	0.82	NA	6	7	NR	<.1	2.8	N/A	N/A
Chromium(III)	NA	N/A	15.5	NA	23	25	NR	<.1	0.19	N/A	N/A
Molybdenum	930	N/A	2.6	NA	25	30	NR	<.1	1.6	N/A	N/A

Table D.II-4
(Continued)

PROPOSED REMEDIATION LEVELS IN SOILS

Constituent of Concern	Expanded Trespasser HI = 0.2 PRG mg/kg	Expanded Trespasser 10^{-6} ILCR PRG mg/kg	Background (95th percentile) mg/kg	ARAR Target	Max. Detected Soil Concentration, mg/kg		Proposed Remediation Levels mg/kg	HI to Receptors from Proposed Remediation Levels		Risk to Receptors from Proposed Remediation Level	
					Surface	Sub surface		Expanded Trespasser	On-Property Farmer	Expanded Trespasser[a]	On-Property Farmer[b]
Nickel	8300	N/A	20.9	NA	39	39	NR	<.1	0.28	N/A	N/A
Silver	130	N/A	2.6	NA	10	18	NR	<.1	7.0	N/A	N/A
Thallium	31	N/A	0.58	NA	0.5	0.5	NR	<.1	0.33	N/A	N/A
Vanadium	1700	N/A	30.4	NA	28	33	NR	<.1	0.57	N/A	N/A
Zinc	>10000	N/A	62.2	NA	65	67	NR	<.1	2.77	N/A	N/
Benzo(a)anthracene	NA	61	ND	NA	4.7	ND	NR	N/A	N/A	$<1x10^{-6}$	$2.4x10^{-4}$
Benzo(a)pyrene	NA	8.8	ND	NA	5.2	ND	NR	N/A	N/A	$<1x10^{-6}$	$2.7x10^{-3}$
Benzo(b)fluoranthene	NA	72	ND	NA	9.7	ND	NR	N/A	N/A	$<1x10^{-6}$	$1.5x10^{-3}$
Chrysene	NA	2000	ND	NA	3.5	ND	NR	N/A	N/A	$<1x10^{-6}$	$1.5x10^{-5}$
Dibenzo(a,h)anthracene	NA	7.9	ND	NA	0.9	ND	NR	N/A	N/A	$<1x10^{-6}$	$5.3x10^{-4}$
Indeno(1,2,3-cd)pyrene	NA	32	ND	NA	4.2	ND	NR	N/A	N/A	$<1x10^{-6}$	$1.3x10^{-2}$

[a]Includes the direct radiation, soil ingestion, and inhalation pathways.
[b]Includes all pathways including the indirect pathways due to food crops.
NA = Not Available.
N/A= Not Applicable.
ND = Not Detected.
NR = No Remediation Required.

be 6.8×10^{-6}.

The total radiological ILCR from the Baseline Risk Assessment to the on-property farmer using the current source term was 2×10^{-3}. If unrestricted use of Operable Unit 4 occurs allowing agricultural use, then the on-property farmer would have a potential combined risk greater than 2×10^{-3} with Pb-210 being the major contributor.

The inorganic PRGs for the expanded trespasser were all above the existing surface and subsurface soil concentrations. When the top six inches of soil is removed then there is no risk from the PAHs. The arsenic ILCR for the trespassing child (current source term) from the Baseline Risk Assessment was 2.7×10^{-7}, and the FS risk assessment estimated 3.1×10^{-7} which can be compared to the 1×10^{-6} ILCR for the expanded trespasser. The ILCR for the on-property farmer for arsenic (current source term, soils and berm) was 3×10^{-4}. The total ILCR for the on-property farmer was 8×10^{-2}, which can be compared to the zero PAH ILCR from the proposed PRLs.

ATTACHMENT D.III

DERIVATION OF ILCRs AND HIs FOR RESIDUAL SOIL CONTAMINATION

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D.III DERIVATION OF ILCRs AND HIs FOR RESIDUAL SOIL CONTAMINATION

D.III.1.0 INTRODUCTION

This attachment to Appendix D of the Operable Unit 4 Feasibility Study (FS), presents and discusses the calculational approach used in deriving ILCRs and HIs for on-property and off-property receptors from long-term exposure to residual contaminants following completion of Operable Unit 4 remedial alternatives. As described in the sections that follow, the assessment of potential ILCRs and HIs for long-term exposures used the methods described in the Final Operable Unit 4 Remedial Investigation (RI) Baseline Risk Assessment, November 1993, which in-turn are based on guidance contained in the Risk Assessment Work Plan Addendum.

Section D.3.2 of Appendix D (FS) discusses the potential receptors and exposure pathways associated with the Operable Unit 4 remedial alternatives, and presents the parameters used in the exposure calculations. As presented in that section, short-term and long-term conceptual models have been developed to ensure that the range of potential release mechanisms and exposure pathways are identified. Long-term exposures are evaluated in Section D.3.2.2. Toxicity data relevant to the assessment of both short-term and long-term risks are presented in Section D.3.3.

D.III.1.1 Contaminant Sources

The Baseline Risk Assessment evaluated all existing contaminant sources within Operable Unit 4. These were the Silo 1 and 2 contents and decant tank sludge (Subunit A); Silo 3 contents (Subunit B); and the silo structures, berm soil, surface soil and subsurface soil (Subunit C). Exposure/ transport media considered in the baseline assessment included surface and berm soil, silo contents, air and airborne particulates, surface water, perched water, and ground water.

Following completion of the remedial action alternatives envisioned for Operable Unit 4, all sources will have been removed with the exception of residual contaminant levels equal to or less than PRLs in subsurface soils (after the contaminated surface soil has been removed from the Operable Unit 4 area). As described in Section D.3.1.2, all Subunit C remedial alternatives (except for the no action alternative) include demolition and removal of the treatment facilities, Silos 1 through 4 structures, decant tank, and piping. They also include removing the surface and subsurface soil as appropriate to reduce the concentration of residual radiological and nonradiological contaminants. Following completion of the Subunit C and other Operable Unit 4 remedial alternatives, residual subsurface soils will be the only contaminant source remaining within the unit boundaries. All silo contents will have

been removed, with Alternatives 3A and 3B shipping the Silo 1,2 and 3 contents to an off-site disposal facility, while Alternatives 2A, 2B, and 4B result in their disposal in an on-property vault.

D.III.1.2 Release Mechanisms

The potential release mechanisms associated with the residual soil contamination include direct contact, penetrating radiation exposure, wind and water erosion, and water leaching. Although the disposal vault is designed to maintain its full integrity for 1000 years; for the purpose of this evaluation, the assumption has been made that the vault's infiltration barriers deteriorate and permit increased infiltration of water. However, it is still reasonable to expect the vault to otherwise survive substantially intact over the long-term, preventing direct contact with the wastes, or surface erosion. Potential ILCRs and HIs associated with the groundwater release and transport pathway incorporating these assumptions are evaluated in Section D.3-4.

D.III.1.3 Receptors and Exposure Pathways

The Baseline Risk Assessment evaluated potential exposures to the groundskeeper and off-property surface water user receptors, in addition to the on-property and off-property resident farmer and child receptors, and the trespassing child receptors. The assessment of risks following remediation examines the same RME and CT on-property resident farmers, on-property resident child, off-property resident farmer, and trespassing child receptors, using the same pathway assumptions and exposure parameter values presented in the Baseline Risk Assessment. The assessment of post-remediation risks also examined an expanded trespasser receptor. As summarized in Table D.3-6 of Appendix D (FS), the expanded trespasser is unique to the post-remediation risk assessment, and was developed to facilitate examination of potential risks with continued land use restrictions.

On-property resident exposure pathways are inhalation, incidental soil ingestion, ingestion of farm products grown in contaminated soil, dermal contact and external radiation. Exposure pathways for the off-property resident farmer, following resuspension of soil contaminants and airborne transport, are inhalation and ingestion of farm products contaminated through airborne deposition. The trespasser receptors exposure pathways are inhalation, incidental soil ingestion, external radiation, and dermal exposure.

The equations for evaluating the expanded trespasser exposure are simply modified versions of the equations employed in the Baseline Risk Assessment for the Future Land Use Without Federal Ownership. The expanded trespasser is discussed in more detail in Section D.III.2.2.

D.III.2.0 CALCULATIONAL APPROACH

As indicated in the preceding sections, the calculation of potential ILCRs and HIs from long-term exposure to residual soil contamination, following completion of remediation, was performed using the methods and exposure parameters described in the Baseline Risk Assessment. Section D.4, Exposure Assessment, of the Baseline Risk Assessment describes the exposure parameters and equations used in estimating receptor exposure to contaminants in applicable media. Section D.5, Risk Characterization, of the Baseline Risk Assessment describes the equations used in estimating receptor ILCRs and HIs. Attachment D.II, Risk Calculation Results of the Baseline Risk Assessment, presents tabular versions of the calculational spreadsheets used in performing the baseline ILCR and HI calculations.

D.III.2.1 ILCR and HI Calculations For Baseline Receptors

To calculate ILCRs and HIs for baseline receptors following completion of remediation, the baseline risk calculations were simply adjusted to reflect reductions in 1) the number of contaminant sources, and 2) the exposure point concentrations following remediation. As discussed in the preceding section, following completion of Operable Unit 4 remedial alternatives, residual subsurface soils will be the only contaminant source remaining with the potential to contribute to surface release and exposure pathways.

Reductions in exposure point concentrations were made to reflect the Proposed Remediation Levels (PRLs) presented in Section 2 of the FS, and discussed further in Attachment D.II. to Appendix D (FS). Contaminant exposure point concentrations were reduced in two instances. In the first instance, Radium-226 concentrations in soil were reduced from 3.8 pCi/g (baseline UCL for measured concentrations) to 2 pCi/g (risk-based PRL). The Radium-226 concentrations in air were reduced by the same factor.

The second adjustment of exposure point concentrations reflected post-remediation conditions relative to organic contaminants in soil. The concentrations of organic contaminants were reduced from their baseline UCL concentrations to zero, reflecting the fact that organic contaminants are only present in the top six inches of surface soils, which are removed by the Subunit C alternatives.

Two revisions were made to the baseline calculational framework in the November 1993 Final Baseline Risk Assessment before proceeding with the post-remediation calculations. In the first revision, a conversion-factor discrepancy was corrected in the airborne radionuclide exposure point concentrations. The discrepancy resulted in airborne exposure point concentrations for radionuclides

that were a factor of 1000 low (Attachment D.II, November 1993 Final Baseline Risk Assessment). The second revision corrected an exposure parameter discrepancy in the baseline calculations for the trespassing child dermal exposure. The HQs contained in Attachment D.II of the November 1993 Final Baseline Risk Assessment were determined to be a factor of 10 high for certain chemicals.

The results of the post-remediation ILCR and HI calculations for baseline receptors are presented in Tables D.III-1 through D.III-10 of this FS. ILCRs and HIs for the on-property resident farmer (RME) are presented in Tables D.III-1 and D.III-2 respectively, which indicate the dominant contributors to ILCR are external radiation (radium-226) and ingestion of farm products (lead-210 and technetium-99), and the dominant contributor to HI is ingestion of farm products (antimony, cadmium and silver).

ILCRs and HIs for the on-property resident farmer (CT) are presented in Tables D.III-3 and D.III-4 respectively, which again indicate the dominant contributors to ILCR are external radiation (radium-226) and ingestion of farm products (lead-210 and technetium-99), and the dominant contributor to HI is ingestion of farm products (antimony, cadmium and silver).

ILCRs and HIs for the on-property resident child are presented in Tables D.III-5 and D.III-6 respectively. Consistent with the other on-property resident receptors, the dominant contributors to ILCR are external radiation (radium-226) and ingestion of farm products (lead-210 and technetium-99), and the dominant contributor to HI is ingestion of farm products (antimony, cadmium and silver).

ILCRs and HIs for the off-property resident farmer are presented in Tables D.III-7 and D.III-8 respectively, which indicate the dominant contributor to ILCR is inhalation of airborne particulates (uranium-238 and chromium), and the dominant contributor to HI is ingestion of farm products (antimony, cadmium, silver, uranium and zinc).

ILCRs and HIs for the trespassing child are presented in Tables D.III-9 and D.III-10 respectively. The dominant contributors to ILCR are inhalation of airborne particulates (uranium-238 and chromium) and external radiation (radium-226), and the dominant contributor to HI is dermal contact (antimony, cadmium, chromium and uranium).

D.III.2.2 ILCR and HI Calculations For The Expanded Trespasser

As discussed previously, the expanded trespasser receptor is unique to the post-remediation risk assessment, and was developed to facilitate examination of potential risks with continued land use restrictions.

The equations for evaluating the expanded trespasser exposure are simply modified versions of the equations employed in the Baseline Risk Assessment for the Future Land Use. The expanded trespasser is an individual who plays on the property as a youth and uses the property less frequently as an adult. It is assumed that the youth is exposed to the site two hours/day for 110 days/year over a period of six years (age 7-12). The 110 days is based on the youth being present on the site from April through October for 3 days a week for 30 weeks. An additional 20 days were added to allow for other visits. The adult is assumed to visit the site one hour/day for 40 days/year over a period of 32 years (one day a week for 30 weeks, plus 10 days). To evaluate cancer risk, both the youth and adult exposure periods were evaluated. The expanded trespasser is assumed to be exposed to soil contaminants via the incidental ingestion, dermal contact, inhalation of dusts, and external radiation pathways. The exposure parameters were the same as for the trespassing child and adult farmer from the Baseline Risk Assessment with one exception. The incidental ingestion rate was assumed to be 100 mg/day.

ILCRs and HIs for the expanded trespasser are presented in Table D.III-11. The dominant contributors to ILCR are inhalation of airborne particulates (uranium-238 and chromium) and external radiation (radium-226), and the dominant contributor to HI is dermal contact (antimony, cadmium, chromium and uranium).

TABLE D.III-1

RESIDUAL ILCR FOR THE ON-PROPERTY RESIDENT FARMER (RME)

Transfer Media >>>>>>>	AIR				SOILS						EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>>>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Dermal Contact	Incidental Ingestion	External Radiation	Root Uptake Veg/Fruit Ingestion	Root Uptake Meat Ingestion	Root Uptake Milk Ingestion	Air	Soil
Constituent												
RADIONUCLIDE											(pCi/cu m)	(pCi/g)
Uranium-238 + 2 dtrs	2.5E-05	2.0E-07	2.8E-09	3.4E-08	N/A	1.8E-06	2.1E-05	4.8E-06	1.4E-07	1.6E-06	4.1E-03	1.4E+01
Radium-226 + 5 dtrs	9.1E-08	5.0E-08	1.1E-09	7.9E-09	N/A	9.5E-07	4.5E-04	9.7E-07	1.2E-07	8.9E-07	2.6E-04	1.8E+00
Lead-210 + 2 dtrs	6.6E-08	1.6E-07	3.7E-09	1.2E-08	N/A	1.3E-05	3.0E-08	7.9E-05	4.4E-06	1.5E-05	1.4E-04	4.5E+00
Radium-228 + 1 dtr	2.4E-08	4.5E-08	6.4E-10	4.6E-09	N/A	5.7E-07	1.6E-04	5.6E-07	7.1E-08	5.1E-07	3.1E-04	1.3E+00
Thorium-228 + 7 dtrs	2.5E-06	2.1E-08	6.5E-12	2.2E-11	N/A	3.1E-07	3.0E-04	1.7E-08	4.0E-10	1.4E-09	2.7E-04	1.3E+00
Strontium + 1 dtr	2.5E-09	1.4E-07	1.1E-08	2.3E-07	N/A	2.9E-07		4.8E-05	4.4E-06	8.9E-05	3.5E-04	1.8E+00
Technetium-99	6.7E-10	1.1E-07	1.8E-07	8.4E-07	N/A	2.1E-08	9.0E-11	2.1E-05	3.5E-05	1.6E-04	6.9E-04	3.6E+00
Total - Radionuclides	2.7E-05	7.3E-07	2.0E-07	1.1E-06		1.7E-05	9.2E-04	1.5E-04	4.4E-05	2.7E-04		
CHEMICAL											(mg/cu m)	(mg/kg)
Arsenic	1.6E-06	3.2E-06	6.6E-07	7.9E-08	2.4E-06	4.1E-05	N/A	1.4E-04	7.0E-05	8.4E-06	1.7E-06	7.8E+00
Benzo(a)anthracene							N/A					
Benzo(a)pyrene							N/A					
Benzo(b)fluoranthene							N/A					
Cadmium (food)	4.9E-07						N/A				1.2E-06	5.4E+00
Chromium	1.2E-05						N/A				4.5E-06	2.0E+01
Chrysene							N/A					
Dibenzo(a,h)anthracene							N/A					
Indeno(1,2,3-cd)pyrene							N/A					
Nickel	4.0E-07						N/A				7.4E-06	3.1E+01
Total - Chemicals	1.5E-05	3.2E-06	6.6E-07	7.9E-08	2.4E-06	4.1E-05		1.4E-04	7.0E-05	8.4E-06		
Grand Total	4.2E-05	3.9E-06	8.6E-07	1.2E-06	2.4E-06	5.8E-05	9.2E-04	2.9E-04	1.1E-04	2.8E-04		

TABLE D.III-2

RESIDUAL HAZARD QUOTIENTS FOR THE ON-PROPERTY RESIDENT FARMER (RME)

Transfer Media >>>>>>>	AIR				SOIL					EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Dermal Contact	Incidental Ingestion	Root Uptake Veg/Fruit Ingestion	Root Uptake Meat Ingestion	Root Uptake Milk Ingestion	Air	Soil
Constituent CHEMICAL										(mg/cu m)	(mg/kg)
Antimony		3.5E-02	5.4E-03	2.2E-03	3.8E-01	2.2E-01	3.6E+00	7.8E-01	3.1E-01	6.6E-06	2.9E+01
Arsenic		6.1E-03	1.3E-03	1.5E-04	4.6E-03	7.8E-02	2.6E-01	1.3E-01	1.6E-02	1.7E-06	7.8E+00
Barium	7.7E-03	3.5E-04	9.4E-06	8.8E-05	9.6E-04	3.3E-03	2.8E-02	1.4E-03	1.3E-02	1.7E-05	7.7E+01
Cadmium (food)		9.0E-03	5.3E-04	3.9E-03	1.7E-02	1.6E-02	1.4E+00	8.6E-02	6.2E-01	1.2E-06	5.4E+00
Chromium		9.1E-04	3.3E-04	3.6E-04	6.5E-02	1.2E-02	3.1E-02	2.0E-02	2.2E-02	4.5E-06	2.0E+01
Molybdenum		8.9E-04	6.1E-04	6.1E-04	2.5E-03	3.6E-03	1.2E-01	9.7E-02	9.7E-02	1.3E-06	6.1E+00
Nickel		1.3E-03	3.1E-04	2.1E-04	6.1E-04	4.6E-03	1.5E-01	3.3E-02	2.2E-02	7.4E-06	3.1E+01
Silver		2.3E-03	8.1E-04	2.1E-02		5.9E-03	3.3E-01	1.2E-01	3.3E+00	2.2E-06	9.8E+00
Thallium		1.6E-03	5.0E-03	9.9E-04	9.4E-03	3.6E-02	7.9E-03	3.4E-01	6.8E-02	1.2E-07	7.1E-01
Uranium		4.0E-03	5.6E-05	6.8E-04	1.9E-01	3.6E-02	8.0E-02	2.3E-03	2.7E-02	1.2E-05	3.6E+01
Vanadium		7.5E-04	1.3E-04	4.1E-06	5.7E-03	1.1E-02	1.8E-02	7.2E-03	2.3E-04	5.6E-06	2.5E+01
Zinc		1.6E-03	8.2E-03	3.3E-03	5.4E-04	5.1E-04	2.6E-01	1.3E+00	5.3E-01	1.2E-05	5.1E+01
Hazard Index	**7.7E-03**	**6.4E-02**	**2.3E-02**	**3.4E-02**	**6.8E-01**	**4.2E-01**	**6.2E+00**	**2.9E+00**	**5.0E+00**		

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TABLE D.III-3

RESIDUAL ILCRs FOR THE ON-PROPERTY RESIDENT FARMER (CT)

Transfer Media >>>>>>>	AIR				SOIL						EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>>>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Dermal Contact	Incidental Ingestion	External Radiation	Root Uptake Veg/Fruit Ingestion	Root Uptake Meat Ingestion	Root Uptake Milk Ingestion	Air	Soil
Constituent												
RADIONUCLIDE											(pCi/cu m)	(pCi/g)
Uranium-238 + 2 dtrs	1.8E-06	1.3E-08	1.9E-10	2.3E-09	N/A	1.2E-07	2.0E-06	3.1E-07	9.1E-09	1.1E-07	4.1E-03	1.4E+01
Radium-226 + 5 dtrs	6.8E-09	3.2E-09	7.3E-11	5.3E-10	N/A	6.5E-08	4.3E-05	6.3E-08	8.4E-09	6.0E-08	2.6E-04	1.8E+00
Lead-210 + 2 dtrs	4.9E-09	1.1E-08	2.5E-10	8.4E-10	N/A	8.9E-07	2.8E-09	5.1E-06	3.0E-07	9.9E-07	1.4E-04	4.5E+00
Radium-228 + 1 dtr	1.8E-09	2.9E-09	4.3E-11	3.1E-10	N/A	3.9E-08	1.5E-05	3.6E-08	4.8E-09	3.5E-08	3.1E-04	1.3E+00
Thorium-228 + 7 dtrs	1.8E-07	1.4E-09	4.4E-13	1.5E-12	N/A	2.1E-08	2.8E-05	1.1E-09	2.7E-11	9.2E-11	2.7E-04	1.3E+00
Strontium + 1 dtr	1.9E-10	8.9E-09	7.6E-10	1.5E-08	N/A	2.0E-08		3.1E-06	3.0E-07	6.0E-06	3.5E-04	1.8E+00
Technetium-99	5.0E-11	7.0E-09	1.2E-08	5.6E-08	N/A	1.4E-09	8.6E-12	1.4E-06	2.3E-06	1.1E-05	6.9E-04	3.6E+00
Total - Radionuclides	**2.0E-06**	**4.7E-08**	**1.3E-08**	**7.5E-08**		**1.2E-06**	**8.8E-05**	**9.9E-06**	**3.0E-06**	**1.8E-05**		
CHEMICAL											(mg/cu m)	(mg/kg)
Arsenic	1.2E-07	2.1E-07	4.4E-08	5.3E-09	7.3E-09	2.3E-06	N/A	8.8E-06	4.7E-06	5.6E-07	1.7E-06	7.8E+00
Benzo(a)anthracene							N/A					
Benzo(a)pyrene							N/A					
Benzo(b)fluoranthene							N/A					
Cadmium (food)	3.7E-08						N/A				1.2E-06	5.4E+00
Chromium	9.0E-07						N/A				4.5E-06	2.0E+01
Chrysene							N/A					
Dibenzo(a,h)anthracene							N/A					
Indeno(1,2,3-cd)pyrene							N/A					
Nickel	3.0E-08						N/A				7.4E-06	3.1E+01
Total - Chemicals	**1.1E-06**	**2.1E-07**	**4.4E-08**	**5.3E-09**	**7.3E-09**	**2.3E-06**		**8.8E-06**	**4.7E-06**	**5.6E-07**		
Grand Total	**3.1E-06**	**2.5E-07**	**5.8E-08**	**8.1E-08**	**7.3E-09**	**3.4E-06**	**8.8E-05**	**1.9E-05**	**7.7E-06**	**1.9E-05**		

TABLE D.III-4

RESIDUAL HAZARD QUOTIENTS FOR THE ON-PROPERTY RESIDENT FARMER (CT)

Transfer Media >>>	AIR				SOIL					EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Dermal Contact	Incidental Ingestion	Root Uptake Veg/Fruit Ingestion	Root Uptake Meat Ingestion	Root Uptake Milk Ingestion	Air	Soil
Constituent CHEMICAL										(mg/cu m)	(mg/kg)
Antimony		1.8E-02	2.8E-03	1.1E-03	9.0E-03	9.4E-02	1.8E+00	4.1E-01	1.6E-01	6.6E-06	2.9E+01
Arsenic		3.0E-03	6.6E-04	7.9E-05	1.1E-04	3.4E-02	1.3E-01	7.0E-02	8.4E-03	1.7E-06	7.8E+00
Barium	4.5E-03	1.8E-04	4.9E-06	4.6E-05	2.3E-05	1.4E-03	1.4E-02	7.1E-04	6.6E-03	1.7E-05	7.7E+01
Cadmium (food)		4.5E-03	2.8E-04	2.0E-03	4.1E-04	7.1E-03	6.8E-01	4.5E-02	3.3E-01	1.2E-06	5.4E+00
Chromium		4.5E-04	1.7E-04	1.9E-04	1.5E-03	5.4E-03	1.5E-02	1.1E-02	1.2E-02	4.5E-06	2.0E+01
Molybdenum		4.5E-04	3.2E-04	3.2E-04	6.0E-05	1.6E-03	6.1E-02	5.1E-02	5.1E-02	1.3E-06	6.1E+00
Nickel		6.4E-04	1.6E-04	1.1E-04	1.4E-05	2.0E-03	7.8E-02	1.7E-02	1.2E-02	7.4E-06	3.1E+01
Silver		1.2E-03	4.2E-04	1.1E-02		2.6E-03	1.6E-01	6.5E-02	1.7E+00	2.2E-06	9.8E+00
Thallium		8.3E-04	2.6E-03	5.2E-04	2.2E-04	1.6E-02	4.0E-03	1.8E-01	3.6E-02	1.2E-07	7.1E-01
Uranium		2.0E-03	2.9E-05	3.5E-04	4.5E-03	1.6E-02	4.0E-02	1.2E-03	1.4E-02	1.2E-05	3.6E+01
Vanadium		3.8E-04	6.8E-05	2.2E-06	1.4E-04	4.7E-03	9.1E-03	3.8E-03	1.2E-04	5.6E-06	2.5E+01
Zinc		7.9E-04	4.3E-03	1.7E-03	1.3E-05	2.2E-04	1.3E-01	6.9E-01	2.8E-01	1.2E-05	5.1E+01
Hazard Index	**4.5E-03**	**3.2E-02**	**1.2E-02**	**1.8E-02**	**1.6E-02**	**1.8E-01**	**3.1E+00**	**1.5E+00**	**2.6E+00**		

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TABLE D.III-5

RESIDUAL ILCRs FOR THE ON-PROPERTY RESIDENT CHILD

Transfer Media >>>>>>>	AIR				SOILS						EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>>>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Dermal Contact	Incidental Ingestion	External Radiation	Root Uptake Veg/Fruit Ingestion	Root Uptake Meat Ingestion	Root Uptake Milk Ingestion	Air	Soil
Constituent												
RADIONUCLIDE											(pCi/cu m)	(pCi/g)
Uranium-238 + 2 dtrs	4.5E-07	1.5E-08	9.4E-11	8.8E-09	N/A	1.7E-07	1.6E-06	3.4E-07	4.5E-09	4.2E-07	4.1E-03	1.4E+01
Radium-226 + 5 dtrs	1.7E-09	3.5E-09	3.6E-11	2.0E-09	N/A	9.1E-08	3.4E-05	6.9E-08	4.1E-09	2.3E-07	2.6E-04	1.8E+00
Lead-210 + 2 dtrs	1.2E-09	1.2E-08	1.2E-10	3.2E-09	N/A	1.2E-06	2.2E-09	5.6E-06	1.5E-07	3.8E-06	1.4E-04	4.5E+00
Radium-228 + 1 dtr	4.4E-10	3.2E-09	2.1E-11	1.2E-09	N/A	5.4E-08	1.2E-05	4.0E-08	2.4E-09	1.3E-07	3.1E-04	1.3E+00
Thorium-228 + 7 dtrs	4.5E-08	1.5E-09	2.2E-13	5.7E-12	N/A	2.9E-08	2.2E-05	1.2E-09	1.3E-11	3.5E-10	2.7E-04	1.3E+00
Strontium + 1 dtr	4.5E-11	9.8E-09	3.7E-10	5.8E-08	N/A	2.7E-08		3.4E-06	1.5E-07	2.3E-05	3.5E-04	1.8E+00
Technetium-99	1.2E-11	7.7E-09	5.9E-09	2.1E-07	N/A	2.0E-09	6.7E-12	1.5E-06	1.2E-06	4.2E-05	6.9E-04	3.6E+00
Total - Radionuclides	4.9E-07	5.2E-08	6.5E-09	2.9E-07		1.6E-06	6.9E-05	1.1E-05	1.5E-06	6.9E-05		
CHEMICAL											(mg/cu m)	(mg/kg)
Arsenic	1.4E-07	1.1E-06	1.0E-07	9.5E-08	3.3E-07	1.5E-05	N/A	4.5E-05	1.1E-05	1.0E-05	1.7E-06	7.8E+00
Benzo(a)anthracene							N/A					
Benzo(a)pyrene							N/A					
Benzo(b)fluoranthene							N/A					
Cadmium (food)	4.2E-08						N/A				1.2E-06	5.4E+00
Chromium	1.0E-06						N/A				4.5E-06	2.0E+01
Chrysene							N/A					
Dibenzo(a,h)anthracene							N/A					
Indeno(1,2,3-cd)pyrene							N/A					
Nickel	3.4E-08						N/A				7.4E-06	3.1E+01
Total - Chemicals	1.2E-06	1.1E-06	1.0E-07	9.5E-08	3.3E-07	1.5E-05		4.5E-05	1.1E-05	1.0E-05		
Grand Total	1.7E-06	1.1E-06	1.1E-07	3.8E-07	3.3E-07	1.7E-05	6.9E-05	5.6E-05	1.2E-05	7.9E-05		

TABLE D.III-6

RESIDUAL HAZARD QUOTIENTS FOR THE ON-PROPERY RESIDENT CHILD

Transfer Media >>>	AIR				SOIL					EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Dermal Contact	Incidental Ingestion	Root Uptake Veg/Fruit Ingestion	Root Uptake Meat Ingestion	Root Uptake Milk Ingestion	Air	Soil
Constituent CHEMICAL										(mg/cu m)	(mg/kg)
Antimony		1.4E-01	9.7E-03	3.0E-02	6.1E-01	9.2E-01	1.4E+01	1.4E+00	4.3E+00	6.6E-06	2.9E+01
Arsenic		2.4E-02	2.3E-03	2.1E-03	7.4E-03	3.3E-01	1.0E+00	2.4E-01	2.2E-01	1.7E-06	7.8E+00
Barium	1.3E-02	1.4E-03	1.7E-05	1.2E-03	1.5E-03	1.4E-02	1.1E-01	2.5E-03	1.8E-01	1.7E-05	7.7E+01
Cadmium (food)		3.5E-02	9.6E-04	5.4E-02	2.8E-02	6.9E-02	5.3E+00	1.5E-01	8.7E+00	1.2E-06	5.4E+00
Chromium		3.5E-03	6.0E-04	5.1E-03	1.0E-01	5.2E-02	1.2E-01	3.6E-02	3.1E-01	4.5E-06	2.0E+01
Molybdenum		3.4E-03	1.1E-03	8.5E-03	4.1E-03	1.5E-02	4.7E-01	1.7E-01	1.4E+00	1.3E-06	6.1E+00
Nickel		3.3E-02	5.6E-04	2.9E-03	9.8E-04	2.0E-02	6.0E-01	6.0E-02	3.1E-01	7.4E-06	3.1E+01
Silver		9.1E-03	1.5E-03	3.0E-01		2.5E-02	1.3E+00	2.2E-01	4.6E+01	2.2E-06	9.8E+00
Thallium		6.4E-03	9.0E-03	1.4E-02	1.5E-02	1.5E-01	3.1E-02	6.1E-01	9.5E-01	1.2E-07	7.1E-01
Uranium		1.6E-02	1.0E-04	9.5E-03	3.1E-01	1.5E-01	3.1E-01	4.1E-03	3.8E-01	1.2E-05	3.6E+01
Vanadium		2.9E-03	2.3E-04	5.8E-05	9.2E-03	4.6E-02	7.0E-02	1.3E-02	3.2E-03	5.6E-06	2.5E+01
Zinc		6.1E-03	1.5E-02	4.6E-02	8.7E-04	2.2E-03	9.9E-01	2.4E+00	7.4E+00	1.2E-05	5.1E+01
Hazard Index	**1.3E-02**	**2.8E-01**	**4.1E-02**	**4.7E-01**	**1.1E+00**	**1.8E+00**	**2.4E+01**	**5.3E+00**	**7.0E+01**		

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TABLE D.III-7

RESIDUAL ILCRs FOR THE OFF-PROPERTY RESIDENT FARMER

Transfer Media >>>>>>>>	AIR				EXPOSURE POINT CONCENTRATION
Exposure Route >>>>>>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Air
Constituent					
RADIONUCLIDE					(pCi/cu m)
Uranium-238 + 2 dtrs	1.9E-06	1.6E-08	2.2E-10	2.6E-09	3.2E-04
Radium-226 + 5 dtrs	6.9E-09	3.8E-09	8.3E-11	6.0E-10	2.0E-05
Lead-210 + 2 dtrs	4.6E-09	1.2E-08	2.6E-10	8.7E-10	1.0E-05
Radium-228 + 1 dtr	1.8E-09	3.4E-09	4.8E-11	3.5E-10	2.3E-05
Thorium-228 + 7 dtrs	1.9E-07	1.6E-09	5.0E-13	1.7E-12	2.1E-05
Strontium + 1 dtr	1.9E-10	1.1E-08	8.8E-10	1.8E-08	2.7E-05
Technetium-99	5.1E-11	8.3E-09	1.4E-08	6.4E-08	5.3E-05
Total Radionuclides	**2.1E-06**	**5.5E-08**	**1.5E-08**	**8.6E-08**	
CHEMICAL					(mg/cu m)
Arsenic	1.3E-07	2.4E-07	5.1E-08	6.1E-09	1.3E-07
Benzo(a)anthracene					
Benzo(a)pyrene					
Benzo(b)fluoranthene					
Cadmium (food)	3.8E-08				9.3E-08
Chromium	9.3E-07				3.4E-07
Chrysene					
Dibenzo(a,h)anthracene					
Indeno(1,2,3-cd)pyrene					
Nickel	3.1E-08				5.7E-07
Total Chemicals	**1.1E-06**	**2.4E-07**	**5.1E-08**	**6.1E-09**	
Grand Total	**3.2E-06**	**3.0E-07**	**6.6E-08**	**9.2E-08**	

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TABLE D.III-8

RESIDUAL HAZARD QUOTIENTS FOR THE OFF-PROPERTY RESIDENT FARMER

Transfer Media >>>>	AIR				EXPOSURE POINT CONCENTRATION
Exposure Route >>>>>>	Inhalation of Air	Deposition on Veg/Fruit Ingestion	Deposition Meat Ingestion	Deposition Milk Ingestion	Air
Constituent CHEMICAL					(mg/cu m)
Antimony		2.7E-03	4.2E-04	1.7E-04	5.0E-07
Arsenic		4.7E-04	9.6E-05	1.2E-05	1.3E-07
Barium	6.0E-04	2.7E-05	7.2E-07	6.7E-06	1.3E-06
Cadmium (food)		6.9E-04	4.1E-05	3.0E-04	9.3E-08
Chromium		6.9E-05	2.5E-05	2.8E-05	3.4E-07
Molybdenum		6.7E-05	4.6E-05	4.6E-05	9.7E-08
Nickel		9.8E-05	2.4E-05	1.6E-05	5.7E-07
Silver		1.8E-04	6.2E-05	1.6E-03	1.7E-07
Thallium		1.3E-04	3.8E-04	7.6E-05	9.0E-09
Uranium		4.0E-03	5.6E-05	6.8E-04	1.2E-05
Vanadium		5.8E-05	9.9E-06	3.2E-07	4.3E-07
Zinc		1.2E-04	6.3E-04	2.5E-04	8.9E-07
Hazard Index	**6.0E-04**	**8.7E-03**	**1.8E-03**	**3.2E-03**	

TABLE D.III-9

RESIDUAL ILCRs FOR THE TRESPASSING CHILD

Transfer Media >>>>>>>	AIR	SOILS			EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>>>>>	Inhalation of Air	Dermal Contact	Incidental Ingestion	External Radiation	Air	Soil
Constituent						
RADIONUCLIDE						
					(pCi/cu m)	(pCi/g)
Uranium-238 + 2 dtrs	4.4E-07	N/A	6.2E-09	1.5E-07	4.1E-03	1.4E+01
Radium-226 + 5 dtrs	1.6E-09	N/A	3.4E-09	3.1E-06	2.6E-04	1.8E+00
Radium-228 + 1 dtr	4.4E-10	N/A	2.0E-09	1.1E-06	3.1E-04	1.3E+00
Thorium-228 + 7 dtrs	4.4E-08	N/A	1.1E-09	2.0E-06	2.7E-04	1.3E+00
Strontium + 1 dtr	4.5E-11	N/A	1.0E-09		3.5E-04	1.8E+00
Technetium-99	1.2E-11	N/A	7.3E-11	6.2E-13	6.9E-04	3.6E+00
Total Radionuclides	**4.9E-07**		**6.0E-08**	**6.3E-06**		
CHEMICAL					(mg/cu m)	(mg/kg)
Arsenic	4.8E-08	7.2E-08	1.9E-07	N/A	1.7E-06	7.8E+00
Benzo(a)anthracene				N/A		
Benzo(a)pyrene				N/A		
Benzo(b)fluoranthene				N/A		
Cadmium (food)	1.4E-08				1.2E-06	5.4E+00
Chromium	3.5E-07				4.5E-06	2.0E+01
Chrysene				N/A		
Dibenzo(a,h)anthracene				N/A		
Indeno(1,2,3-cd)pyrene				N/A		
Nickel	1.2E-08				7.4E-06	3.1E+01
Total Chemicals	**4.3E-07**	**7.2E-08**	**1.9E-07**			
Grand Total	**9.1E-07**	**7.2E-08**	**2.5E-07**	**6.3E-06**		

TABLE D.III-10

RESIDUAL HAZARD QUOTIENTS FOR THE TRESPASSING CHILD

Transfer Media >>>	AIR	SOIL		EXPOSURE POINT CONCENTRATION	
Exposure Route >>>>>	Inhalation of Air	Dermal Contact	Incidental Ingestion	Air	Soil
Constituent					
CHEMICAL				(mg/cu m)	(mg/kg)
Antimony		6.6E-02	5.9E-03	6.6E-06	2.9E+01
Arsenic		3.8E-04	2.1E-03	1.7E-06	7.8E+00
Barium	1.3E-03	1.7E-04	9.1E-05	1.7E-05	7.7E+01
Cadmium (food)		1.5E-02	4.5E-04	1.2E-06	5.4E+00
Chromium		1.1E-02	3.4E-04	4.5E-06	2.0E+01
Molybdenum		4.4E-04	1.0E-04	1.3E-06	6.1E+00
Nickel		1.4E-03	1.3E-04	7.4E-06	3.1E+01
Silver			1.6E-04	2.2E-06	9.8E+00
Thallium		1.6E-03	9.8E-04	1.2E-07	7.1E-01
Uranium		3.3E-02	9.9E-04	1.2E-05	3.6E+01
Vanadium		1.0E-03	3.0E-04	5.6E-06	2.5E+01
Zinc		9.7E-05	1.4E-05	1.2E-05	5.1E+01
Hazard Index	**1.3E-03**	**1.3E-01**	**1.2E-02**		

TABLE D.III-11
Derivation of Residual ILCR and HI for the Expanded Trespasser

Constituent	Residual Soil Concentration (a)	ILCR per Unit Soil Concentration (b)	Residual ILCR
CARCINOGENS			
Radionuclides (pCi/g)			
Uranium-238 + 2 dtrs	1.4E+01	1.7E-08	2.3E-07
Radium-226 + 5 dtrs	1.8E+00	5.6E-07	1.0E-06
Lead-210 + 2 dtrs	4.5E+00	1.3E-08	5.8E-08
Radium-228 + 1 dtrs	1.3E+00	5.0E-07	6.5E-07
Thorium-228 + 7 dtr	1.3E+00	5.0E-07	6.5E-07
Strontium-90 + 1 dtr	1.8E+00	7.0E-10	1.3E-09
Technetium-99	3.6E+00	2.6E-11	9.3E-11
Total Radionuclides			**2.6E-06**
CHEMICAL (mg/Kg)			
Arsenic	7.8E+00	4.3E-08	3.4E-07
Cadmium	5.4E+00	4.3E-11	2.3E-10
Chromium	2.0E+01	2.3E-10	4.7E-09
Nickel	3.1E+01	4.8E-12	1.5E-10
Total Chemicals			**3.4E-07**
TOTAL ILCR			**2.9E-06**

TOXICANTS (mg/Kg)		HI per Unit Soil Concentration	Residual HI
Antimony	2.9E+01	6.0E-03	1.8E-01
Arsenic	7.8E+00	3.3E-04	2.6E-03
Barium	7.7E+01	1.7E-05	1.3E-03
Cadmium	5.4E+00	6.5E-03	3.5E-02
Chromium	2.0E+01	1.5E-04	3.1E-03
Molybdenum	6.1E+00	1.8E-04	1.1E-03
Nickel	3.1E+01	2.0E-05	6.3E-04
Silver	9.8E+00	1.3E-03	1.3E-02
Thallium	7.1E-01	5.4E-03	3.9E-03
Uranium	3.6E+01	1.4E-03	4.9E-02
Vanadium	2.5E+01	9.7E-05	2.5E-03
Zinc	5.1E+01	1.7E-05	8.6E-04
TOTAL HI			**2.9E-01**

a - Residual exposure point concentration values are baseline UCL of the arithmetic mean for detected concentrations, with the exception of radium-226, where the residual concentration is equal to the proposed remediation level.

b - Values for ILCR and HI per unit soil concentration are derived by dividing the target ILCR and HI levels, 1E-06 and 0.2 respectively, by the proposed remediation goal (PRG) soil concentrations presented in Table 2-6 of the FS.

APPENDIX E

DETAILED COST ESTIMATES

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LIST OF ACRONYMS

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CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
cm	centimeter
DOT	U.S. Department of Transportation
EPA	U.S. Environmental Protection Agency
ft	feet
ft^2	square feet
ft^3	cubic feet
HEPA	High Efficiency Particulate Air
in.	inch
kg	kilogram
km	Kilometer
lb	pound
m	meter
m^3	cubic meters
mi	mile
min.	minute
NTS	Nevada Test Site
O&M	operation and maintenance
RTS	radon treatment system
yd^3	cubic yard

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E.1.0 INTRODUCTION

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Cost estimates are used in the feasibility study process under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to eliminate those remediation alternatives which are significantly more expensive than competing alternatives but do not offer commensurate performance or health protectiveness. These estimates are required to be order-of-magnitude level accuracy, as defined by the American Association of Cost Engineers.

The cost estimates were based on a variety of cost-estimating data such as cost curves, generic unit costs, vendor information, conventional cost-estimating guides, commercial remedial costs, and previous similar estimates as modified by site-specific information. The categories of costs considered were (1) capital cost and (2) operation and maintenance (O&M) cost. The capital cost includes the cost of constructing remediation and disposal facilities, and purchasing equipment. Cost estimates were prepared to aid in the evaluation of alternatives using information currently available. The cost estimates presented are order-of-magnitude estimates with an intended accuracy range of -30 percent to +50 percent. Estimates are considered to be order-of-magnitude because of the uncertainties in the information used to develop the alternatives. Final costs will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final scope, final schedule, final engineering design, and other variables. As a result, final costs will vary from the estimates presented here. Because of these factors, funding needs should be carefully reviewed before specific financial decisions are made or final remedial action budgets are established.

O&M costs included are those incurred during the remediation and following remediation (post-remediation). Only the in situ and on-property disposal alternatives, alternatives requiring the long-term maintenance and monitoring of a multimedia cap or a disposal facility, will incur post-remediation costs. A present worth analysis was conducted for all of the alternatives so that alternatives with costs incurred over differing time periods could be compared on an equivalent basis. A discount rate of seven percent was used in the present worth analysis.

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E.2.0 ORGANIZATION

The cost estimates for each alternative provided at the end of this section consist of the following:

- Alternative cost summary sheet
  - capital costs of alternative (per component)
  - O&M costs (during remediation and post-remediation)
  - present worth cost of the alternative
- Estimating services summary sheet (per component, where applicable)
  - summary of direct costs of component and related indirect costs
- Direct capital cost details sheet (per component)
  - detailed equipment and services
- O&M (during remediation) sheet (where applicable)

The cost estimates were sequentially arranged by subunit and alternative. For those more complex alternatives, i.e., those that require significant construction, removal, treatment, and disposal activities (Alternatives 2A through 6A and 2B through 4B), the major capital activities or components have been costed separately. The sum of these component capital costs is the total capital cost of the alternative. This "component" approach to the cost estimates allows the direct comparison of costs of significant aspects of similar alternatives. The remaining less complex alternatives (Alternatives 1A, 1B, and Subunit C alternatives) use one detailed capital cost estimate for the entire alternative. Alternatives 1A, 1B, 1C, and 2C are also supported by an O&M cost estimate. There are no post-remediation O&M costs associated with Alternatives 3C.1, 3C.2, and 3C.3.

The eleven major components of the cost estimates include:

1) Site preparation
2) Waste processing facility
3) Waste removal (hydraulic or pneumatic)
4) Waste treatment equipment (vitrification or cement stabilization)
5) Disposal vault (on property)
6) Packaging
7) Transportation and disposal
8) Demolition and removal
9) Decontamination and decommissioning
10) O&M during remediation
11) Post-remediation O&M

Items 1 through 4 above are supported by a direct cost estimate, which details the equipment and services required to construct that component and a component summary estimate, which shows the indirect costs and the total cost of that component of the alternative. Item 5 is a scaled cost and is listed on the alternative cost summary sheet only. Item 6 is listed on the alternative cost summary sheet only showing direct, indirect, and total cost and is based on a unit cost. Item 7 is listed on the alternative cost summary sheet as a single line item and a subcontracted cost; there are no indirect costs associated with this item. Items 8 and 9 are presented on the estimating services summary sheet only, showing the direct, indirect, and total cost. Item 10 is supported by the O&M cost sheet. Item 11 is a scaled cost for the on-property disposal facilities and, therefore, is shown only on the alternative cost summary sheet.

E.3.0 COST COMPONENTS

E.3.1 CAPITAL COSTS

Capital costs are those expenditures required to initiate and install a remedial action. They do not include those costs required to operate and maintain the remedial action. Capital costs consist of direct and indirect costs. Direct costs are those expenditures necessary for the installation of the remedial action. These include equipment, labor, and materials. Indirect costs include expenditures for engineering, financial, supervision, and other services necessary to carry out a remedial action.

E.3.1.1 Direct Costs

Direct costs include the following:

- Remedial action construction - These costs include the installation of structural grout (Alternatives 1A and 1B), the construction of caps and slurry walls (Alternatives 1A, 1B, and 1C), the installation of leachate collection/detection systems (Alternatives 1A and 1B), the construction of on-property disposal facilities (Alternatives 2A, 4A, 6A, 2B, 4B and 2C), the installation of monitoring wells (Alternatives 1A, 2A, 4A, 6A, 1B, 2B, 4B, 1C, and 2C), the demolition of silos and excavation/removal of soils and debris (Alternatives 1C, 2C, and 3C), and decontamination and decommissioning activities (Alternatives 1C, 2C, and 3C).

  The cost for the multimedia cap for Alternative 1C was scaled from the detailed costs for the cap in Alternative 1A.

- Component equipment - These costs include the purchase and/or installation of radon treatment system (RTS) equipment (all Subunits A and B alternatives), silo demolition and decontamination equipment (all Subunit C alternatives), silo material removal and treatment equipment (Alternatives 2A through 6A and 2B through 4B), and monitoring equipment.

- Site preparation - These costs include the clearing and grading of the site for preparation of construction activities or remediation activities. Also included are access and remediation site road construction, fencing and site lighting, equipment staging areas, and electrical and water utilities.

- Remediation facilities - These costs include the construction of those buildings or facilities required for the implementation of the remedial action. Covered in this category are the new RTS building (Alternatives 2A through 5A and 2B through 3B), material treatment/packaging facilities (Alternatives 2A through 6A and 2B through 4B), and the silo structures decontamination/removal (All Subunit C alternatives).

  The cost for the on-property disposal facilities were scaled from the cost for the site-wide engineered waste management facility. As a result, there are no detailed costs for the individual disposal facilities for each alternative. These scaled capital costs appear as a single line item on the alternative cost summary sheet for each alternative, as applicable.

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- Packing - This includes the cost of purchasing the containers and the labor associated with handling, filling, and documentation.

- Transportation and disposal - These include the costs for transporting the treated material and treatment residuals to an off-property disposal facility and the costs for disposing the material at an existing disposal facility or the construction of a disposal facility at an off-site location. These costs do not include those costs for the construction of an on-property disposal facility. These costs are included under remedial action construction.

E.3.1.2 Indirect Costs

Indirect costs are those costs required to support the design, construction, and management of the installation of the remedial action. Costs incurred to support the construction activities include those required for the purchase of small tools and consumable items (welding machines, welding rods, grinding wheels, etc.,); the use of temporary facilities and utilities during the construction phase only; initial safety training and ongoing safety meetings; health physics support during construction; the general contractor's markup, overhead, and profit; and the payroll burden and benefits of the construction force. The payroll burden and benefits include health insurance, unemployment benefits, Social Security, and workmen's compensation insurance. Additional indirect costs are those incurred in the engineering, design, and management of the construction and installation of the remedial action.

Sales tax, risk budget, and contingency are added as a percentage of the overall costs of the remedial action alternative. A sales tax of six percent has been applied to all capital equipment purchases and services. Although sales tax is not typically applicable to CERCLA remediation activities, the State of Ohio requires that sales tax be charged on all equipment purchased. The risk budget was used to account for the uncertainties in the actual cost values to cover a statistical probability of a -30 percent to +50 percent accuracy range. A risk budget of 11 percent was assumed. Contingency is included to cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties. The amount of contingency is dependent on the status of design, procurement, and construction, and the complexity and uncertainties of the component parts of the project. A contingency of 20 percent, which is appropriate per U.S. Environmental Protection Agency (EPA) guidance (EPA 1988), has been added to account for unforeseen circumstances which may result in additional costs. Escalation, which would account for the increase in labor and material costs during the construction period, was not considered in the present worth analysis per EPA's costing guidance manual.

E.3.2 Operation and Maintenance Costs

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E.3.2.1 Operation and Maintenance Costs During Remediation

O&M costs during remediation (also referred to as short-term O&M costs) are those post-construction/installation costs necessary to ensure the continued effectiveness of a remedial action. Costs are those incurred during the remedial action (e.g., material removal, treatment, and disposal activities). The components of these costs are:

- Operations and maintenance labor - These costs include all wages, salaries, training, overhead, and fringe benefits associated with the labor needed for operations and maintenance during and after the remedial action. Craft labor rates were used for these estimates.

- Materials and energy - These costs include such items as treatment chemicals or additives, process water, and electricity.

- Purchased services - These include professional services such as sampling and analytical costs. These have been costed for the post-remediation O&M component for all in situ and on-property disposal alternatives.

E.3.2.2 Post-Remediation Operation and Maintenance Costs

Costs incurred following the implementation of the remedial action are considered post-remediation or long-term O&M costs. Only those alternatives that leave the material in situ or dispose of it on property will incur these costs. Post-remediation costs include maintenance and repair of the disposal facility or multimedia cap, media sampling and analysis (i.e., air, surface water, groundwater, and leachate), and maintenance and repair of groundwater monitoring wells. Long-term O&M costs would be conducted until FEMP site-wide remedial action objectives are attained. For cost purposes, the duration of these costs was considered to be 30 years following the completion of the implementation of the remedial action. The components of these costs are identical to those described for O&M during remediation.

The post-remediation costs for Alternatives 1A and 1B are based on the specific design and size of the multimedia caps used for these alternatives. The post-remediation cost for Alternative 1C was scaled from the Alternatives 1A and 1B costs and is reported on the alternative cost summary sheet only. The costs for the on-property disposal facilities were scaled from the site-wide engineered waste management facility costs and are reported on the alternative cost summary sheet only.

E.4.0 BASIS OF ESTIMATE

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The basis of estimate for each cost component defined in Section E.3.0 is provided in this section. There are no costs associated with any of the no-action alternatives (Alternatives 0A, 0B, and 0C).

E.4.1 SITE PREPARATION

Site preparation is applicable to all Subunits A and B alternatives, except for the no-action alternatives and in situ containment alternatives. Site preparation includes clearing and grubbing vegetated areas required for the material processing area, the packaging pad for the removed berm material, the material slurry transfer trench, utilities, and the roads and equipment staging areas. The basis of estimate includes the following assumptions:

- Areas provided in Table E.4-1 would be cleared and grubbed.
- Filling would be performed where necessary. The volume of fill was estimated to be 11,500 cubic meters (m^3) [15,000 cubic yards (yd^3)]. It was assumed that this soil could be obtained from excess on-site soil.
- New fencing would be added across the southern end of the remediation area, around the interim storage area, and between the proposed parking area and the equipment staging area. Fencing would be a 2-meter (m) [7-foot (ft)] high, barbed wire topped chain link fence. Approximately 550 linear m (1,800 ft) would be required. It is assumed that seven gates would be required, each 4.6 m (15 ft) wide and 2 m (7 ft) high, and topped with barbed wire.
- An equipment staging area would be added to the north end of the remediation site. This area would consist of 15 centimeters (cm) [6 inches (in.)] of crushed stone (1 in. maximum diameter) applied over an area 45 m (150 ft) by 60 m (200 ft) [2700 square meters (m^2)] [30,000 square feet (ft^2)].
- Approximately 450 m (1,500 ft) of 6 m (20 ft) wide roads would be constructed in the remediation area. The roads would be constructed of 15 cm (6 in.) deep crushed stone 2.5 cm (1 in.) maximum diameter.
- Approximately 6500 m^2 (70,000 ft^2) of seed and mulch would be used in the remediation area.
- Three 18 m (60 ft) double width trailers would be provided to house personnel decontamination and dress-out activities, administrative activities, and health physics activities.
- Twenty security lights containing 200-watt neon vapor lamps would be mounted throughout the remediation area on 9 m (30 ft) high poles. Approximately 1800 m (6,000 ft) of 12-gauge wire would be required for these lights.
- Six transformers would be provided.

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TABLE E.4–1

ALTERNATIVE MATERIAL VOLUMES AND DISPOSAL QUANTITY ESTIMATES

Alternative	Material Volume: Untreated Waste yd³ (m³)	Material Volume: D & D/ Soil Material[a] yd³ (m³)	Volume Increase(+) or Reduction(–) Due to Treatment: Range	Volume Increase(+) or Reduction(–) Due to Treatment: % Used for Calcs	Disposal Quantity: Final Volume yd³ (m³) ft³	No. of Packages [43 ft³/pkg]	Disposal Vault Data: Volume Req'd (ft³) [64 ft³/pkg]	Disposal Vault Data: No. of Cells [120000 ft³/cell]	Disposal Vault Data: Footprint (ft²) [7500 ft²/cell]	Disposal Vault Data: Vault Area ha (acres)	Overall Impacted Area[b] ha (acres)
SUBUNIT A											
1A	8890 (6790)	0	0	0	8890 (6790) 240030	N/A	N/A	N/A	N/A	4 (10)[c]	5 (12.4)
2A/Vit	8890 (6790)	0	–50.3 to 68	–59	3645 (2770) 98415	2412 [d]	154368	2	15000	2.8 (6.9)	4.3 (10.6)
2A/Cem	8890 (6790)	0	+136 to 216	+169	23903 (18166) 645380	15009	960576	8	60000	4.3 (10.6)	5.8 (14.3)
3A.1/Vit	8890 (6790)	0	–50.3 to 68	–59	3645 (2770) 98415	2412 [d]	154368	2	15000	N/A	1.5 (3)
3A.1/Cem	8890 (6790)	0	+136 to 216	+169	23903 (18166) 645380	15009	960576	8	60000	N/A	1.5 (3)
3A.2/Vit	8890 (6790)	0	–50.3 to 68	–59	3645 (2770) 98415	2412 [d]	154368	2	15000	N/A	1.5 (3)
3A.2/Cem	8890 (6790)	0	+136 to 216	+169	23903 (18166) 645380	15009	960576	8	60000	N/A	1.5 (3)
4A/Vit	8890 (6790)	0	---	+14[e]	10153 (7716) 274147	6404 [d]	409856	4	30000	3.3 (8.2)	4.8 (11.9)
4A/Cem	8890 (6790)	0	---	+121[f]	19663 (14944) 530894	12348	790272	7	52500	4 (10)	5.5 (12.8)
5A.1/Vit	8890 (6790)	0	---	+14[e]	10153 (7716) 274147	6404 [d]	409856	4	30000	N/A	1.5 (3)
5A.1/Cem	8890 (6790)	0	---	+121[f]	19663 (14944) 530894	12348	790272	7	52500	N/A	1.5 (3)
5A.2/Vit	8890 (6790)	0	---	+14[e]	10153 (7716) 274147	6404 [d]	409856	4	30000	N/A	1.5 (3)
5A.2/Cem	8890 (6790)	0	---	+121[f]	19663 (14944) 530894	12348	790272	7	52500	N/A	1.5 (3)
6A	8890 (6790)	0	0	0	8890 (6790) 240030	5582	357248	3	22500	3 (7.5)	4.5 (11.1)
SUBUNIT B											
1B	5088 (3890)	0	0	0	5088 (3890) 137366	N/A	N/A	N/A	N/A	2 (5)[c]	3 (7.5)
2B/Vit	5088 (3890)	0	–50.3 to 68	–62	1935 (1471) 52245	1282 [d]	82048	1	7500	2.4 (6)	3.9 (9)
2B/Cem	5088 (3890)	0	+50 to 63	+55	7894 (5999) 213142	4957	317248	3	22500	3 (7.5)	4.5 (11.1)
3B.1/Vit	5088 (3890)	0	–50.3 to 68	–62	1935 (1471) 52245	1282 [d]	82048	1	7500	N/A	1.5 (3)
3B.1/Cem	5088 (3890)	0	+50 to 63	+55	7894 (5999) 213142	4957	317248	3	22500	N/A	1.5 (3)
3B.2/Vit	5088 (3890)	0	–50.3 to 68	–62	1935 (1471) 52245	1282 [d]	82048	1	7500	N/A	1.5 (3)
3B.2/Cem	5088 (3890)	0	+50 to 63	+55	7894 (5999) 213142	4957	317248	3	22500	N/A	1.5 (3)
4B	5088 (3890)	0	0	0	5088 (3890) 137366	3195	204480	2	15000	2.8 (6.9)	4.3 (10.6)
SUBUNIT C											
1C	0	32214 (24634)	N/A	N/A	32214 (24634) 869778	N/A	N/A	N/A	N/A	4 (10)[c]	5 (12.4)
2C	0	32214 (24634)	N/A	N/A	32214 (24634) 869778	N/A	N/A	11	82500	4.7 (11.6)	5.7 (14.1)
3C.1	0	32214 (24634)	N/A	N/A	32214 (24634) 869778	26215 [g]	1677760	N/A	N/A	N/A	1 (2)
3C.2	0	32214 (24634)	N/A	N/A	32214 (24634) 869778	N/A	N/A	N/A	N/A	N/A	1 (2)
3C.3	0	32214 (24634)	N/A	N/A	32214 (24634) 869778	N/A	N/A	N/A	N/A	N/A	1 (2)

Notes:

All D&D/Soil material is included in Subunit C and consists of 793 cy Silos 1,2,3,4 material; 29 cy drum handling building pad and sump lift concrete; 365 cy decant sump tank, process piping and trenches, and RTS; 10,537 cy berm soil; 4,444 cy surface soil; 14,646 cy subsoil; and 1,400 cy waste processing and platform material.

[b] Overall impacted area consists of vault area (if applicable) plus 0.5 ha for staging area and 0.5 ha for administrative facilities (for all alternatives), plus 0.5 ha for waste processing facilities (for Alternatives 2A–5A and 2B–3B only).

[c] Spatial requirements of multimedia cap rather than of a vault provided for Alternatives 1A, 1B, and 1C.

[d] Number of packages based on package weight of 7,260 lb, assuming material density of 178 lb/cf, rather than on volume noted.

[e] Resultant volume increase due to the combination of chemical extraction followed by vitrification of the high activity component. Material consists of 444 cy of vitrified high activity waste and 9710 cy of low activity material.

[f] Resultant volume increase due to the combination of chemical extraction followed by cement stabilization of the high–activity component. Material consists of 9952 cy of cement stabilized high activity waste and 9710 cy of low activity material.

[g] Number of packages based on package weight of 7,260 lb, assuming an average density of 245 lb/cf for the decant sump tank, process piping and trenches, and RTS. Packages based on volume for the other Subunit C materials.

- Buried water lines would be provided at the site. It was assumed that approximately 90 m (320 ft) of 4 cm (1.5 in.) diameter and 30 m (100 ft) of 5 cm (2 in.) diameter carbon steel piping would be installed.

- Buried sewer piping [90 m (300 ft) of 10 cm (4 in.) diameter concrete piping] would be installed.

- An electric steam boiler would be provided, rated at 141,500 british thermal units per hour, 150 pounds per hour, and 30 pounds per square inch (gauge) pressure.

E.4.2 WASTE PROCESSING

Waste processing costs are applicable to Alternatives 2A through 6A and 2B through 4B. For Alternatives 2A through 5A and 2B through 4B, components of the waste processing cost include construction of the waste processing facility, the process area general ventilation system, and the new RTS. Costs were estimated for the latter alternatives based on the following assumptions:

- The waste processing facility would be a modified two-story pre-engineered building built on slab. The first floor would provide approximately 1350 m^2 (14,400 ft^2) and the second floor would have 50 m^2 (500 ft^2). The waste facility would be fully insulated and would have a 10-year design life span.

- The walls of the processing rooms and the storage room would be shielded with 61-cm (24-in.) thick concrete.

- Approximate dimensions of the various areas of the building were estimated to be as follows: processing area--820 m^2 (8,800 ft^2), administrative/personnel area--300 m^2 (3,200 ft^2), miscellaneous equipment area--450 m^2 (4,800 ft^2), and storage area--220 m^2 (2,400 ft^2).

- The ventilation system for the general process area would operate continuously and would either recirculate or exhaust to the atmosphere. This system would not be designed to remove radon.

- The general process area ventilation would provide seven air changes per hour. The system would include a 1135 cubic meters per minute (m^3/min) [40,000 cubic feet per minute (cfm)] blower and High Efficiency Particulate Air (HEPA) filter, and 91 m (300 ft) of 1.5 m (60 in.) diameter ductwork with dampers and fittings. A second redundant train would be installed.

- A separate ventilation train would be used in the event radon is detected in the process area. The general process area ventilation system would shut down if radon is detected in the general process area.

- The RTS for process air would consist of a 30 m^3/min (1,000 cfm) blower, a calcium sulfate media dehumidification vessel, a carbon adsorption canister, a HEPA filter, and approximately 61 m (200 ft) of 25 cm (10 in.) diameter ductwork (with dampers and fittings). This system would be rated for 30 m^3/min (1,000 cfm), and the system would exhaust to atmosphere. A second redundant train would be installed.

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- For Subunits A and B alternatives with off-site disposal (Alternatives 3A.1, 3A.2, 4A, 5A.1, 5A.2, 3B.1 and 3B.2), a 1350-m^2 (15,000-ft^2) temporary staging and storage facility would be provided to facilitate coordination of production from the treatment facility and off-site transportation and disposal.

For Alternatives 6A and 4B, costs of the waste processing facility were based on the following assumptions:

- The waste processing facility would be a one-story pre-engineered building [1350 m^2 (15,000 ft^2)].
- The walls of the processing room would be shielded with 61-cm (24-in.) thick concrete.
- The ventilation system for the general process area would operate continuously and would either recirculate or exhaust to the atmosphere. This system would not be designed to remove radon.
- The general process area ventilation would be as previously described.
- For Alternative 6A only, a horizontal belt filter for sludge dewatering would be provided.

E.4.3 VITRIFICATION

Vitrification is a component of Alternatives 2A/Vit, 3A.1/Vit, 3A.2/Vit, 4A/Vit, 5A.1/Vit, 5A.2/Vit, 2B/Vit, 3B.1/Vit, and 3B.2/Vit. This cost item includes the cost of the vitrification equipment, RTS, and off-gas system, and is estimated based on the following:

- The vitrification equipment would operate 24 hours per day and would be designed to treat 11,800 kilograms per day (kg/day) (13 tons/day) of waste material.
- Vitrification equipment includes a horizontal belt filter for sludge dewatering (for Subunit A alternatives only), filtrate recycle tank, surge tank, sodium carbonate and carbon storage/feed facilities, process piping, pumps, mixers, and a joule-heated melter.
- The off-gas treatment system would be rated at 4 m^3/min (150 cfm). It would consist of blowers, scrubbers, carbon absorbers, and HEPA filters.
- A RTS for the headspace for Silos 1 and 2 and the decant sump would be provided.
- The RTSs would each be rated at 40 m^3/min (1,500 cfm). Each would consist of a blower, carbon absorbers, and driers.

E.4.4 HYDRAULIC REMOVAL/TRANSFER SYSTEM

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This cost component is applicable to Alternatives 2A through 6A and includes the support superstructure and work platform, rail trolleys, an enclosure for the hydraulic equipment, a concrete material transfer pit, a RTS and building for the silo structures, and the hydraulic removal equipment. Assumptions used for the cost estimate include:

- The work platform would be a rail-mounted, 54-m (180-ft) structure truss that would span the silos.
- A 2.4 m (8 ft) wide by 2.4 m (8 ft) long by 9 m (30 ft) high, 1.3 cm (0.5 in.) thick plexiglass enclosure would be provided for the drive unit of the hydraulic removal equipment.
- The silo RTS would be as described for the vitrification system RTS for the silo headspace. The RTS equipment building would be 6 m (20 ft) long by 9 m (30 ft) wide by 3 m (10 ft) high, with 0.3 m (1 ft) thick concrete walls.
- The hydraulic removal equipment would consist of a slurry pump.
- A 60 m (200 ft) long, below-grade concrete pit with a removable concrete lid would be constructed between the silo and the waste processing facility. This pit would contain the double-walled material transfer piping and serve as a secondary containment for the piping.

E.4.5 DISPOSAL VAULT

A disposal vault is a component of Alternatives 2A, 4A, 6A, 2B, 4B, and 2C. The vault design for Subunits A and B alternatives is the same, but the vault design for Alternative 2C does not include radon or intruder barriers. The cost of the disposal vault was estimated as follows:

- Cost for the on-property, above-grade disposal vault was estimated at a unit cost of \$939/m^3 (\$718/yd^3) for Subunits A and B vaults, and a unit cost of \$751/m^3 (\$574/yd^3) for the Subunit C vault.
- The unit cost was based on a conceptual design for a vault consisting of individual modular cells, each capable of holding 3400 m^3 [(120,000 cubic feet (ft^3)] of material. As additional disposal volume space is required, additional modular cells would be added. For cost estimating purposes, cell numbers were estimated by rounding up to the nearest whole number.
- The size of the disposal vault was based on the number of packages noted in Table E.4-1, assuming each package occupies 2 m^3 (64 ft^3) of space. The number of cells that would be required, vault footprint, and cover area were estimated assuming a cell size of 3400 m^3 (120,000 ft^3), and are provided in Table E.4-1.
- The design of the vault includes a multimedia cap, liner, intruder barrier (Subunits A and B only), and leachate collection/detection system.

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E.4.6 PACKAGING

Packaging is a component of Alternatives 2A through 6A, and 2B through 6B. Packaging cost includes the cost of purchasing the containers and the labor associated with handling, filling, and documentation. Estimated cost is based on the following:

- Packages would be U.S. Department of Transportation (DOT) specification 7A-Type A containers with exterior dimensions of 1.2 m (4 ft) wide by 1.2 m (4 ft) long by 1.2 m (4 ft) depth. Interior dimensions would be 1.1 m (3.5 ft) width by 1.1 m (3.5 ft) length by 1.1 m (3.5 ft) depth, providing 1.2 m^3 (43 ft^3) of storage per package.

- The number of packages for alternatives that include vitrification were based on a maximum package weight of 3300 kg [7260 pounds (lb)], assuming a material density of 105 kg/m^3 (178 lb/ft^3).

- The number of packages for alternatives that include cement stabilization were based on a maximum package volume of 1.2 m^3 (43 ft^3).

- Total volume that would be packaged was based on the volume of material provided in Table E.4-1. Final packaging volume was estimated assuming the volume reduction (for vitrification alternatives) or volume increase (for cement stabilization alternatives) noted in Table E.4-1.

- Total packaging cost was estimated assuming the number of containers indicated on Table E.4-1.

- A unit cost of $955 per container was determined based on a material cost of $650 per unit and a labor cost of 16 man-hours per unit for handling, filling, and documentation.

E.4.7 CEMENT STABILIZATION

Cement Stabilization is a component of Alternatives 2A/Cem, 3A.1/Cem, 3A.2/Cem, 4A/Cem, 5A.1/Cem, 5A.2/Cem, 2B/Cem, 3B.1/Cem, and 3B.2/Cem. This cost item includes the cost of the cement stabilization equipment and was based on the following:

- The cement stabilization equipment would operate 24 hours/day and would be designed to treat 11,800 kg/day (13 tons/day) of residue.

- Cement stabilization equipment includes a surge tank, screw feeder, stabilization mixers, flyash, cement, and blast furnace slag storage/feed facilities, process piping, pumps, and mixers.

E.4.8 TRANSPORTATION

Transportation is a component of Alternatives 3A.1, 3A.2, 4A, 5A.1, 5A.2, 3B.1, 3B.2, 3C.1, 3C.2, and 3C.3. This cost item includes transportation of the packaged material and is based on the following assumptions:

- For alternatives that include disposal at the Nevada Test Site (NTS) (Alternatives 3A.1, 4A, 5A.1, 3B.1, and 3C.1), packages would be transported by rail to within approximately 500 kilometers (km) [300 miles (mi)] of the disposal facility and then transported by truck the remainder of the distance.

- For alternatives that include disposal at the permitted commercial disposal site (Alternative 3C.3), packages would be transported by rail to the facility.

- For alternatives that include disposal at the new facility within approximately 500 km (300 mi) from the FEMP site (Alternatives 3A.2, 5A.2, 3B.2, and 3C.2), packages would be transported by truck to the facility.

- Rail costs were estimated using a unit rate of $2.47 per railcar per km ($3.97 per railcar per mi). Railcars were assumed to weigh 8165 kg (180,000 lb) each.

- Truck costs were estimated using a unit rate of $0.24 per lb [for the total 500 km (300 mi) trip].

E.4.9 DISPOSAL

Alternatives 3A.1, 5A.1, 3B.1, and 3C.1 include disposal at NTS, and Alternatives 3A.2, 5A.2, 3B.2, and 3C.2 include disposal at a permitted commercial disposal facility. Costs were estimated based on the following:

- Disposal costs for packaged material that would be disposed at NTS were estimated assuming a unit disposal cost of $353/m^3 ($10/ft^3).

- Disposal costs for material that would be disposed at a permitted commercial facility were estimated assuming a unit disposal cost of $1200/m^3 ($34/ft^3).

E.4.10 PNEUMATIC REMOVAL/TRANSFER SYSTEM

The pneumatic removal/transfer system is a component of Alternatives 2B through 4B. This cost component includes the support superstructure and work platform, rail system, filter/receiver, glove box, and the pneumatic removal equipment. If a removal alternative were selected for Subunit A, the support superstructure and work platform, rail system, and filter/receiver would not be required for the pneumatic removal transfer system. Assumptions used for the cost estimate include:

- The work platform would be a rail-mounted, 54-m (180-ft) structure truss that would span the silos.

- A glove box would used at the interface of the pneumatic removal system and the silo dome.

- The air suctioned from the silo would be separated in a filter/receiver adjacent to the work platform.

- The pneumatic removal equipment would consist of a cutterhead, vacuum, and dredging pump.

E.4.11 DEMOLITION AND REMOVAL

This cost component is part of Alternatives 2C and 3C, and involves the decontamination and demolition of Silos 1, 2, 3, and 4 and the waste processing facility. Costs were estimated based on the following:

- Site preparation would include clearing and grubbing of approximately 4.2 ha (10.5 acres) for the above-grade disposal vault. A haul road approximately 0.32 km (0.8 mile) would be constructed.

- The material would include contaminated silo rubble, the existing RTS of Silos 1 and 2, surface and subsurface soils, drum handling pad, the decant sump tank, process piping and trenches, and the waste processing facilities, including the equipment superstructure.

- All the concrete from Silos 1, 2, 3, and 4 would require disposal.

- Approximately 790 m (2,600 ft) of process piping in the process trenches would be cut into manageable sections but not decontaminated prior to disposal.

- A backhoe-mounted pneumatic hammer would be used to fracture the concrete piping trenches. Estimated volume of concrete from trenches would be 240 m^3 (315 yd^3).

- Subsoil beneath Silos 1 and 2 would be excavated to a depth of approximately 1.5 m (5 ft) and laterally to the toe of the berm. Contaminated pockets of subsoil would also be excavated. Subsoil quantities were estimated to be 11,198 m^3 (14,646 yd^3).

E.5.0 PRESENT WORTH ANALYSIS

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Present worth analysis provides a method of evaluating and comparing costs that occur over different time periods by discounting all future expenditures to the present year. The costs for different remedial action alternatives can be compared on the basis of a single figure. From a financial standpoint, the objective of the present worth calculation is to determine those funds needed today to capitalize the remedial action over its duration, given the discount rate. To determine present worth costs, the following equation was used:

$$P = A\,[\,1-(\,1+i\,)^{-n}\,)\,/\,i\,]$$

Where:
- P = present worth
- A = uniform annual payment required to fund the alternative
- i = discount rate
- n = number of periods over which the uniform annual payments are made

In order to perform the present worth calculation, it will be assumed that all costs (capital, O&M during remediation, and post-remediation O&M) will be paid out in equal annual payments over the time period in which they are incurred. For example, if a remediation alternative expends $300,000 over a three year period in capital construction costs (or O&M costs), the uniform annual outlay will be $100,000. The total present worth will be the sum of the present worth for the capital costs, the O&M during remediation, and the post-remediation O&M (if applicable).

The discount rate used for the present worth calculations is seven percent per CERCLA guidance (EPA 1988), as revised by correspondence from EPA's Office of Emergency and Remedial Response (EPA 1993) for sites which have a Record of Decision targeted for fiscal year 1994 and thereafter. The durations for the alternatives are provided in Table E.5-1. Capital, O&M, and present worth costs are provided in Table E.5-2.

TABLE E.5-1

CONSTRUCTION AND O&M PERIODS FOR ALTERNATIVES

ALTERNATIVE	CONSTRUCTION PERIOD (years)	O&M DURING REMEDIATION (years)	O&M POST-REMEDIATION (years)
1A	1.5	.3	30
2A through 5A	3	3	30 (2A,4A,5A)
6A	1	2	30
1B	1.5	.2	30
2B through 3B	3	1	30 (2B)
4B	2	2	30
1C through 3C	2	N/A	30 (1C,2C)

N/A - Not applicable.

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TABLE E.5–2

ALTERNATIVE COSTS

Alternative	COST[a]			
	Capital	O&M During Remediation	Post–Remediation O&M	Total Present Worth
SUBUNIT A				
1A	16,050,100	483,200	3,351,000	16,519,200
2A/Vit	36,537,400	11,692,500	3,425,400	43,601,900
2A/Cem	71,238,200	11,715,700	3,582,000	74,038,600
3A.1/Vit	37,986,600	11,692,500	0	43,452,700
3A.1/Cem	69,865,400	11,715,700	0	71,356,300
3A.2/Vit	38,100,100	11,692,500	0	43,551,900
3A.2/Cem	72,299,500	11,715,700	0	73,485,300
4A/Vit	64,235,300	29,188,000	3,462,000	83,146,200
4A/Cem	77,964,100	29,460,800	3,462,000	95,393,000
5A.1/Vit	64,413,400	29,188,100	0	81,870,100
5A.1/Cem	76,567,700	29,460,800	0	92,739,600
5A.2/Vit	65,940,700	1,948,800	0	83,206,000
5A.2/Cem	79,906,100	29,460,800	0	95,659,600
6A	34,696,400	1,948,800	3,425,400	35,619,700
SUBUNIT B				
1B	11,765,000	126,300	2,562,000	11,938,900
2B/Vit	25,221,500	4,923,000	3,162,000	27,971,300
2B/Cem	35,932,600	4,923,000	3,207,000	37,358,600
3B.1/Vit	26,610,900	4,923,000	0	27,878,700
3B.1/Cem	36,129,000	4,056,000	0	35,393,200
3B.2/Vit	26,703,700	4,923,000	0	27,959,800
3B.2/Cem	37,550,800	4,056,000	0	36,636,800
4B	21,825,300	1,094,000	3,207,000	22,045,600
SUBUNIT C				
1C	35,017,600	0	3,099,000	32,937,800
2C	36,340,200	0	3,567,000	34,327,000
3C.1	76,219,700	0	0	68,902,600
3C.2	48,650,600	0	0	43,980,100
3C.3	37,763,500	0	0	34,138,200

[a]Values are given in dollars ($).

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REFERENCES

-5039

U.S. Environmental Protection Agency, 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," EPA/540/G-89/004, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1993, Memorandum from Office of Emergency and Remedial Response to EPA Regional Directors, OWSER Directive No. 9355.3-20, June 25.

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ALTERNATIVE 1A

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 1.5
O&M DURING REMEDIATION (YRS): 0.3
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 1A: IN-SITU CONTAINMENT

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-14B	IN-SITU CONTAINMENT	$4,356,000	$7,693,600	$12,049,600
	TOTAL CAPITAL	$4,356,000	$7,693,600	$12,049,600
	RISK BUDGET (11.0%)	$479,200	$846,300	$1,325,500
	SUBTOTAL	$4,835,200	$8,539,900	$13,375,100
	CONTINGENCY (20.0%)	$967,000	$1,708,000	$2,675,000
	TOTAL ESTIMATED INSTALLED COST	$5,802,200	$10,247,900	$16,050,100
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$483,200
	POST-REMEDIATION			$3,351,000
	TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)			$16,519,200

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File: SUM1A.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-14 B
CLIENT: US DOE
PROJECT TITLE: ALTERNATIVE 1A-IN-SITU CONTAINMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	INSTALLTION CAP COSTS	71,275		$1,176,750		$654,009	$1,830,800
-5089	RUN RELOCATION COSTS	21,907		$361,684		$253,465	$615,100
	FILL SOUTH OF SILO COSTS	5,223		$86,232		$59,968	$146,200
	MONITORING EQUIPMENTS COSTS	32		$528		$7,060	$7,600
	CAPPING SECURITY COSTS	4,455		$73,552		$92,351	$165,900
	ANCILLARY ITEM COSTS	2,939		$48,523		$58,882	$107,400
	RADON GAS TREATMENT SYSTEM COSTS	440		$7,264		$27,996	$35,300
	SUBCONTRACTOR COSTS	28,805			$1,447,716		$1,447,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	135,076	17.50	$1,754,500	$1,447,700	$1,153,700	$4,356,000
SUPERVISION & SUPPRT LABOR	28.0%			$491,000			$491,000
SMALL TOOLS	$1.50					$202,600	$202,600
CONSUMABLES	$1.50					$202,600	$202,600
EQUIPMENT RENTAL	$3.00					$405,200	$405,200
TEMP. FACILITIES	4.0%			$24,600		$45,600	$70,200
TEMP. UTILITIES	1.0%			$6,100		$11,400	$17,500
JOB CLEAN-UP	6.0%			$36,800		$68,400	$105,200
SAFETY	7.0%			$43,000		$79,800	$122,800
HEALTH PHYSICS	20.0% $2,356,000			$471,200			$471,200
CERCLA $1,500	PER PERSON 2,000					$101,300	$101,300
BOND	1.0% $4,356,000					$43,600	$43,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$145,400	$145,400
OVERHEAD & PROFIT	9.0% $6,734,600					$606,100	$606,100
EMISSION MODELING	0.50% $4,356,000			$7,600		$14,200	$21,800
PSAR/FSAR(SAFE RPT)	0.50% $4,356,000			$7,600		$14,200	$21,800
PAYRL BRD.&BENFT.	52.0% $2,842,400			$1,478,000			$1,478,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$4,320,400		$3,094,100	$8,862,300
CONSTR. MGMT.	4.0% $8,862,300						$354,500
SUB-TOTAL 3							$9,216,800
SOIL/WATER/AIR	1.0% $4,356,000			$15,200		$28,300	$43,500
HOME OFFICE EXP.	1.0% $9,216,800						$92,200
PROJ.MGMT.FERMCO	8.0% $9,216,800						$737,300
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$1,772,500
SUB-TOTAL 4	OFFICE COSTS						$11,862,300
SALES TAX	6.0% $3,122,400						$187,300
SUB-TOTAL 5							$12,049,600
RISK BUDGET	11.0%						$1,325,500
SUB-TOTAL 6							$13,375,100
CONTINGENCY	20.0%						$2,675,000
TOTAL ESTIMATED INSTALLED COST							$16,050,100

EST.FILE #:3096-14.

ALTERNATIVE # 1A- IN-SITU CONTAINMENT.(SILO 1 & 2).

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	INSTALLATION OF CAP- CAPITAL COST.							
1	SOIL FILL AROUND SILOS,90 COMPACTION,12"LIFT,10 MILES HAUL DIST.	107,149	CYD	37,502	$364,307	$619,158	-	$983,465
2	DRAIN TILE,4"-1/2 SINGLE WALL (DRAINAGE LAYER)	2,723	LFT	580	$6,263	$9,576	-	$15,839
3	PUSH PIPE-4",PLASTIC FILTER TYPE,SLOTTED (LEACHATE COLLECTION).	250	LFT	25	$750	$413	-	$1,163
4	PVC PIPE-4",PLASTIC TYPE. (LEACHATE COLLECTION).	1,900	LFT	190	$912	$3,137	-	$4,049
5	MANHOLES HDPE LINED, 6'DIA X 28' DEEP	6	EA	144	$16,950	$2,377	-	$19,327
6	CLAY LAYER, 98% COMPACTION,8-6" LIFTS,10 MI HAUL DIST.,E-7 PERM.	36,079	CYD	16,236	$122,669	$268,056	-	$390,725
7	DRAINAGE LAYER,2'LAYER GRADED AGGR.FILTER,BLANKET,15 MILES HAUL	17,090	CYD	5,076	$58,277	$83,805	-	$142,082
8	VEGETATION LAYER 2'LAYER,85% COMPACTION,2-12"LIFTS.,10 MILE HAUL.	17,440	CYD	7,848	$59,296	$129,570	-	$188,866
9	SEEDING, FERTILIZER & MULCHING	29,100	SYD	1,397	$4,365	$23,064	-	$27,429
10	GEOTEXTILE	261,900	SFT	1,509	$13,095	$24,914	-	$38,009
11	H.D.P.E. LINER TEXTURED, 40 MIL THICK.	28,500	SYD	768	$7,125	$12,680	-	$19,805
	SUBTOTAL CAP COSTS.	1	LS	71,275	$654,009	$1,176,750	-	$1,830,759
	PADDY'S RUN RELOCATION - CAPITAL COSTS.							
1	BORROW FILL FOR PADDY'S RUN(10 MILES ROUNDTRIP)(85% COMPACTION).	69,158	CYD	20,540	$235,829	$339,115	-	$574,944
2	FILTER FABRIC-OF COMPATIBLE MATERIAL	51,120	SFT	294	$2,556	$4,854	-	$7,410
3	SEED FERTILIZE & MULCH AROUND PADDY'S RUN	15,560	SYD	747	$2,334	$12,333	-	$14,667
4	RIPRAP (TWO LAYERS, STONE DIAMETER, 4")	1,262	CYD	326	$12,746	$5,382	-	$18,128
	SUBTOTAL PADDY'S RUN COSTS.	1	LS	21,907	$253,465	$361,684	-	$615,149

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	FILL SOUTH OF SILO 1.– CAPITAL COSTS.							
1	BORROW REQ'D. TO ESTABLISH EVEN GRADE PRIOR TO CONSTRUCTION OF	17,586	CYD	5,223	$59,968	$86,232	–	$146,200
–	CAP, 90% COMPACTION,12" LIFT,10 MILES HAUL DISTANCE.	–	–	–	–	–	–	
	SUBTOTAL FILL SOUTH OF SILO 1.	1	LS	5,223	$59,968	$86,232	–	$146,200
	MONITORING EQUIPMENT.							
1	RADON MONITORING INSTRUMENT.	1	EA	32	$7,000	$528	–	$7,528
2	ALUMINUM HOUSING FOR RADON MONITORING EQUIPMENT.	1	EA	–	$60	–	–	$60
	SUBTOTAL MONITORING WELLS.	1	LS	32	$7,060	$528	–	$7,588
	CAPPING SECURITY COSTS							
1	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	23	EA	736	$29,716	$12,151	–	$41,867
2	POWER LINES FOR LIGHTS, 12 AWG	12,000	FT	3,468	$41,398	$57,257	–	$98,655
3	ADMINISTRATION BUILDING w/LIGHT & HEATER.250 SFT SHOP BUILT.	1	EA	16	$18,000	$264	–	$18,264
4	CONCRETE PAD FOR ADMINISTRATION BUILDING.	1	LS	23	$1,737	$380	–	$2,117
5	ELECTRICAL POWER ALLOWANCE FOR ADMINISTRATION BUILDING.	1	LS	32	$500	$528	–	$1,028
6	THREE PERMANENT SURVEY MARKERS REFERENCED TO USGS ~ NGS MONUMEI	1	LS	180	$1,000	$2,972	–	$3,972
	SUBTOTAL CAPPING SECURITY.	1	LS	4,455	$92,351	$73,552	–	$165,903
	ANCILLIARY ITEMS/GROUT PLANT– CAPITAL COSTS.							
1	GLOVE BAG.	20	EA	4	$2,000	$66	–	$2,066
2	TEMPORARY LIGHTING	24	EA.	768	$31,008	$12,680	–	$43,688
3	POWER LINES FOR LIGHTS, 12 AWG	7,500	FT	2,167	$25,874	$35,777	–	$61,651
	SUBTOTAL GROUT PLANT/ITEMS CAPITAL COSTS.	1	LS	2,939	$58,882	$48,523	–	$107,405
	RADON GAS TREATMENT SYSTEM.							
1	HEPA FILTERS, 1,000 CFM CAPACITY.	1	EA	8	$160	$132	–	$292
2	DEHUMIIDIFIERS, 500 CFM CAP. CALCIUM SULFATE (4' DIA X 6' TALL).	2	EA	16	$3,000	$264	–	$3,264
3	CARBON ADSORBERS CANISTERS,(4'DIA X 6' TALL), 500 CFM CAPACITY.	2	EA	16	$8,000	$264	–	$8,264
4	FAN, 1,000 CFM, 2" SP (ASSUMED), 480V–3PH–60 CYCLE.	1	EA	32	$2,000	$528	–	$2,528
5	RADON GAS MONITORS, STERLING MODEL RGM–3.	2	EA	16	$11,590	$264	–	$11,854
6	DUCTWORK–6" DIA. FLEXIBLE	800	FT	80	$504	$1,321	–	$1,825
7	DUCTWORK–12" DIA. FLEXIBLE	640	FT	64	$698	$1,057	–	$1,755
8	DAMPERS–6" DIA w/ BAR OR EPT. SEALS DESIGNED FOR FULL PRESSURE.	20	EA	160	$1,540	$2,642	–	$4,182
9	DAMPERS–12" DIA w/ BAR OR EPT. SEALS DESIGNED FOR FULL PRESSURE.	6	EA	48	$504	$792	–	$1,296
	SUBTOTAL RADON GAS TREATMENT SYSTEM ITEMS.	1	LS	440	$27,996	$7,264	–	$35,260
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	106,271	$1,153,731	$1,754,533	–	$2,908,264

	SUBCONTRACT COSTS							
1	SOIL BENTONITE SLURRY WALL,50'DEEP,970 FT LGTH.,3' WIDE	5400	CYD	5,459			$388,800	$388,800
2	SCRAPE 3" OF VEGETATION FROM BERM AREA	700	CYD	105			$6,554	$6,554
2	SITE PREPARATION FOR SLURRY WALL, CLEARING & GRUBBING.	0.2750	ACRES	12			$638	$638
3	EXCAVATE EARTH AROUND PADDY'S RUN	9,078	CYD	191			$45,390	$45,390
4	SCRAPE 3" OF VEGETATION FOR CAP CONSTRUCTION.	508	CYD	98			$6,128	$6,128
5	CLUSTER MONITORING WELLS, 40 FEET DEEP.(CLUSTER OF 4 WELLS)	6	PLCS	1,728	–	–	$76,800	$76,800
6	CLUSTER MONITORING WELLS, 70 FEET DEEP.(CLUSTER OF 4 WELLS).	6	PLCS	2,304	–	–	$134,400	$134,400
7	CLUSTER MONITORING WELLS,135 FEET DEEP.(CLUSTER OF 4 WELLS)	6	PLCS	11,520	–	–	$388,800	$388,800
8	CLUSTER MONITORING WELLS,215 FEET DEEP.(CLUSTER OF 4 WELLS)	6	PLCS	11,520	–	–	$619,200	$619,200
9	STAKES FOR RADIATION	1	LS	80	–	–	$38,431	$38,431
10	CHAIN LINK FENCE,8 FT.TOPPED w/ 3 STRANDS BARBED WIRE.	1,900	FT	171	–	–	$15,520	$15,520
11	GATES CHAIN LINK 8 FT HIGH X 3 FT.WIDE.	2	EA	48	–	–	$550	$550
12	GATES CHAIN LINK 8 FT HIGH X 10 FT.WIDE.	1	EA	24	–	–	$350	$350
13	GATES CHAIN LINK 8 FT HIGH X 20 FT.WIDE.	1	EA	24	–	–	$550	$550
14	SECURITY ROADS,15 FT.WIDE,6"CRUSHED GRAVEL w/BINDER(2"THK),INTERIOR.	1,905	FT	286	–	–	$34,290	$34,290
15	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,905	FT	191	–	–	$20,955	$20,955
16	SERVICE ROADS,15 FT.WIDE,6"CRUSHED GRAVEL w/BINDER(2"THK),EXTERIOR.	2,062	FT	309	–	–	$37,116	$37,116
17	PREPARATION OF SURFACE FOR ACCESS ROADS.	2,062	FT	206	–	–	$22,682	$22,682
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	34,276	–	–	$1,837,154	$1,837,154
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	140,547	$1,153,731	$1,754,533	$1,837,154	$4,745,418

-5089

FERNALD PROJECT

I. T.PROJECT NO.:409194

ALTERNATIVE # 1A- IN-SITU CONTAINMENT.(SILO 1 & 2) POST REMEDIATION COSTS.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

-5039

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	1ST OR 2ND TIER OR EQUP.RNTAL.	TOTAL COST
	POST REMEDIATION O.& M. COSTS.	-	-	-	-	-	-	-
		-	-	-	-	-	-	-
1	RADIATION MONITORING ANNUALLY. FOR 30 YEARS.	30	EA	2,400	-	$81,312	$1,000	$82,312
2	AIR MONITORING FOR RADON,ANNUALLY FOR 30 YEARS.	30	EA	-	-	-	-	$12,300
3	AIR MONITORING FOR AMBIENT AIR. DITTO.	30	EA	-	-	-	-	$13,838
4	GROUND WATER MONITORING FOR 30 YEARS.	30	EA	9,600	-	$325,248	-	$325,248
5	ANALYTICAL WATER SAMPLES FOR RADIONUCLIDES.	1,200	EA	7,200	-	-	$2,164,800	$2,164,800
6	ANALYTICAL WATER SAMPLES FOR HSL/METALS.	1,200	EA	7,200	-	-	INCL.IN ABOVE.	-
7	ANNUAL INSPECTION.	1	LS	140	-	-	$3,828	$3,828
8	REPLACEMENT WELLS.(FOR 16 WELLS)	1	LS	-	-	-	$203,200	$203,200
9	REPLACEMENT OF RADON MONITORING EQUIPMENT (3 PCS.)	1	LS	-	$32,053	$5,036	-	$37,089
10	CERCLA 5- YEAR REEVALUATION.	6	EA	4,000	-	$300,000	-	$300,000
11	MOWING COSTS.	6	ACRES	288	-	-	$22,975	$22,975
12	REFERTILIZATION.	6	ACRES	1,328	-	-	$64,369	$64,369
13	ANNUAL INSPECTION.	6	ACRES	840	-	-	$22,966	$22,966
14	EROSION CONTROL.	6	ACRES	1,080	-	-	$9,175	$9,175
15	REPAIRS RESULTING FROM SHRINK/WELL OR FROZEN/THAW FORCES.	6	ACRES	1,548	-	-	$9,175	$9,175
16	ALLOW ROUTINE MAINTENANCE FOR SECURITY ITEMS FOR 30 YEARS.	1	LS	720	$60,000	$27,360	$20,000	$107,360
	O.& M.COSTS.ALT.#1A - POST REMEDIATION COSTS.(SILO1 & 2).	1	LS	36,344	$92,053	$738,956	$2,521,488	$3,352,497

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ALTERNATIVE 2A

VITRIFICATION

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 2A: REMOVAL, STABILIZATION W/VITRIFICATION, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-8A	SITE PREPARATION	$768,600	$660,000	$1,428,600
3096-5A	WASTE PROCESSING	$1,008,500	$1,065,000	$2,073,500
3096-12A	VITRIFICATION	$2,935,500	$1,703,600	$4,639,100
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
-	DISPOSAL VAULT	$937,100	$1,595,500	$2,532,600
-	PACKAGING (2,412 PKGS. @ $955/PKG.)	$636,800	$1,666,700	$2,303,500
TOTAL CAPITAL		$12,941,900	$14,488,600	$27,430,500
RISK BUDGET (11.0%)		$1,423,600	$1,593,700	$3,017,300
SUBTOTAL		$14,365,500	$16,082,300	$30,447,800
CONTINGENCY (20.0%)		$2,873,100	$3,216,500	$6,089,600
TOTAL ESTIMATED INSTALLED COST		$17,238,600	$19,298,800	$36,537,400
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$11,692,500
POST-REMEDIATION				$3,425,400
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$43,601,900

File: SUM2AVIT.WK3

EST FILE #: 3096-8 A -5039
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CIVIL AND EXCAVATION COSTS	2,750		$45,403		$155,239	$200,600
	ELECTRICAL COSTS	585		$9,659		$77,040	$86,700
	PIPING COSTS	628		$10,368		$3,185	$13,600
	SUBCONCTRACTOR COSTS	5,386			$467,734		$467,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,349	16.50	$65,400	$467,700	$235,500	$768,600
SUPERVISION & SUPPRT LABOR	28.0%			$18,000			$18,000
SMALL TOOLS	$1.50					$14,000	$14,000
CONSUMABLES	$1.50					$14,000	$14,000
EQUIPMENT RENTAL	$3.00					$28,000	$28,000
TEMP. FACILITIES	4.0%			$900		$1,700	$2,600
TEMP. UTILITIES	1.0%			$200		$400	$6[illegible]
JOB CLEAN-UP	6.0%			$1,400		$2,600	$4,0[illegible]
SAFETY	7.0%			$1,600		$3,000	$4,600
HEALTH PHYSICS	20.0%	$87,500		$17,500			$17,500
CERCLA $1,500	PER PERSON	2,000				$7,000	$7,000
BOND	1.0%	$768,600				$7,700	$7,700
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$15,100	$15,100
OVERHEAD & PROFIT	9.0%	$901,700				$81,200	$81,200
EMISSION MODELING	0.50%	$768,600		$1,300		$2,500	$3,800
PSAR/FSAR(SAFE RPT)	0.50%	$768,600		$1,300		$2,500	$3,800
PAYRL BRD.&BENFT.	52.0%	$107,600		$56,000			$56,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$163,600		$415,200	$1,046,500
CONSTR. MGMT.	4.0%	$1,046,500					$41,900
SUB-TOTAL 3							$1,088,400
SOIL/WATER/AIR	1.0%	$768,600		$2,700		$5,000	$7,700
HOME OFFICE EXP.	1.0%	$1,088,400					$10,900
PROJ.MGMT.FERMCO	8.0%	$1,088,400					$87,100
ENGINEERING 20.0%	Title I	7.0%	Title II	10.0%	Title III	3.0%	$209,300
SUB-TOTAL 4	OFFICE COSTS						$1,403,400
SALES TAX	6.0%	$420,200					$25,200
SUB-TOTAL 5							$1,428,600
RISK BUDGET	11.0%						$157,100
SUB-TOTAL 6							$1,585,700
CONTINGENCY	20.0%						$317,100
TOTAL ESTIMATED INSTALLED COST							$1,902,800

EST.FILE #: 3096-8.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F H GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
-		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
14	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
15	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
16	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
18	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	$66
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,963	$235,464	$65,430	-	$300,894

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5089

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,234	$13,234
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$467,734	$467,734
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,349	$235,464	$65,430	$467,734	$768,628

-5099

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-5 A
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0%	$234,800		$47,000			$47,000
CERCLA $1,500	PER PERSON	2,000				$8,900	$8,900
BOND	1.0%	$1,008,500				$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$24,300	$24,300
OVERHEAD & PROFIT	9.0%	$1,250,400				$112,500	$112,500
EMISSION MODELING	0.50%	$1,008,500		$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50%	$1,008,500		$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0%	$285,400		$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0%	$1,521,500					$60,900
SUB-TOTAL 3							$1,582,400
SOIL/WATER/AIR	1.0%	$1,008,500		$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0%	$1,582,400					$15,800
PROJ.MGMT.FERMCO	8.0%	$1,582,400					$126,600
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0%	$572,100					$34,300
SUB-TOTAL 5							$2,073,500
RISK BUDGET	11.0%						$228,100
SUB-TOTAL 6							$2,301,600
CONTINGENCY	20.0%						$460,300
TOTAL ESTIMATED INSTALLED COST							$2,761,900

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING - PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	2	EA	96	$16,600	$1,824		$18,424
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$28,000	$1,824		$29,824
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	38,160	LBS	4,476	$68,020	$85,044		$153,064
16	DAMPER 40,000 CFM.	1	EA	96	$900	$1,824		$2,724
-	PROCESS AREA VENTILATION SYSTEM, RADON.	-	-	-	-	-		-
17	RADON GAS MONITOR	3	EA	32	$21,000	$608		$21,608
18	BLOWER,1,000 CFM,1"SP.	2	EA	16	$3,000	$304		$3,304
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	64	$21,800	$1,216		$23,016
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	16	$2,600	$304		$2,904
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2,700	LBS	332	$5,061	$6,308		$11,369
23	DAMPER 1,000 CFM.	1	EA	16	$400	$304		$704
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT (30 FT EAVES, FULLY INSULATED, HVAC).	1	EA	1,600	–	–	$432,000	$432,000
–		–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

EST FILE #: 3096-12 A
CLIENT: US DOE
PROJECT TITLE: VITRIFICATION EQUIPMENT

-5089

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	VITRIFICATION EQUIPMENT COSTS	1,348		$23,776		$528,488	$552,300
	RADON TREATMENT SYSTEM COSTS	375		$6,614		$17,932	$24,500
	OFF-GAS SYSTEM COSTS	880		$15,521		$103,136	$118,700
	SUBCONTRACTOR COSTS (ADJ. TO CURRENT COST)	1,380			$2,240,000		$2,240,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	3,983	16.50	$45,900	$2,240,000	$649,600	$2,935,500
SUPERVISION & SUPPRT LABOR	28.0%			$13,000			$13,000
SMALL TOOLS	$1.50					$6,000	$6,000
CONSUMABLES	$1.50					$6,000	$6,000
EQUIPMENT RENTAL	$3.00					$11,900	$11,900
TEMP. FACILITIES	4.0%			$600		$1,200	$1,800
TEMP. UTILITIES	1.0%			$200		$300	$500
JOB CLEAN-UP	6.0%			$1,000		$1,800	$2,8[illegible]
SAFETY	7.0%			$1,100		$2,100	$3,[illegible]
HEALTH PHYSICS	20.0% $61,800			$12,400			$12,400
CERCLA $1,500	PER PERSON 2,000					$3,000	$3,000
BOND	1.0% $2,935,500					$29,400	$29,400
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$34,800	$34,800
OVERHEAD & PROFIT	9.0% $3,060,300					$275,400	$275,400
EMISSION MODELING	0.50% $2,935,500			$5,100		$9,500	$14,600
PSAR/FSAR(SAFE RPT)	0.50% $2,935,500			$5,100		$9,500	$14,600
PAYRL BRD.&BENFT.	52.0% $84,400			$43,900			$43,900
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$128,300		$1,040,500	$3,408,800
CONSTR. MGMT.	4.0% $3,408,800						$136,400
SUB-TOTAL 3							$3,545,200
SOIL/WATER/AIR	1.0% $2,935,500			$10,300		$19,100	$29,400
HOME OFFICE EXP.	1.0% $3,545,200						$35,500
PROJ.MGMT.FERMCO	8.0% $3,545,200						$283,600
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$681,800
SUB-TOTAL 4	OFFICE COSTS						$4,575,500
SALES TAX	6.0% $1,059,600						$63,600
SUB-TOTAL 5							$4,639,100
RISK BUDGET	11.0%						$510,300
SUB-TOTAL 6							$5,149,400
CONTINGENCY	20.0%						$1,029,900
TOTAL ESTIMATED INSTALLED COST							$6,179,300

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERMI

-5089

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0%	$1,768,367		$353,700			$353,700
CERCLA $1,500	PER PERSON	2,000				$55,500	$55,500
BOND	1.0%	$6,655,385				$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$332,700	$332,700
OVERHEAD & PROFIT	9.0%	$8,513,685				$766,200	$766,200
EMISSION MODELING	0.50%	$6,655,385		$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50%	$6,655,385		$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0%	$2,145,267		$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0%	$10,461,800					$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0%	$6,655,385		$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0%	$10,880,300					$108,800
PROJ.MGMT.FERMCO	8.0%	$10,880,300					$870,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0%	$7,244,300					$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A- REMOVAL,STABILIZATION, ON-PROPERTY DISPOSAL.(SILO 1 & 2)
OPERATION & MAINTENANCE COSTS.-VITRIFICATION OPTION.

FY 93-1 DOLLARS

06/09/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	1,880,296	GALS	-	$37,606	-	-	$37,606
2	SODA ASH	4,112,640	LBS	-	$318,730	-	-	$318,730
3	CARBON	41,126	LBS	-	$28,788	-	-	$28,788
4	ELECTRICITY	18,521,530	KWHR	-	$846,619	-	-	$846,619
5	CRAFT LABOR.	300,000	HRS	300,000	-	$10,164,000	-	$10,164,000
6	SUPERVISION LABOR.	4,424	HRS	4,424	-	$296,762	-	$296,762
	SUBTOTAL OPERATION & MAINTENANCE COSTS.-VITRIFICATION OPTION	1	LS	304,424	$1,231,743	$10,460,762	-	$11,692,505

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ALTERNATIVE 2A

CEMENT STABILIZATION

DATE: 03-Dec-9

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 2A: REMOVAL, CEMENT STABILIZATION, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-8A	SITE PREPARATION	$768,600	$660,000	$1,428,600
3096-5A	WASTE PROCESSING	$1,008,500	$1,065,000	$2,073,500
3096-10A	CEMENT STABILIZATION	$2,590,500	$2,843,300	$5,433,800
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
-	DISPOSAL VAULT	$5,831,000	$9,928,500	$15,759,500
-	PACKAGING (15,009 PKGS. @ $955/PKG.)	$3,962,400	$10,371,200	$14,333,600
TOTAL CAPITAL		$20,816,400	$32,665,800	$53,482,200
RISK BUDGET (11.0%)		$2,289,800	$3,593,200	$5,883,000
SUBTOTAL		$23,106,200	$36,259,000	$59,365,200
CONTINGENCY (20.0%)		$4,621,200	$7,251,800	$11,873,000
TOTAL ESTIMATED INSTALLED COST		$27,727,400	$43,510,800	$71,238,200
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$11,715,700
	POST-REMEDIATION			$3,582,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$74,038,600

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-8 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

-5039

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CIVIL AND EXCAVATION COSTS	2,750		$45,403		$155,239	$200,600
	ELECTRICAL COSTS	585		$9,659		$77,040	$86,700
	PIPING COSTS	628		$10,368		$3,185	$13,600
	SUBCONCTRACTOR COSTS	5,386			$467,734		$467,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,349	16.50	$65,400	$467,700	$235,500	$768,600
SUPERVISION & SUPPRT LABOR	28.0%			$18,000			$18,000
SMALL TOOLS	$1.50					$14,000	$14,000
CONSUMABLES	$1.50					$14,000	$14,000
EQUIPMENT RENTAL	$3.00					$28,000	$28,000
TEMP. FACILITIES	4.0%			$900		$1,700	$2,600
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,600	$4,000
SAFETY	7.0%			$1,600		$3,000	$4,600
HEALTH PHYSICS	20.0%	$87,500		$17,500			$17,500
CERCLA $1,500	PER PERSON	2,000				$7,000	$7,000
BOND	1.0%	$768,600				$7,700	$7,700
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$15,100	$15,100
OVERHEAD & PROFIT	9.0%	$901,700				$81,200	$81,200
EMISSION MODELING	0.50%	$768,600		$1,300		$2,500	$3,800
PSAR/FSAR(SAFE RPT)	0.50%	$768,600		$1,300		$2,500	$3,800
PAYRL BRD.&BENFT.	52.0%	$107,600		$56,000			$56,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$163,600		$415,200	$1,046,500
CONSTR. MGMT.	4.0%	$1,046,500					$41,900
SUB-TOTAL 3							$1,088,400
SOIL/WATER/AIR	1.0%	$768,600		$2,700		$5,000	$7,700
HOME OFFICE EXP.	1.0%	$1,088,400					$10,900
PROJ.MGMT.FERMCO	8.0%	$1,088,400					$87,100
ENGINEERING 20.0%	Title I	7.0%	Title II	10.0%	Title III	3.0%	$209,300
SUB-TOTAL 4	OFFICE COSTS						$1,403,400
SALES TAX	6.0%	$420,200					$25,200
SUB-TOTAL 5							$1,428,600
RISK BUDGET	11.0%						$157,100
SUB-TOTAL 6							$1,585,700
CONTINGENCY	20.0%						$317,100
TOTAL ESTIMATED INSTALLED COST							$1,902,800

EST.FILE #: 3096-8.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

5089

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
-		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
14	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
15	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
16	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
18	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	$66
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,963	$235,464	$65,430	-	$300,894

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,234	$13,234
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$467,734	$467,734
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,349	$235,464	$65,430	$467,734	$768,628

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-5 A
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	AVG. 14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,6[illegible]
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,[illegible]
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0% $234,800			$47,000			$47,000
CERCLA $1,500	PER PERSON 2,000					$8,900	$8,900
BOND	1.0% $1,008,500					$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$24,300	$24,300
OVERHEAD & PROFIT	9.0% $1,250,400					$112,500	$112,500
EMISSION MODELING	0.50% $1,008,500			$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50% $1,008,500			$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0% $285,400			$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0% $1,521,500						$60,900
SUB-TOTAL 3							$1,582,400
SOIL/WATER/AIR	1.0% $1,008,500			$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0% $1,582,400						$15,800
PROJ.MGMT.FERMCO	8.0% $1,582,400						$126,600
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III	3.0%			$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0% $572,100						$34,300
SUB-TOTAL 5							$2,073,500
RISK BUDGET	11.0%						$228,100
SUB-TOTAL 6							$2,301,600
CONTINGENCY	20.0%						$460,300
TOTAL ESTIMATED INSTALLED COST							$2,761,900

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY- CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

584

5089

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-10 A
CLIENT: US DOE
PROJECT TITLE: CEMENT STABILIZATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY AND EQUIPMENT COSTS (CURRENT COST ESTIMATE)	17,866		$518,100	$673,530	$1,398,870	$2,590,500
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	17,866	19.00	$518,100	$673,500	$1,398,900	$2,590,500
SUPERVISION & SUPPRT LABOR	28.0%			$145,000			$145,000
SMALL TOOLS	$1.50					$26,800	$26,800
CONSUMABLES	$1.50					$26,800	$26,800
EQUIPMENT RENTAL	$3.00					$53,600	$53,600
TEMP. FACILITIES	4.0%			$7,300		$13,500	$20,800
TEMP. UTILITIES	1.0%			$1,800		$3,400	$5,200
JOB CLEAN-UP	6.0%			$10,900		$20,200	$31,100
SAFETY	7.0%			$12,700		$23,600	$36,300
HEALTH PHYSICS	20.0%	$695,800		$139,200			$139,200
CERCLA $1,500	PER PERSON	2,000				$13,400	$13,400
BOND	1.0%	$2,590,500				$25,900	$25,900
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$95,800	$95,800
OVERHEAD & PROFIT	9.0%	$3,210,400				$288,900	$288,900
EMISSION MODELING	0.50%	$2,590,500		$4,500		$8,400	$12,900
PSAR/FSAR(SAFE RPT)	0.50%	$2,590,500		$4,500		$8,400	$12,900
PAYRL BRD.&BENFT.	52.0%	$844,000		$438,900			$438,900
SUBTOTAL 2	DIRECT AND INDIRECT FILED COSTS			$1,282,900		$2,007,600	$3,964,000
CONSTR. MGMT.	4.0%	$3,964,000					$158,600
SUB-TOTAL 3							$4,122,600
SOIL/WATER/AIR	1.0%	$2,590,500		$9,100		$16,800	$25,900
HOME OFFICE EXP.	1.0%	$4,122,600					$41,200
PROJ.MGMT.FERMCO	8.0%	$4,122,600					$329,800
ENGINEERING 20.0%	Title I	7.0%	Title II	10.0%	Title III	3.0%	$792,800
SUB-TOTAL 4	OFFICE COSTS						$5,312,300
SALES TAX	6.0%	$2,024,400					$121,500
SUB-TOTAL 5							$5,433,800
RISK BUDGET	11.0%						$597,700
SUB-TOTAL 6							$6,031,500
CONTINGENCY	20.0%						$1,206,300
TOTAL ESTIMATED INSTALLED COST							$7,237,800

EST FILE # 5099
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,[illegible]
SAFETY	7.0%			$32,300		$59,900	$92,[illegible]
HEALTH PHYSICS	20.0% $1,768,367			$353,700			$353,700
CERCLA $1,500	PER PERSON 2,000					$55,500	$55,500
BOND	1.0% $6,655,385					$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$332,700	$332,700
OVERHEAD & PROFIT	9.0% $8,513,685					$766,200	$766,200
EMISSION MODELING	0.50% $6,655,385			$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50% $6,655,385			$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0% $2,145,267			$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0% $10,461,800						$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0% $6,655,385			$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0% $10,880,300						$108,800
PROJ.MGMT.FERMCO	8.0% $10,880,300						$870,400
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0% $7,244,300						$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A- REMOVAL,STABILIZATION, ON-PROPERTY DISPOSAL.(SILO 1 & 2)
OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/09/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	8,528,000	GALS	-	$170,560	-	-	$170,560
2	BLAST FURNACE SLAG.	6,324,000	LBS	-	$94,860	-	-	$94,860
3	CEMENT	13,264,000	LBS	-	$437,712	-	-	$437,712
4	FLYASH	3,787,000	LBS	-	$22,722	-	-	$22,722
5	ELECTRICITY	11,575,780	KWHR	-	$529,129	-	-	$529,129
6	CRAFT LABOR.	300,000	HRS	300,000	-	$10,164,000	-	$10,164,000
7	SUPERVISION LABOR.	4,424	HRS	4,424	-	$296,762	-	$296,762
	SUBTOTAL OPERATION & MAINTENACE COSTS.-CEMENT STABILIZATION OPTION	1	LS	304,424	$1,254,983	$10,460,762	-	$11,715,745

588

-5089

ALTERNATIVE 3A.1

VITRIFICATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3A.1: REMOVAL, STABILIZATION W/VITRIFICATION, OFF-SITE DISPOSAL AT NTS

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-8A	SITE PREPARATION	$768,600	$660,000	$1,428,600
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-12A	VITRIFICATION	$2,935,500	$1,703,600	$4,639,100
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
-	TRANSPORTATION	$1,268,100		$1,268,100
-	DISPOSAL	$1,302,500		$1,302,500
-	PACKAGING (2,412 PKGS. @ $955/PKG.)	$636,800	$1,666,700	$2,303,500
TOTAL CAPITAL		$15,262,700	$13,255,800	$28,518,500
RISK BUDGET (11.0%)		$1,678,900	$1,458,100	$3,137,000
SUBTOTAL		$16,941,600	$14,713,900	$31,655,500
CONTINGENCY (20.0%)		$3,388,300	$2,942,800	$6,331,100
TOTAL ESTIMATED INSTALLED COST		$20,329,900	$17,656,700	$37,986,600
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$11,692,500
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$43,452,700

590

-5038

File: SUM3A1VI.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-8 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

-5089

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CIVIL AND EXCAVATION COSTS	2,750		$45,403		$155,239	$200,600
	ELECTRICAL COSTS	585		$9,659		$77,040	$86,700
	PIPING COSTS	628		$10,368		$3,185	$13,600
	SUBCONCTRACTOR COSTS	5,386			$467,734		$467,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,349	16.50	$65,400	$467,700	$235,500	$768,600
SUPERVISION & SUPPRT LABOR	28.0%			$18,000			$18,000
SMALL TOOLS	$1.50					$14,000	$14,000
CONSUMABLES	$1.50					$14,000	$14,000
EQUIPMENT RENTAL	$3.00					$28,000	$28,0[illegible]
TEMP. FACILITIES	4.0%			$900		$1,700	$2,[illegible]
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,600	$4,000
SAFETY	7.0%			$1,600		$3,000	$4,600
HEALTH PHYSICS	20.0%	$87,500		$17,500			$17,500
CERCLA $1,500	PER PERSON	2,000				$7,000	$7,000
BOND	1.0%	$768,600				$7,700	$7,700
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$15,100	$15,100
OVERHEAD & PROFIT	9.0%	$901,700				$81,200	$81,200
EMISSION MODELING	0.50%	$768,600		$1,300		$2,500	$3,800
PSAR/FSAR(SAFE RPT)	0.50%	$768,600		$1,300		$2,500	$3,800
PAYRL BRD.&BENFT.	52.0%	$107,600		$56,000			$56,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$163,600		$415,200	$1,046,500
CONSTR. MGMT.	4.0%	$1,046,500					$41,900
SUB-TOTAL 3							$1,088,400
SOIL/WATER/AIR	1.0%	$768,600		$2,700		$5,000	$7,700
HOME OFFICE EXP.	1.0%	$1,088,400					$10,900
PROJ.MGMT.FERMCO	8.0%	$1,088,400					$87,100
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$209,300
SUB-TOTAL 4	OFFICE COSTS						$1,403,400
SALES TAX	6.0%	$420,200					$25,200
SUB-TOTAL 5							$1,428,600
RISK BUDGET	11.0%						$157,100
SUB-TOTAL 6							$1,585,700
CONTINGENCY	20.0%						$317,100
TOTAL ESTIMATED INSTALLED COST							$1,902,80[illegible]

EST.FILE #: 3096-8.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
-		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
14	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
15	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
16	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
18	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	$66
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,963	$235,464	$65,430	-	$300,894

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ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,234	$13,234
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$467,734	$467,734
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,349	$235,464	$65,430	$467,734	$768,628

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

5039

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0%	$234,800		$47,000			$47,000
CERCLA $1,500	PER PERSON	2,000				$8,900	$8,900
BOND	1.0%	$1,008,500				$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$24,300	$24,300
OVERHEAD & PROFIT	9.0%	$1,250,400				$112,500	$112,500
EMISSION MODELING	0.50%	$1,008,500		$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50%	$1,008,500		$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0%	$285,400		$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0%	$1,521,500					$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0%	$1,008,500		$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0%	$1,582,400					$15,800
PROJ.MGMT.FERMCO	8.0%	$1,582,400					$126,600
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0%	$572,100					$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

5089

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

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ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-12 A
CLIENT: US DOE
PROJECT TITLE: VITRIFICATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	VITRIFICATION EQUIPMENT COSTS	1,348		$23,776		$528,488	$552,300
	RADON TREATMENT SYSTEM COSTS	375		$6,614		$17,932	$24,500
	OFF-GAS SYSTEM COSTS	880		$15,521		$103,136	$118,700
	SUBCONTRACTOR COSTS (ADJ. TO CURRENT COST)	1,380			$2,240,000		$2,240,000
SUB-TOTAL 1	DIRECT FIELD COSTS	3,983	AVG. 16.50	$45,900	$2,240,000	$649,600	$2,935,500
SUPERVISION & SUPPRT LABOR	28.0%			$13,000			$13,000
SMALL TOOLS	$1.50					$6,000	$6,000
CONSUMABLES	$1.50					$6,000	$6,000
EQUIPMENT RENTAL	$3.00					$11,900	$11,900
TEMP. FACILITIES	4.0%			$600		$1,200	$1,800
TEMP. UTILITIES	1.0%			$200		$300	$500
JOB CLEAN-UP	6.0%			$1,000		$1,800	$2,[illegible]
SAFETY	7.0%			$1,100		$2,100	$3,[illegible]
HEALTH PHYSICS	20.0%	$61,800		$12,400			$12,400
CERCLA $1,500	PER PERSON	2,000				$3,000	$3,000
BOND	1.0%	$2,935,500				$29,400	$29,400
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$34,800	$34,800
OVERHEAD & PROFIT	9.0%	$3,060,300				$275,400	$275,400
EMISSION MODELING	0.50%	$2,935,500		$5,100		$9,500	$14,600
PSAR/FSAR(SAFE RPT)	0.50%	$2,935,500		$5,100		$9,500	$14,600
PAYRL BRD.&BENFT.	52.0%	$84,400		$43,900			$43,900
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$128,300		$1,040,500	$3,408,800
CONSTR. MGMT.	4.0%	$3,408,800					$136,400
SUB-TOTAL 3							$3,545,200
SOIL/WATER/AIR	1.0%	$2,935,500		$10,300		$19,100	$29,400
HOME OFFICE EXP.	1.0%	$3,545,200					$35,500
PROJ.MGMT.FERMCO	8.0%	$3,545,200					$283,600
ENGINEERING	20.0% Title I	7.0% Title II	10.0%	Title III	3.0%		$681,800
SUB-TOTAL 4	OFFICE COSTS						$4,575,500
SALES TAX	6.0%	$1,059,600					$63,600
SUB-TOTAL 5							$4,639,100
RISK BUDGET	11.0%						$510,300
SUB-TOTAL 6							$5,149,400
CONTINGENCY	20.0%						$1,029,900
TOTAL ESTIMATED INSTALLED COST							$6,179,300

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

-5039

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0%	$1,768,367		$353,700			$353,700
CERCLA $1,500	PER PERSON	2,000				$55,500	$55,500
BOND	1.0%	$6,655,385				$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$332,700	$332,700
OVERHEAD & PROFIT	9.0%	$8,513,685				$766,200	$766,200
EMISSION MODELING	0.50%	$6,655,385		$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50%	$6,655,385		$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0%	$2,145,267		$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0%	$10,461,800					$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0%	$6,655,385		$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0%	$10,880,300					$108,800
PROJ.MGMT.FERMCO	8.0%	$10,880,300					$870,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0%	$7,244,300					$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3A.1 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL TO NTS(SILO 1 & 2)
OPERATION & MAINTENANCE COSTS.-VITRIFICATION OPTION.

FY 93-1 DOLLARS

06/09/93

ESTIMATOR: F.H.GASLIGHTALA

PROJ.ENGR: JOE PACELLA

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	1,880,296	GALS	-	$37,606	-	-	$37,606
2	SODA ASH	4,112,640	LBS	-	$318,730	-	-	$318,730
3	CARBON	41,126	LBS	-	$28,788	-	-	$28,788
4	ELECTRICITY	18,521,530	KWHR	-	$846,619	-	-	$846,619
5	CRAFT LABOR.	300,000	HRS	300,000	-	$10,164,000	-	$10,164,000
6	SUPERVISION LABOR.	4,424	HRS	4,424	-	$296,762	-	$296,762
	SUBTOTAL OPERATION & MAINTENACE COSTS.-VITRIFICATION OPTION	1	LS	304,424	$1,231,743	$10,460,762	-	$11,692,505

-5039

ALTERNATIVE 3A.1

CEMENT STABILIZATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3A.1: REMOVAL, CEMENT STABILIZATION, OFF-SITE DISPOSAL AT NTS

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-8A	SITE PREPARATION	$768,600	$660,000	$1,428,600
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-10A	CEMENT STABILIZATION	$2,590,500	$2,843,300	$5,433,800
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	TRANSPORTATION	$5,574,000		$5,574,000
–	DISPOSAL	$8,104,800		$8,104,800
–	PACKAGING (15,009 PKGS. @ $955/PKG.)	$3,962,400	$10,371,200	$14,333,600
TOTAL CAPITAL		$29,351,500	$23,100,000	$52,451,500
RISK BUDGET (11.0%)		$3,228,700	$2,541,000	$5,769,700
SUBTOTAL		$32,580,200	$25,641,000	$58,221,200
CONTINGENCY (20.0%)		$6,516,000	$5,128,200	$11,644,200
TOTAL ESTIMATED INSTALLED COST		$39,096,200	$30,769,200	$69,865,400
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$11,715,700
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$71,356,300

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File: [redacted]3A1CE.WK3

-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-8 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CIVIL AND EXCAVATION COSTS	2,750		$45,403		$155,239	$200,600
	ELECTRICAL COSTS	585		$9,659		$77,040	$86,700
	PIPING COSTS	628		$10,368		$3,185	$13,600
	SUBCONCTRACTOR COSTS	5,386			$467,734		$467,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,349	16.50	$65,400	$467,700	$235,500	$768,600
SUPERVISION & SUPPRT LABOR	28.0%			$18,000			$18,000
SMALL TOOLS	$1.50					$14,000	$14,000
CONSUMABLES	$1.50					$14,000	$14,000
EQUIPMENT RENTAL	$3.00					$28,000	$28,000
TEMP. FACILITIES	4.0%			$900		$1,700	$2,600
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,600	$4,000
SAFETY	7.0%			$1,600		$3,000	$4,600
HEALTH PHYSICS	20.0%	$87,500		$17,500			$17,500
CERCLA $1,500	PER PERSON	2,000				$7,000	$7,000
BOND	1.0%	$768,600				$7,700	$7,700
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$15,100	$15,100
OVERHEAD & PROFIT	9.0%	$901,700				$81,200	$81,200
EMISSION MODELING	0.50%	$768,600		$1,300		$2,500	$3,800
PSAR/FSAR(SAFE RPT)	0.50%	$768,600		$1,300		$2,500	$3,800
PAYRL BRD.&BENFT.	52.0%	$107,600		$56,000			$56,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$163,600		$415,200	$1,046,500
CONSTR. MGMT.	4.0%	$1,046,500					$41,900
SUB-TOTAL 3							$1,088,400
SOIL/WATER/AIR	1.0%	$768,600		$2,700		$5,000	$7,700
HOME OFFICE EXP.	1.0%	$1,088,400					$10,900
PROJ.MGMT.FERMCO	8.0%	$1,088,400					$87,100
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$209,300
SUB-TOTAL 4	OFFICE COSTS						$1,403,400
SALES TAX	6.0%	$420,200					$25,200
SUB-TOTAL 5							$1,428,600
RISK BUDGET	11.0%						$157,100
SUB-TOTAL 6							$1,585,700
CONTINGENCY	20.0%						$317,100
TOTAL ESTIMATED INSTALLED COST							$1,902,800

EST.FILE #: 3096-8.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
-		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
14	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
15	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
16	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
18	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	$66
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,963	$235,464	$65,430	-	$300,894

-5089

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ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,234	$13,234
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$467,734	$467,734
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,349	$235,464	$65,430	$467,734	$768,628

5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST #: -5039 -5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,7[illegible]
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,[illegible]
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0% $234,800			$47,000			$47,000
CERCLA $1,500	PER PERSON 2,000					$8,900	$8,900
BOND	1.0% $1,008,500					$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$24,300	$24,300
OVERHEAD & PROFIT	9.0% $1,250,400					$112,500	$112,500
EMISSION MODELING	0.50% $1,008,500			$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50% $1,008,500			$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0% $285,400			$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0% $1,521,500						$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0% $1,008,500			$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0% $1,582,400						$15,800
PROJ.MGMT.FERMCO	8.0% $1,582,400						$126,600
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0% $572,100						$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
		-	-	-	-	-	-	-
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	2	EA	96	$16,600	$1,824		$18,424
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$28,000	$1,824		$29,824
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	38,160	LBS	4,476	$68,020	$85,044		$153,064
16	DAMPER 40,000 CFM.	1	EA	96	$900	$1,824		$2,724
-	PROCESS AREA VENTILATION SYSTEM, RADON.	-	-	-	-	-		-
17	RADON GAS MONITOR	3	EA	32	$21,000	$608		$21,608
18	BLOWER,1,000 CFM,1"SP.	2	EA	16	$3,000	$304		$3,304
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	64	$21,800	$1,216		$23,016
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	16	$2,600	$304		$2,904
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2,700	LBS	332	$5,061	$6,308		$11,369
23	DAMPER 1,000 CFM.	1	EA	16	$400	$304		$704
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

-5039

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ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-10 A
CLIENT: US DOE
PROJECT TITLE: CEMENT STABILIZATION EQUIPMENT

-5039

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY AND EQUIPMENT COSTS (CURRENT COST ESTIMATE)	17,866		$518,100	$673,530	$1,398,870	$2,590,500
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	17,866	19.00	$518,100	$673,500	$1,398,900	$2,590,500
SUPERVISION & SUPPRT LABOR	28.0%			$145,000			$145,000
SMALL TOOLS	$1.50					$26,800	$26,800
CONSUMABLES	$1.50					$26,800	$26,800
EQUIPMENT RENTAL	$3.00					$53,600	$53,600
TEMP. FACILITIES	4.0%			$7,300		$13,500	$20,800
TEMP. UTILITIES	1.0%			$1,800		$3,400	$5,200
JOB CLEAN-UP	6.0%			$10,900		$20,200	$31,100
SAFETY	7.0%			$12,700		$23,600	$36,300
HEALTH PHYSICS	20.0%	$695,800		$139,200			$139,200
CERCLA $1,500	PER PERSON	2,000				$13,400	$13,400
BOND	1.0%	$2,590,500				$25,900	$25,900
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$95,800	$95,800
OVERHEAD & PROFIT	9.0%	$3,210,400				$288,900	$288,900
EMISSION MODELING	0.50%	$2,590,500		$4,500		$8,400	$12,900
PSAR/FSAR(SAFE RPT)	0.50%	$2,590,500		$4,500		$8,400	$12,900
PAYRL BRD.&BENFT.	52.0%	$844,000		$438,900			$438,900
SUBTOTAL 2	DIRECT AND INDIRECT FILED COSTS			$1,282,900		$2,007,600	$3,964,000
CONSTR. MGMT.	4.0%	$3,964,000					$158,600
SUB-TOTAL 3							$4,122,600
SOIL/WATER/AIR	1.0%	$2,590,500		$9,100		$16,800	$25,900
HOME OFFICE EXP.	1.0%	$4,122,600					$41,200
PROJ.MGMT.FERMCO	8.0%	$4,122,600					$329,800
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$792,800
SUB-TOTAL 4	OFFICE COSTS						$5,312,300
SALES TAX	6.0%	$2,024,400					$121,500
SUB-TOTAL 5							$5,433,800
RISK BUDGET	11.0%						$597,700
SUB-TOTAL 6							$6,031,500
CONTINGENCY	20.0%						$1,206,300
TOTAL ESTIMATED INSTALLED COST							$7,237,800

-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,[illegible]
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,[illegible]
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0% $1,768,367			$353,700			$353,700
CERCLA $1,500	PER PERSON 2,000					$55,500	$55,500
BOND	1.0% $6,655,385					$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$332,700	$332,700
OVERHEAD & PROFIT	9.0% $8,513,685					$766,200	$766,200
EMISSION MODELING	0.50% $6,655,385			$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50% $6,655,385			$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0% $2,145,267			$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0% $10,461,800						$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0% $6,655,385			$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0% $10,880,300						$108,800
PROJ.MGMT.FERMCO	8.0% $10,880,300						$870,400
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0% $7,244,300						$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3A.1 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL TO NTS. (SILO 1 & 2)
OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/09/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	8,528,000	GALS	-	$170,560	-	-	$170,560
2	BLAST FURNACE SLAG.	6,324,000	LBS	-	$94,860	-	-	$94,860
3	CEMENT	13,264,000	LBS	-	$437,712	-	-	$437,712
4	FLYASH	3,787,000	LBS	-	$22,722	-	-	$22,722
5	ELECTRICITY	11,575,780	KWHR	-	$529,129	-	-	$529,129
6	CRAFT LABOR.	300,000	HRS	300,000	-	$10,164,000	-	$10,164,000
7	SUPERVISION LABOR.	4,424	HRS	4,424	-	$296,762	-	$296,762
	SUBTOTAL OPERATION & MAINTENACE COSTS.-CEMENT STABILIZATION OPTION	1	LS	304,424	$1,254,983	$10,460,762	-	$11,715,745

610

-5038

ALTERNATIVE 3A.2

VITRIFICATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3A.2: REMOVAL, STABILIZATION W/VITRIFICATION, OFF-SITE DISPOSAL AT FACILITY 300 MILES FROM FEMP

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-8A	SITE PREPARATION	$768,600	$660,000	$1,428,600
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-12A	VITRIFICATION	$2,935,500	$1,703,600	$4,639,100
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	TRANSPORTATION	$123,200		$123,200
–	DISPOSAL VAULT	$937,100	$1,595,500	$2,532,600
–	PACKAGING (2,412 PKGS. @ $955/PKG.)	$636,800	$1,666,700	$2,303,500
TOTAL CAPITAL		$13,752,400	$14,851,300	$28,603,700
RISK BUDGET (11.0%)		$1,512,800	$1,633,600	$3,146,400
SUBTOTAL		$15,265,200	$16,484,900	$31,750,100
CONTINGENCY (20.0%)		$3,053,000	$3,297,000	$6,350,000
TOTAL ESTIMATED INSTALLED COST		$18,318,200	$19,781,900	$38,100,100
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$11,692,500
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$43,551,900

File: SUM3A2VI.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-8 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CIVIL AND EXCAVATION COSTS	2,750		$45,403		$155,239	$200,600
	ELECTRICAL COSTS	585		$9,659		$77,040	$86,700
	PIPING COSTS	628		$10,368		$3,185	$13,600
	SUBCONCTRACTOR COSTS	5,386			$467,734		$467,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,349	16.50	$65,400	$467,700	$235,500	$768,600
SUPERVISION & SUPPRT LABOR	28.0%			$18,000			$18,000
SMALL TOOLS	$1.50					$14,000	$14,000
CONSUMABLES	$1.50					$14,000	$14,000
EQUIPMENT RENTAL	$3.00					$28,000	$28,[illegible]
TEMP. FACILITIES	4.0%			$900		$1,700	$2,[illegible]
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,600	$4,000
SAFETY	7.0%			$1,600		$3,000	$4,600
HEALTH PHYSICS	20.0%	$87,500		$17,500			$17,500
CERCLA $1,500	PER PERSON	2,000				$7,000	$7,000
BOND	1.0%	$768,600				$7,700	$7,700
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$15,100	$15,100
OVERHEAD & PROFIT	9.0%	$901,700				$81,200	$81,200
EMISSION MODELING	0.50%	$768,600		$1,300		$2,500	$3,800
PSAR/FSAR(SAFE RPT)	0.50%	$768,600		$1,300		$2,500	$3,800
PAYRL BRD.&BENFT.	52.0%	$107,600		$56,000			$56,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$163,600		$415,200	$1,046,500
CONSTR. MGMT.	4.0%	$1,046,500					$41,900
SUB-TOTAL 3							$1,088,400
SOIL/WATER/AIR	1.0%	$768,600		$2,700		$5,000	$7,700
HOME OFFICE EXP.	1.0%	$1,088,400					$10,900
PROJ.MGMT.FERMCO	8.0%	$1,088,400					$87,100
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$209,300
SUB-TOTAL 4	OFFICE COSTS						$1,403,400
SALES TAX	6.0%	$420,200					$25,200
SUB-TOTAL 5							$1,428,600
RISK BUDGET	11.0%						$157,100
SUB-TOTAL 6							$1,585,700
CONTINGENCY	20.0%						$317,100
TOTAL ESTIMATED INSTALLED COST							$1,902,8[illegible]

EST.FILE #: 3096-8.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
-		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
14	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
15	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
16	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
18	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	$66
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,963	$235,464	$65,430	-	$300,894

614

-5099

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,234	$13,234
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$467,734	$467,734
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,349	$235,464	$65,430	$467,734	$768,628

5089

615

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

-5039

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0%	$234,800		$47,000			$47,000
CERCLA $1,500	PER PERSON	2,000				$8,900	$8,900
BOND	1.0%	$1,008,500				$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$24,300	$24,300
OVERHEAD & PROFIT	9.0%	$1,250,400				$112,500	$112,500
EMISSION MODELING	0.50%	$1,008,500		$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50%	$1,008,500		$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0%	$285,400		$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0%	$1,521,500					$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0%	$1,008,500		$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0%	$1,582,400					$15,800
PROJ.MGMT.FERMCO	8.0%	$1,582,400					$126,600
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0%	$572,100					$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN HHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY- CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

5098

6-1

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-12 A
CLIENT: US DO[redacted]
PROJECT TIT[redacted] EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	VITRIFICATION EQUIPMENT COSTS	1,348		$23,776		$528,488	$552,300
	RADON TREATMENT SYSTEM COSTS	375		$6,614		$17,932	$24,500
	OFF-GAS SYSTEM COSTS	880		$15,521		$103,136	$118,700
	SUBCONTRACTOR COSTS (ADJ. TO CURRENT COST)	1,380			$2,240,000		$2,240,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	3,983	16.50	$45,900	$2,240,000	$649,600	$2,935,500
SUPERVISION & SUPPRT LABOR	28.0%			$13,000			$13,000
SMALL TOOLS	$1.50					$6,000	$6,000
CONSUMABLES	$1.50					$6,000	$6,000
EQUIPMENT RENTAL	$3.00					$11,900	$11,900
TEMP. FACILITIES	4.0%			$600		$1,200	$1,800
TEMP. UTILITIES	1.0%			$200		$300	$500
JOB CLEAN-UP	6.0%			$1,000		$1,800	$2,[illegible]
SAFETY	7.0%			$1,100		$2,100	$3,2[illegible]
HEALTH PHYSICS	20.0%	$61,800		$12,400			$12,400
CERCLA $1,500	PER PERSON	2,000				$3,000	$3,000
BOND	1.0%	$2,935,500				$29,400	$29,400
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$34,800	$34,800
OVERHEAD & PROFIT	9.0%	$3,060,300				$275,400	$275,400
EMISSION MODELING	0.50%	$2,935,500		$5,100		$9,500	$14,600
PSAR/FSAR(SAFE RPT)	0.50%	$2,935,500		$5,100		$9,500	$14,600
PAYRL BRD.&BENFT.	52.0%	$84,400		$43,900			$43,900
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$128,300		$1,040,500	$3,408,800
CONSTR. MGMT.	4.0%	$3,408,800					$136,400
SUB-TOTAL 3							$3,545,200
SOIL/WATER/AIR	1.0%	$2,935,500		$10,300		$19,100	$29,400
HOME OFFICE EXP.	1.0%	$3,545,200					$35,500
PROJ.MGMT.FERMCO	8.0%	$3,545,200					$283,600
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$681,800
SUB-TOTAL 4	OFFICE COSTS						$4,575,500
SALES TAX	6.0%	$1,059,600					$63,600
SUB-TOTAL 5							$4,639,100
RISK BUDGET	11.0%						$510,300
SUB-TOTAL 6							$5,149,400
CONTINGENCY	20.0%						$1,029,900
TOTAL ESTIMATED INSTALLED COST							$6,179,300

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

-5039

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0%	$1,768,367		$353,700			$353,700
CERCLA $1,500	PER PERSON	2,000				$55,500	$55,500
BOND	1.0%	$6,655,385				$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$332,700	$332,700
OVERHEAD & PROFIT	9.0%	$8,513,685				$766,200	$766,200
EMISSION MODELING	0.50%	$6,655,385		$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50%	$6,655,385		$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0%	$2,145,267		$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0%	$10,461,800					$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0%	$6,655,385		$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0%	$10,880,300					$108,800
PROJ.MGMT.FERMCO	8.0%	$10,880,300					$870,400
ENGINEERING	20.0% Title I	7.0% Title II	10.0%	Title III	3.0%		$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0%	$7,244,300					$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3A.2 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL AT FACILITY,WITHIN 300 MILES OF FEMP.(SILO 1 & 2)
OPERATION & MAINTENANCE COSTS.-VITRIFICATION OPTION.

FY 93-1 DOLLARS

06/09/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	1,880,296	GALS	-	$37,606	-	-	$37,606
2	SODA ASH	4,112,640	LBS	-	$318,730	-	-	$318,730
3	CARBON	41,126	LBS	-	$28,788	-	-	$28,788
4	ELECTRICITY	18,521,530	KWHR	-	$846,619	-	-	$846,619
5	CRAFT LABOR.	300,000	HRS	300,000	-	$10,164,000	-	$10,164,000
6	SUPERVISION LABOR.	4,424	HRS	4,424	-	$296,762	-	$296,762
	SUBTOTAL OPERATION & MAINTENACE COSTS.-VITRIFICATION OPTION	1	LS	304,424	$1,231,743	$10,460,762	-	$11,692,505

ALTERNATIVE 3A.2

CEMENT STABILIZATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3A.2: REMOVAL, CEMENT STABILIZATION, OFF-SITE DISPOSAL AT FACILITY 300 MILES FROM FEMP

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-8A	SITE PREPARATION	$768,600	$660,000	$1,428,600
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-12A	VITRIFICATION	$2,935,500	$1,703,600	$4,639,100
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	TRANSPORTATION	$541,500		$541,500
–	DISPOSAL VAULT	$5,831,000	$9,928,400	$15,759,400
–	PACKAGING (15,009 PKGS. @ $955/PKG.)	$3,962,400	$10,371,200	$14,333,600
TOTAL CAPITAL		$22,390,200	$31,888,700	$54,278,900
RISK BUDGET (11.0%)		$2,462,900	$3,507,800	$5,970,700
SUBTOTAL		$24,853,100	$35,396,500	$60,249,600
CONTINGENCY (20.0%)		$4,970,600	$7,079,300	$12,049,900
TOTAL ESTIMATED INSTALLED COST		$29,823,700	$42,475,800	$72,299,500
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$11,715,700
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$73,485,300

623

-5089

File: SUM3A2CE.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-8 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CIVIL AND EXCAVATION COSTS	2,750		$45,403		$155,239	$200,600
	ELECTRICAL COSTS	585		$9,659		$77,040	$86,700
	PIPING COSTS	628		$10,368		$3,185	$13,600
	SUBCONCTRACTOR COSTS	5,386			$467,734		$467,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,349	16.50	$65,400	$467,700	$235,500	$768,600
SUPERVISION & SUPPRT LABOR	28.0%			$18,000			$18,000
SMALL TOOLS	$1.50					$14,000	$14,000
CONSUMABLES	$1.50					$14,000	$14,000
EQUIPMENT RENTAL	$3.00					$28,000	$28,000
TEMP. FACILITIES	4.0%			$900		$1,700	$2,600
TEMP. UTILITIES	1.0%			$200		$400	$6[illegible]
JOB CLEAN-UP	6.0%			$1,400		$2,600	$4,00[illegible]
SAFETY	7.0%			$1,600		$3,000	$4,600
HEALTH PHYSICS	20.0%	$87,500		$17,500			$17,500
CERCLA $1,500	PER PERSON	2,000				$7,000	$7,000
BOND	1.0%	$768,600				$7,700	$7,700
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$15,100	$15,100
OVERHEAD & PROFIT	9.0%	$901,700				$81,200	$81,200
EMISSION MODELING	0.50%	$768,600		$1,300		$2,500	$3,800
PSAR/FSAR(SAFE RPT)	0.50%	$768,600		$1,300		$2,500	$3,800
PAYRL BRD.&BENFT.	52.0%	$107,600		$56,000			$56,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$163,600		$415,200	$1,046,500
CONSTR. MGMT.	4.0%	$1,046,500					$41,900
SUB-TOTAL 3							$1,088,400
SOIL/WATER/AIR	1.0%	$768,600		$2,700		$5,000	$7,700
HOME OFFICE EXP.	1.0%	$1,088,400					$10,900
PROJ.MGMT.FERMCO	8.0%	$1,088,400					$87,100
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$209,300
SUB-TOTAL 4	OFFICE COSTS						$1,403,400
SALES TAX	6.0%	$420,200					$25,200
SUB-TOTAL 5							$1,428,600
RISK BUDGET	11.0%						$157,100
SUB-TOTAL 6							$1,585,700
CONTINGENCY	20.0%						$317,100
TOTAL ESTIMATED INSTALLED COST							$1,902,800

EST.FILE #: 3096-8.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
-		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
14	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
15	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
16	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
18	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	$66
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,963	$235,464	$65,430	-	$300,894

625

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ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,234	$13,234
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$467,734	$467,734
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,349	$235,464	$65,430	$467,734	$768,628

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

-5039

EST FILE #: 3096-5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0%	$234,800		$47,000			$47,000
CERCLA $1,500	PER PERSON	2,000				$8,900	$8,900
BOND	1.0%	$1,008,500				$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$24,300	$24,300
OVERHEAD & PROFIT	9.0%	$1,250,400				$112,500	$112,500
EMISSION MODELING	0.50%	$1,008,500		$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50%	$1,008,500		$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0%	$285,400		$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0%	$1,521,500					$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0%	$1,008,500		$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0%	$1,582,400					$15,800
PROJ.MGMT.FERMCO	8.0%	$1,582,400					$126,600
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0%	$572,100					$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING - PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-12 A
CLIENT: US DOE
PROJECT TITLE: VITRIFICATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	VITRIFICATION EQUIPMENT COSTS	1,348		$23,776		$528,488	$552,300
	RADON TREATMENT SYSTEM COSTS	375		$6,614		$17,932	$24,500
	OFF-GAS SYSTEM COSTS	880		$15,521		$103,136	$118,700
	SUBCONTRACTOR COSTS (ADJ. TO CURRENT COST)	1,380			$2,240,000		$2,240,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	3,983	16.50	$45,900	$2,240,000	$649,600	$2,935,500
SUPERVISION & SUPPRT LABOR	28.0%			$13,000			$13,000
SMALL TOOLS	$1.50					$6,000	$6,000
CONSUMABLES	$1.50					$6,000	$6,000
EQUIPMENT RENTAL	$3.00					$11,900	$11,900
TEMP. FACILITIES	4.0%			$600		$1,200	$1,800
TEMP. UTILITIES	1.0%			$200		$300	$500
JOB CLEAN-UP	6.0%			$1,000		$1,800	$2,8[illegible]
SAFETY	7.0%			$1,100		$2,100	$3,2[illegible]
HEALTH PHYSICS	20.0% $61,800			$12,400			$12,400
CERCLA $1,500	PER PERSON 2,000					$3,000	$3,000
BOND	1.0% $2,935,500					$29,400	$29,400
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$34,800	$34,800
OVERHEAD & PROFIT	9.0% $3,060,300					$275,400	$275,400
EMISSION MODELING	0.50% $2,935,500			$5,100		$9,500	$14,600
PSAR/FSAR(SAFE RPT)	0.50% $2,935,500			$5,100		$9,500	$14,600
PAYRL BRD.&BENFT.	52.0% $84,400			$43,900			$43,900
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$128,300		$1,040,500	$3,408,800
CONSTR. MGMT.	4.0% $3,408,800						$136,400
SUB-TOTAL 3							$3,545,200
SOIL/WATER/AIR	1.0% $2,935,500			$10,300		$19,100	$29,400
HOME OFFICE EXP.	1.0% $3,545,200						$35,500
PROJ.MGMT.FERMCO	8.0% $3,545,200						$283,600
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$681,800
SUB-TOTAL 4	OFFICE COSTS						$4,575,500
SALES TAX	6.0% $1,059,600						$63,600
SUB-TOTAL 5							$4,639,100
RISK BUDGET	11.0%						$510,300
SUB-TOTAL 6							$5,149,400
CONTINGENCY	20.0%						$1,029,900
TOTAL ESTIMATED INSTALLED COST							$6,179,300

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

5039

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0% $1,768,367			$353,700			$353,700
CERCLA $1,500	PER PERSON 2,000					$55,500	$55,500
BOND	1.0% $6,655,385					$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$332,700	$332,700
OVERHEAD & PROFIT	9.0% $8,513,685					$766,200	$766,200
EMISSION MODELING	0.50% $6,655,385			$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50% $6,655,385			$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0% $2,145,267			$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0% $10,461,800						$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0% $6,655,385			$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0% $10,880,300						$108,800
PROJ.MGMT.FERMCO	8.0% $10,880,300						$870,400
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0% $7,244,300						$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3A.2 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL AT FACILITY,WITHIN 300 MILES OF FEMP.(SILO 1 & 2)
OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/09/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	8,528,000	GALS	-	$170,560	-	-	$170,560
2	BLAST FURNACE SLAG.	6,324,000	LBS	-	$94,860	-	-	$94,860
3	CEMENT	13,264,000	LBS	-	$437,712	-	-	$437,712
4	FLYASH	3,787,000	LBS	-	$22,722	-	-	$22,722
5	ELECTRICITY	11,575,780	KWHR	-	$529,129	-	-	$529,129
6	CRAFT LABOR.	300,000	HRS	300,000	-	$10,164,000	-	$10,164,000
7	SUPERVISION LABOR.	4,424	HRS	4,424	-	$296,762	-	$296,762
	SUBTOTAL OPERATION & MAINTENACE COSTS.-CEMENT STABILIZATION OPTION	1	LS	304,424	$1,254,983	$10,460,762	-	$11,715,745

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ALTERNATIVE 4A

VITRIFICATION

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 4A: REMOVAL, CHEMICAL EXTRACTION, STABILIZATION W/VITRIFICATION, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-6A	SITE PREPARATION	$780,500	$676,400	$1,456,900
3096-5A	WASTE PROCESSING	$1,008,500	$1,065,000	$2,073,500
3096-9A	CHEMICAL EXTRACTION EQUIPMENT	$10,154,300	$7,246,700	$17,401,000
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	DISPOSAL VAULT	$2,488,000	$4,236,200	$6,724,200
–	PACKAGING (6,404 PKGS. @ $955/PKG.)	$1,690,700	$4,425,200	$6,115,900
TOTAL CAPITAL		$22,777,400	$25,447,300	$48,224,700
RISK BUDGET (11.0%)		$2,505,500	$2,799,200	$5,304,700
SUBTOTAL		$25,282,900	$28,246,500	$53,529,400
CONTINGENCY (20.0%)		$5,056,600	$5,649,300	$10,705,900
TOTAL ESTIMATED INSTALLED COST		$30,339,500	$33,895,800	$64,235,300
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$29,188,000
POST-REMEDIATION				$3,462,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$83,146,200

634

-5089

File: SUM4AVIT.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-6 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	4,148		$68,485		$243,764	$312,200
	SUBCONCTRACTOR COSTS	5,386			$468,274		$468,300
SUB-TOTAL 1	DIRECT FIELD COSTS	9,534	AVG. 17.00	$68,500	$468,300	$243,800	$780,500
SUPERVISION & SUPPRT LABOR	28.0%			$19,000			$19,000
SMALL TOOLS	$1.50					$14,300	$14,300
CONSUMABLES	$1.50					$14,300	$14,300
EQUIPMENT RENTAL	$3.00					$28,600	$28,600
TEMP. FACILITIES	4.0%			$1,000		$1,800	$2,800
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,700	$4,1[illegible]
SAFETY	7.0%			$1,700		$3,100	$4,8[illegible]
HEALTH PHYSICS	20.0% $91,800			$18,400			$18,400
CERCLA	$1,500 PER PERSON 2,000					$7,200	$7,200
BOND	1.0% $780,500					$7,800	$7,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$15,600	$15,600
OVERHEAD & PROFIT	9.0% $918,000					$82,600	$82,600
EMISSION MODELING	0.50% $780,500			$1,400		$2,500	$3,900
PSAR/FSAR(SAFE RPT)	0.50% $780,500			$1,400		$2,500	$3,900
PAYRL BRD.&BENFT.	52.0% $113,000			$58,800			$58,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$171,800		$427,200	$1,067,200
CONSTR. MGMT.	4.0% $1,067,200						$42,700
SUB-TOTAL 3							$1,109,900
SOIL/WATER/AIR	1.0% $780,500			$2,700		$5,100	$7,800
HOME OFFICE EXP.	1.0% $1,109,900						$11,100
PROJ.MGMT.FERMCO	8.0% $1,109,900						$88,800
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$213,400
SUB-TOTAL 4	OFFICE COSTS						$1,431,000
SALES TAX	6.0% $432,300						$25,900
SUB-TOTAL 5							$1,456,900
RISK BUDGET	11.0%						$160,300
SUB-TOTAL 6							$1,617,200
CONTINGENCY	20.0%						$323,400
TOTAL ESTIMATED INSTALLED COST							$1,940,600

EST.FILE #: 3096-6.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
14	TRANSFORMER,120 KVA,480 VAC 3 PHASE, TO 240/120 VAC 1 PHASE.	1	EA	125	$3,300	$2,064	-	$5,364
	SUBTOTAL.	1	LS	3,460	$235,579	$57,126	-	$292,705

636

039

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRY FORWARD	1	LS	3,460	$235,579	$57,126	-	$292,705
							-	
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
17	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
							-	
-	SEWER:	-	-	-	-	-	-	
18	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
19	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	
20	STEAM BOILER, ELECTRIC, 141,500 BTUH, 150 #/HR, 30 PSIG.	1	EA	60	$5,000	$991	-	$5,991
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	4,148	$243,764	$68,485	-	$312,249

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$468,274	$468,274
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,534	$243,764	$68,485	$468,274	$780,523

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-5089

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

-5039

EST FILE #: 3096-5 A
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY

ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD
DATE 24-Aug-93

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	AVG. 14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0%	$234,800		$47,000			$47,000
CERCLA $1,500	PER PERSON	2,000				$8,900	$8,900
BOND	1.0%	$1,008,500				$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$24,300	$24,300
OVERHEAD & PROFIT	9.0%	$1,250,400				$112,500	$112,500
EMISSION MODELING	0.50%	$1,008,500		$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50%	$1,008,500		$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0%	$285,400		$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0%	$1,521,500					$60,900
SUB-TOTAL 3							$1,582,400
SOIL/WATER/AIR	1.0%	$1,008,500		$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0%	$1,582,400					$15,800
PROJ.MGMT.FERMCO	8.0%	$1,582,400					$126,600
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%	Title III 3.0%				$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0%	$572,100					$34,300
SUB-TOTAL 5							$2,073,500
RISK BUDGET	11.0%						$228,100
SUB-TOTAL 6							$2,301,600
CONTINGENCY	20.0%						$460,300
TOTAL ESTIMATED INSTALLED COST							$2,761,900

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING - PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

3089

639

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

-5038

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-9 A 5039
CLIENT: US DOE
PROJECT TITLE: CHEMICAL EXTRACTION / VITRIFICATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY AND EQUIPMENT COSTS	17,123		$302,060		$9,572,284	$9,874,300
	SUBCONTRACTOR COSTS				$280,000		$280,000
SUB-TOTAL 1	DIRECT FIELD COSTS	17,123	AVG. 17.64	$302,100	$280,000	$9,572,300	$10,154,300
SUPERVISION & SUPPRT LABOR	28.0%			$85,000			$85,000
SMALL TOOLS	$1.50					$25,700	$25,700
CONSUMABLES	$1.50					$25,700	$25,700
EQUIPMENT RENTAL	$3.00					$51,400	$51,400
TEMP. FACILITIES	4.0%			$4,200		$7,900	$12[illegible]
TEMP. UTILITIES	1.0%			$1,100		$2,000	$3[illegible]
JOB CLEAN-UP	6.0%			$6,300		$11,800	$18,100
SAFETY	7.0%			$7,400		$13,700	$21,100
HEALTH PHYSICS	20.0%	$406,100		$81,200			$81,200
CERCLA $1,500	PER PERSON	2,000				$12,800	$12,800
BOND	1.0%	$10,154,300				$101,500	$101,500
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$493,700	$493,700
OVERHEAD & PROFIT	9.0%	$11,085,700				$997,700	$997,700
EMISSION MODELING	0.50%	$10,154,300		$17,800		$33,000	$50,800
PSAR/FSAR(SAFE RPT)	0.50%	$10,154,300		$17,800		$33,000	$50,800
PAYRL BRD.&BENFT.	52.0%	$522,900		$271,900			$271,900
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$794,800		$11,382,200	$12,456,900
CONSTR. MGMT.	4.0%	$12,456,900					$498,300
SUB-TOTAL 3							$12,955,200
SOIL/WATER/AIR	1.0%	$10,154,300		$35,500		$66,000	$101,500
HOME OFFICE EXP.	1.0%	$12,955,200					$129,600
PROJ.MGMT.FERMCO	8.0%	$12,955,200					$1,036,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$2,491,400
SUB-TOTAL 4	OFFICE COSTS						$16,714,100
SALES TAX	6.0%	$11,448,200					$686,900
SUB-TOTAL 5							$17,401,000
RISK BUDGET	11.0%						$1,914,100
SUB-TOTAL 6							$19,315,100
CONTINGENCY	20.0%						$3,863,000
TOTAL ESTIMATED INSTALLED COST							$23,178,1[illegible]

EST.FILE #: 3096-9.

SILO 1. & 2.

CHEMICAL EXTRACTION/VITRIFICATION EQUIPMENT.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CHEMICAL EXTRACTION,-EQUIPMENT CAPITAL COST ESTIMATE							
1	M-201,M-202,AGITATORS-STAGES 1 &2,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	56	$40,000	$988		$40,988
2	M-301-M-306,AGITATORS-STAGES 1 &6,RINSE TANK C.S.RUBBER LINED	6	EA.	168	$120,000	$2,964		$122,964
3	M-203-M204,AGITATORS-STAGES 3 &4,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
4	M-205-M-206,AGITATORS-STAGES 5 &6,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
5	M-403,AGITATOR EDTA CRYSTALLIZER,C.S.RUBBER LINED.	1	EA.	24	$15,000	$423		$15,423
6	M-404,AGITATOR EDTA DISSOLVER,C.S.RUBBER LINED.	1	EA.	32	$18,000	$564		$18,564
7	M-503,AGITATOR-FLASH MIX TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
8	M-504,AGITATOR-FLOCCULATION TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
9	M-105,AGITATORS-KCL MIX TANK,C.S.RUBBER LINED	1	EA.	24	$18,000	$423		$18,423
10	M-108,AGITATOR-KCL SOAK TANK C.S. RUBBER LINED.	1	EA.	40	$50,000	$706		$50,706
11	M-106,AGITATOR-KCL TANK C.S.RUBBER LINED.	1	EA.	36	$40,000	$635		$40,635
12	F-201-F-206,BELT FILTERS-STAGES 1-6, 304 S.S.,3'X9'.	6	EA.	1,200	$1,110,000	$21,168		$1,131,168
13	F-106,BELT FILTER-KCL/SOLIDS,316L S.S.BELT FILTER.	1	EA.	200	$185,000	$3,528		$188,528
14	F-501,BELT FILTER-SLUDGE, BELT FILTER PRESS	1	EA.	200	$140,000	$3,528		$143,528
15	F-101,BELT FILTER-SLURRY, BELT FILTER,3'X10'.	1	EA.	200	$185,000	$3,528		$188,528
16	F-301-F-306,CENTRIFUGES- STAGES 1-6,304 S.S.CENTRIFUGES	6	EA.	600	$600,000	$10,584		$610,584
17	T-505,CLARIFIER, EPOXY COATED STEEL	1	EA.	80	$20,000	$1,411		$21,411
18	M-505,CLARIFIER RAKE, EPOXY COATED STEEL.	1	EA.	4	$0	$71		$71
19	C-101,CONVEYOR-ADDITIVES	1	EA.	40	$11,306	$706		$12,012
20	D-501,DRYER-SLUDGE, GAS FIRED COUNTER CURRENT DRYER.	1	EA.	200	$550,000	$3,528		$553,528
21	F-401,FILTER-FILTER, 3'X6' BELT FILTER ACID PROOF.	1	EA.	200	$185,000	$3,528		$188,528
22	H-101,HOPPER-ADDITIVES	1	EA.	80	$5,000	$1,411		$6,411
23	H-101,HOPPER-KCL,C.S.RUBBER LINED, 5,000 LBS.	1	EA.	80	$5,000	$1,411		$6,411
24	P-201-P-206,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
25	P-301-P-306,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
26	P-505,PUMP-CLARIFIER SLUDGE PUMP,POSITIVE DISPLACEMENT,	1	EA.	25	$2,200	$441		$2,641
-	LINED, 0.7 GPM.	-	-	-	-	-		-
27	P-404,PUMP-EDTA CIRCULATING,CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
28	P-405, PUMP-EDTA FEED CENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
29	P-403, PUMP EDTA,SLURRY, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
30	P-104, PUMP FILTRATECENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
	SUBTOTAL THIS PAGE.			4,305	$3,466,506	$75,942	-	$3,542,448

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A- REMOVAL,STABILIZATION,ON-PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	CARRYFORWARD			4,305	$3,466,506	$75,942	-	$3,542,448
31	P-402,PUMP-HCL,PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	-	$2,441
32	P-106,PUMP-KCL, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
33	P-105,'PUMP-KCL MIX TANK PUMP, CENTRIFUGAL, RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
34	P-108,PUMP-KCL SOLIDS SLURRY PUMP,CENTRIFUGAL,RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
35	P-502,PUMP-NALMET PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	-	$2,441
36	P-501,PUMP-NaOH,PLASTIC METERING, 0.25 gpm.	1	EA.	25	$1,500	$441	-	$1,941
37	P-401,PUMP-NH3, PLASTIC METERING, 0.7 GPM.	1	EA.	25	$2,000	$441	-	$2,441
38	P-101,PUMP-SLURRY,CENTRIFUGAL RUBBER LINED,32 GPM.	1	EA.	40	$4,000	$706	-	$4,706
39	P-207,PUMP-STRONG EXTRACT, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	-	$4,706
40	P-406,PUMP-WEAK CENTRATE, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	-	$4,706
41	S-402,SCRUBBER-HCL,FIBERGLAS, 1,000CFM.	1	EA.	48	$8,800	$847	-	$9,647
42	S-401,SCRUBBER-NH3, FIBERGLASS, 250 CFM.	1	EA.	48	$12,400	$847	-	$13,247
43	SI-103,STEAM INJECTORS-STAGES 5&6 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
44	SI-105,STEAM INJECTORS-EDTA TANKS	2	EA.	40	$3,460	$706	-	$4,166
45	SI-101,STEAM INJECTORS-STAGES 1&2 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
46	SI-104,STEAM INJECTORS-STAGES 1-6 RINSE TANKS	6	EA.	120	$10,380	$2,117	-	$12,497
47	SI-102,STEAM INJECTORS-STAGES 3&4 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
48	B-101,BOILER FOR STEAM INJECTION,ROUGH ESTIMATE OF SIZING,225,000 LBS.	1	EA.	400	$930,000	$7,056	-	$937,056
49	T-502,TANK-NALMET,FIBERGLASS,3,000 GALLONS.	1	EA.	20	$4,948	$353	-	$5,301
50	T-402,TANK-HCL STORAGE,FIBERGLASS,7,500 GALLONS.	1	EA.	40	$6,426	$706	-	$7,132
51	T-401,TANK-NH3 STORAGE,FIBERGLASS,10,000 GALLONS.	1	EA.	40	$7,063	$706	-	$7,769
52	T-503,TANK-FLASH MIX,PLASTIC, 30 GALLONS.	1	EA.	4	$300	$71	-	$371
53	T-504,TANK-FLOCCULATION, PLASTIC, 300 GALLONS.	1	EA.	8	$1,000	$141	-	$1,141
54	T-501,TANK-NaOH, STEEL, 1,000 GALLONS.	1	EA.	20	$3,000	$353	-	$3,353
55	T-403,TANK-EDTA CRYSTALLIZER TANK,CARBON STEEL,RUBBER LINED,1,000 GAL.	1	EA.	20	$3,000	$353	-	$3,353
56	T-105,TANK-KCL MIX, RUBBER LINED, 2,000 GALLONS.	1	EA.	40	$5,000	$706	-	$5,706
57	T-301-T-306,TANKS-STAGES 1-6 RINSE,RUBBER LINED,3,000 GALLONS.	6	EA.	100	$36,000	$1,764	-	$37,764
58	T-201,T-202,TANKS-STAGES 1 & 2 EXTRACTION,RUBBER LINED,3,000 GALS.	2	EA.	40	$12,000	$706	-	$12,706
59	T-404,TANK-EDTA DISSOLVER, CARBON STEEL, RUBBER LINED, 5,000 GALS.	1	EA.	40	$7,000	$706	-	$7,706
60	T-203,T-204,TANKS-STAGES 3&4 EXTRACTION, RUBBER LINED,6,000 GALLONS.	2	EA.	80	$14,000	$1,411	-	$15,411
61	T-207,TANK,STRONG EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	-	$7,706
62	T-406,TANK WEAK EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	-	$7,706
	SUBTOTAL THIS PAGE.			5,953	$4,587,163	$105,021	-	$4,692,184

-5088

FERNALD PROJECT – OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93–1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			5,953	$4,587,163	$105,021	–	$4,692,184
63	T–106,TANK–KCL RUBBER LINED,10,000 GALLONS.	1	EA.	40	$8,000	$706	–	$8,706
64	T–205,T–206,TANKS–STAGES 5&6, RUBBER LINED,12,000 GALLONS.	2	EA.	80	$17,000	$1,411	–	$18,411
65	T–405,TANK–EDTA STORAGE, C.S. RUBBER LINED,15,000 GALLONS.	1	EA.	100	$10,000	$1,764	–	$11,764
66	T–108,TANK–KCL SOAK, RUBBER LINED,15,000 GALLONS.	1	EA.	40	$10,000	$706	–	$10,706
67	T–104,TANK–FILTRATE,CARBON STEEL,15,000 GALLONS.80C.	1	EA.	40	$10,000	$706	–	$10,706
70	I–501,VITRIFIER,OFF–GAS TREATMENT SYSTEM.,1.05 TON PER DAY.	1	EA.	3,200	$871,795	$56,448	–	$928,243
–	OFF–GAS TREATMENT SYSTEM.	1	EA.	800	$217,949	$14,112	–	$232,061
71	INSTRUMENTATION & CONTROL, 15% OF PURCHASED EQUIPMENT COST.	1	LS	1,538	$859,786	$27,130	–	$886,916
72	PROCESS PIPING, 12% OF PURCHASED EQUIPMENT COST.	1	LS	1,230	$687,829	$21,697	–	$709,526
73	ELECTRICAL, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
74	AUXILIARIES, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	17,123	$9,572,284	$302,060	–	$9,874,344
	SUBCONTRACT COSTS			–	–	–	–	–
1	ADDITIVE FEED SYSTEM (PRORATED).	1	LS	–	–	–	$280,000	$280,000
2	PROCESS VESSEL RADON TREATMENT SYSTEM (PRORATED).	1	LS	–	–	–	–	–
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	–	–	–	$280,000	$280,000
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	17,123	$9,572,284	$302,060	$280,000	$10,154,344

5089

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

-5089

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,2
HEALTH PHYSICS	20.0% $1,768,367			$353,700			$353,
CERCLA $1,500	PER PERSON 2,000					$55,500	$55,500
BOND	1.0% $6,655,385					$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$332,700	$332,700
OVERHEAD & PROFIT	9.0% $8,513,685					$766,200	$766,200
EMISSION MODELING	0.50% $6,655,385			$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50% $6,655,385			$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0% $2,145,267			$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0% $10,461,800						$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0% $6,655,385			$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0% $10,880,300						$108,800
PROJ.MGMT.FERMCO	8.0% $10,880,300						$870,400
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0% $7,244,300						$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 4A REMOVAL,CHEMICAL EXTRACTION, STABILIZATION,ON-PROPERTY DISPOSAL.(SILO 1 & 2)
OPERATION AND MAINTENANCE COSTS-VITRIFICATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

A PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	CRAFT LABOR	381,077	MHRS	381,077	-	$12,910,889	-	$12,910,889
2	SUPERVISORY LABOR.	5,803	MHRS	5,803	-	$389,265	-	$389,265
3	PROCESS WATER.	76,084,000	GALS	-	$1,521,680	-	-	$1,521,680
4	LOW PRESSURE STEAM.	-	-	-	INCLUDED	-	-	-
5	WASTE WATER DISCHARGE.	-	-	-	INCLUDED	-	-	-
6	ELECTRICITY-FOR CHEMICAL EXTRACTION MACHINERY, VITRIFICATION UNIT.	15,582,000	KWH	-	$712,253	-	-	$712,253
7	NALMET 8154	5,720	TONS	-	$7,092,800	-	-	$7,092,800
8	DIAMMONIUM EDTA	780	TONS	-	$1,185,980	-	-	$1,185,980
9	KCL (AS POTASSIUM MURIATE)	2,430	TONS	-	$194,400	-	-	$194,400
10	HCL (AS 32% SOLUTION)	15,300	TONS	-	$3,396,600	-	-	$3,396,600
11	NH3 (AS 29% NH3)	4,500	TONS	-	$1,417,343	-	-	$1,417,343
12	FLYASH	10,420	TONS	-	$125,040	-	-	$125,040
13	SODAASH	1,560	TONS	-	$241,800	-	-	$241,800
	SUBTOTAL OPERATIONS			386,880	$15,887,896	$13,300,154	-	$29,188,050

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-5039

ALTERNATIVE 4A

CEMENT STABILIZATION

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 4A: REMOVAL, CHEMICAL EXTRACTION, CEMENT STABILIZATION, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-6A	SITE PREPARATION	$780,500	$676,400	$1,456,900
3096-5A	WASTE PROCESSING	$1,008,500	$1,065,000	$2,073,500
3096-30A	CHEMICAL EXTRACTION EQUIPMENT	$9,314,000	$6,476,200	$15,790,200
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	DISPOSAL VAULT	$4,797,200	$8,168,200	$12,965,400
–	PACKAGING (12,348 PKGS. @ $955/PKG.)	$3,259,900	$8,532,500	$11,792,400
	TOTAL CAPITAL	$25,815,500	$32,716,100	$58,531,600
	RISK BUDGET (11.0%)	$2,839,700	$3,598,800	$6,438,500
	SUBTOTAL	$28,655,200	$36,314,900	$64,970,100
	CONTINGENCY (20.0%)	$5,731,000	$7,263,000	$12,994,000
	TOTAL ESTIMATED INSTALLED COST	$34,386,200	$43,577,900	$77,964,100
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$29,460,800
	POST-REMEDIATION			$3,462,000
	TOTAL PRESENT WORTH COST (CAPITAL AND O&M)			$95,393,000

649

File: [redacted]4ACEM.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

-5039

EST FILE #: 3096-6 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	4,148		$68,485		$243,764	$312,200
	SUBCONCTRACTOR COSTS	5,386			$468,274		$468,300
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,534	17.00	$68,500	$468,300	$243,800	$780,500
SUPERVISION & SUPPRT LABOR	28.0%			$19,000			$19,000
SMALL TOOLS	$1.50					$14,300	$14,300
CONSUMABLES	$1.50					$14,300	$14,300
EQUIPMENT RENTAL	$3.00					$28,600	$28,600
TEMP. FACILITIES	4.0%			$1,000		$1,800	$2,800
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,700	$4,100
SAFETY	7.0%			$1,700		$3,100	$4,800
HEALTH PHYSICS	20.0%	$91,800		$18,400			$18,400
CERCLA $1,500	PER PERSON	2,000				$7,200	$7,200
BOND	1.0%	$780,500				$7,800	$7,800
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$15,600	$15,600
OVERHEAD & PROFIT	9.0%	$918,000				$82,600	$82,600
EMISSION MODELING	0.50%	$780,500		$1,400		$2,500	$3,900
PSAR/FSAR(SAFE RPT)	0.50%	$780,500		$1,400		$2,500	$3,900
PAYRL BRD.&BENFT.	52.0%	$113,000		$58,800			$58,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$171,800		$427,200	$1,067,200
CONSTR. MGMT.	4.0%	$1,067,200					$42,700
SUB-TOTAL 3							$1,109,900
SOIL/WATER/AIR	1.0%	$780,500		$2,700		$5,100	$7,800
HOME OFFICE EXP.	1.0%	$1,109,900					$11,100
PROJ.MGMT.FERMCO	8.0%	$1,109,900					$88,800
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$213,400
SUB-TOTAL 4	OFFICE COSTS						$1,431,000
SALES TAX	6.0%	$432,300					$25,900
SUB-TOTAL 5							$1,456,900
RISK BUDGET	11.0%						$160,300
SUB-TOTAL 6							$1,617,200
CONTINGENCY	20.0%						$323,400
TOTAL ESTIMATED INSTALLED COST							$1,940,600

EST.FILE #: 3096-6.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
14	TRANSFORMER,120 KVA,480 VAC 3 PHASE, TO 240/120 VAC 1 PHASE.	1	EA	125	$3,300	$2,064	-	$5,364
	SUBTOTAL.	1	LS	3,460	$235,579	$57,126	-	$292,705

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRY FORWARD	1	LS	3,460	$235,579	$57,126	-	$292,705
							-	
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
17	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
							-	
-	SEWER:	-	-	-	-	-	-	
18	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
19	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	
20	STEAM BOILER, ELECTRIC, 141,500 BTUH, 150 #/HR, 30 PSIG.	1	EA	60	$5,000	$991	-	$5,991
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	4,148	$243,764	$68,485	-	$312,249

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$468,274	$468,274
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,534	$243,764	$68,485	$468,274	$780,523

-5088

EST FILE #: 3096-5 A 5039
CLIENT: US D
PROJECT TITLE: WASTE PROCESSING FACILITY

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,[illegible]
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10[illegible]
SAFETY	7.0%			$4,300		$8,000	$12,[illegible]
HEALTH PHYSICS	20.0% $234,800			$47,000			$47,000
CERCLA $1,500	PER PERSON 2,000					$8,900	$8,900
BOND	1.0% $1,008,500					$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$24,300	$24,300
OVERHEAD & PROFIT	9.0% $1,250,400					$112,500	$112,500
EMISSION MODELING	0.50% $1,008,500			$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50% $1,008,500			$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0% $285,400			$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0% $1,521,500						$60,900
SUB-TOTAL 3							$1,582,400
SOIL/WATER/AIR	1.0% $1,008,500			$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0% $1,582,400						$15,800
PROJ.MGMT.FERMCO	8.0% $1,582,400						$126,600
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0% $572,100						$34,300
SUB-TOTAL 5							$2,073,500
RISK BUDGET	11.0%						$228,100
SUB-TOTAL 6							$2,301,600
CONTINGENCY	20.0%						$460,300
TOTAL ESTIMATED INSTALLED COST							$2,761,900

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	2	EA	96	$16,600	$1,824		$18,424
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$28,000	$1,824		$29,824
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	38,160	LBS	4,476	$68,020	$85,044		$153,064
16	DAMPER 40,000 CFM.	1	EA	96	$900	$1,824		$2,724
-	PROCESS AREA VENTILATION SYSTEM, RADON.	-	-	-	-	-		-
17	RADON GAS MONITOR	3	EA	32	$21,000	$608		$21,608
18	BLOWER,1,000 CFM,1"SP.	2	EA	16	$3,000	$304		$3,304
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	64	$21,800	$1,216		$23,016
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	16	$2,600	$304		$2,904
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2,700	LBS	332	$5,061	$6,308		$11,369
23	DAMPER 1,000 CFM.	1	EA	16	$400	$304		$704
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-30 A
CLIENT: US DOE
PROJECT TITLE: CHEMICAL EXTRACTION / CEMENT STABILIZATION EQUIPMENT

-5039

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY & EQUIPMENT COSTS	13,123		$231,500		$8,482,540	$8,714,000
	SUBCONTRACTOR COSTS				$600,000		$600,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	13,123	17.64	$231,500	$600,000	$8,482,500	$9,314,000
SUPERVISION & SUPPRT LABOR	28.0%			$65,000			$65,000
SMALL TOOLS	$1.50					$19,700	$19,700
CONSUMABLES	$1.50					$19,700	$19,700
EQUIPMENT RENTAL	$3.00					$39,400	$39,400
TEMP. FACILITIES	4.0%			$3,200		$6,000	$9,200
TEMP. UTILITIES	1.0%			$800		$1,500	$2,300
CLEAN-UP	6.0%			$4,900		$9,000	$13,900
TY	7.0%			$5,700		$10,500	$16,200
HEALTH PHYSICS	20.0%	$311,100		$62,200			$62,200
CERCLA	$1,500	PER PERSON	2,000			$9,800	$9,800
BOND	1.0%	$9,314,000				$93,100	$93,100
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$435,700	$435,700
OVERHEAD & PROFIT	9.0%	$10,100,200		-		$909,000	$909,000
EMISSION MODELING	0.50%	$9,314,000		$16,300		$30,300	$46,600
PSAR/FSAR(SAFE RPT)	0.50%	$9,314,000		$16,300		$30,300	$46,600
PAYRL BRD.&BENFT.	52.0%	$405,900		$211,100			$211,100
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$617,000		$10,096,500	$11,313,500
CONSTR. MGMT.	4.0%	$11,313,500					$452,500
SUB-TOTAL 3							$11,766,000
SOIL/WATER/AIR	1.0%	$9,314,000		$32,600		$60,500	$93,100
HOME OFFICE EXP.	1.0%	$11,766,000					$117,700
PROJ.MGMT.FERMCO	8.0%	$11,766,000					$941,300
ENGINEERING	20.0% Title I	7.0% Title II	10.0%	Title III	3.0%		$2,262,700
SUB-TOTAL 4	OFFICE COSTS						$15,180,800
SALES TAX	6.0%	$10,157,000					$609,400
SUB-TOTAL 5							$15,790,200
RISK BUDGET	11.0%						$1,736,900
SUB-TOTAL 6							$17,527,100
CONTINGENCY	20.0%						$3,505,400
TOTAL ESTIMATED INSTALLED COST							$21,032,500

08/24/93

EST.FILE #:3096-30.

CHEMICAL EXTRACTION/CEMENT STABILIZATION EQUIPMENT.

FY 93-1 DOLLARS

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CHEMICAL EXTRACTION,-EQUIPMENT CAPITAL COST ESTIMATE.							
1	M-201,M-202,AGITATORS-STAGES 1 &2,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	56	$40,000	$988		$40,988
2	M-301-M-306,AGITATORS-STAGES 1 &6,RINSE TANK C.S.RUBBER LINED	6	EA.	168	$120,000	$2,964		$122,964
3	M-203-M204,AGITATORS-STAGES 3 &4,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
4	M-205-M-206,AGITATORS-STAGES 5 &6,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
5	M-403,AGITATOR EDTA CRYSTALLIZER,C.S.RUBBER LINED.	1	EA.	24	$15,000	$423		$15,423
6	M-404,AGITATOR EDTA DISSOLVER,C.S.RUBBER LINED.	1	EA.	32	$18,000	$564		$18,564
7	M-503,AGITATOR-FLASH MIX TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
8	M-504,AGITATOR-FLOCCULATION TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
9	M-105,AGITATORS-KCL MIX TANK,C.S.RUBBER LINED	1	EA.	24	$18,000	$423		$18,423
10	M-108,AGITATOR-KCL SOAK TANK C.S. RUBBER LINED.	1	EA.	40	$50,000	$706		$50,706
11	M-106,AGITATOR-KCL TANK C.S.RUBBER LINED.	1	EA.	36	$40,000	$635		$40,635
12	F-201-F-206,BELT FILTERS-STAGES 1-6, 304 S.S.,3'X9'.	6	EA.	1,200	$1,110,000	$21,168		$1,131,168
13	F-106,BELT FILTER-KCL/SOLIDS,316L S.S.BELT FILTER.	1	EA.	200	$185,000	$3,528		$188,528
14	F-501,BELT FILTER-SLUDGE, BELT FILTER PRESS	1	EA.	200	$140,000	$3,528		$143,528
15	F-101,BELT FILTER-SLURRY, BELT FILTER,3'X10'.	1	EA.	200	$185,000	$3,528		$188,528
16	F-301-F-306,CENTRIFUGES- STAGES 1-6,304 S.S.CENTRIFUGES	6	EA.	600	$600,000	$10,584		$610,584
17	T-505,CLARIFIER, EPOXY COATED STEEL	1	EA.	80	$20,000	$1,411		$21,411
18	M-505,CLARIFIER RAKE, EPOXY COATED STEEL.	1	EA.	4	$0	$71		$71
19	C-101,CONVEYOR-ADDITIVES	1	EA.	40	$11,306	$706		$12,012
20	D-501,DRYER-SLUDGE, GAS FIRED COUNTER CURRENT DRYER.	1	EA.	200	$550,000	$3,528		$553,528
21	F-401,FILTER-FILTER, 3'X6' BELT FILTER ACID PROOF.	1	EA.	200	$185,000	$3,528		$188,528
22	H-101,HOPPER-ADDITIVES	1	EA.	80	$5,000	$1,411		$6,411
23	H-101,HOPPER-KCL,C.S.RUBBER LINED, 5,000 LBS.	1	EA.	80	$5,000	$1,411		$6,411
24	P-201-P-206,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
25	P-301-P-306,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
26	P-505,PUMP-CLARIFIER SLUDGE PUMP,POSITIVE DISPLACEMENT,	1	EA.	25	$2,200	$441		$2,641
-	LINED, 0.7 GPM.	-	-	-	-	-		-
27	P-404,PUMP-EDTA CIRCULATING,CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
28	P-405, PUMP-EDTA FEED CENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
29	P-403, PUMP EDTA,SLURRY, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
30	P-104, PUMP FILTRATECENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
	SUBTOTAL THIS PAGE.			4,305	$3,466,506	$75,942	-	$3,542,448

-5089

FERNALD PROJECT – OU4

08/24/93

I. T.PROJECT NO.:409194

ESTIMATOR: F.H.GASLIGHTWALA

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

PROJ.ENGR: JOE PACELLI

SUMMARY OF CAPITAL COSTS.

PROJ. MGR: SUSAN RHYNE.

FY 93–1 DOLLARS

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			4,305	$3,466,506	$75,942	–	$3,542,448
31	P–402,PUMP–HCL,PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	–	$2,441
32	P–106,PUMP–KCL, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
33	P–105,'PUMP–KCL MIX TANK PUMP, CENTRIFUGAL, RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
34	P–108,PUMP–KCL SOLIDS SLURRY PUMP,CENTRIFUGAL,RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
35	P–502,PUMP–NALMET PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	–	$2,441
36	P–501,PUMP–NaOH,PLASTIC METERING, 0.25 gpm.	1	EA.	25	$1,500	$441	–	$1,941
37	P–401,PUMP–NH3, PLASTIC METERING, 0.7 GPM.	1	EA.	25	$2,000	$441	–	$2,441
38	P–101,PUMP–SLURRY,CENTRIFUGAL RUBBER LINED,32 GPM.	1	EA.	40	$4,000	$706	–	$4,706
39	P–207,PUMP–STRONG EXTRACT, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	–	$4,706
40	P–406,PUMP–WEAK CENTRATE, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	–	$4,706
41	S–402,SCRUBBER–HCL,FIBERGLAS, 1,000CFM.	1	EA.	48	$8,800	$847	–	$9,647
42	S–401,SCRUBBER–NH3, FIBERGLASS, 250 CFM.	1	EA.	48	$12,400	$847	–	$13,247
43	SI–103,STEAM INJECTORS–STAGES 5&6 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
44	SI–105,STEAM INJECTORS–EDTA TANKS	2	EA.	40	$3,460	$706	–	$4,166
45	SI–101,STEAM INJECTORS–STAGES 1&2 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
46	SI–104,STEAM INJECTORS–STAGES 1–6 RINSE TANKS	6	EA.	120	$10,380	$2,117	–	$12,497
47	SI–102,STEAM INJECTORS–STAGES 3&4 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
48	B–101,BOILER FOR STEAM INJECTION,ROUGH ESTIMATE OF SIZING,225,000 LBS.	1	EA.	400	$930,000	$7,056	–	$937,056
49	T–502,TANK–NALMET,FIBERGLASS,3,000 GALLONS.	1	EA.	20	$4,948	$353	–	$5,301
50	T–402,TANK–HCL STORAGE,FIBERGLASS,7,500 GALLONS.	1	EA.	40	$6,426	$706	–	$7,132
51	T–401,TANK–NH3 STORAGE,FIBERGLASS,10,000 GALLONS.	1	EA.	40	$7,063	$706	–	$7,769
52	T–503,TANK–FLASH MIX,PLASTIC, 30 GALLONS.	1	EA.	4	$300	$71	–	$371
53	T–504,TANK–FLOCCULATION, PLASTIC, 300 GALLONS.	1	EA.	8	$1,000	$141	–	$1,141
54	T–501,TANK–NaOH, STEEL, 1,000 GALLONS.	1	EA.	20	$3,000	$353	–	$3,353
55	T–403,TANK–EDTA CRYSTALLIZER TANK,CARBON STEEL,RUBBER LINED,1,000 GAL.	1	EA.	20	$3,000	$353	–	$3,353
56	T–105,TANK–KCL MIX, RUBBER LINED, 2,000 GALLONS.	1	EA.	40	$5,000	$706	–	$5,706
57	T–301–T–306,TANKS–STAGES 1–6 RINSE,RUBBER LINED,3,000 GALLONS.	6	EA.	100	$36,000	$1,764	–	$37,764
58	T–201,T–202,TANKS–STAGES 1 & 2 EXTRACTION,RUBBER LINED,3,000 GALS.	2	EA.	40	$12,000	$706	–	$12,706
59	T–404,TANK–EDTA DISSOLVER, CARBON STEEL, RUBBER LINED, 5,000 GALS.	1	EA.	40	$7,000	$706	–	$7,706
60	T–203,T–204,TANKS–STAGES 3&4 EXTRACTION, RUBBER LINED,6,000 GALLONS.	2	EA.	80	$14,000	$1,411	–	$15,411
61	T–207,TANK,STRONG EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	–	$7,706
62	T–406,TANK WEAK EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	–	$7,706
	SUBTOTAL THIS PAGE.			5,953	$4,587,163	$105,021	–	$4,692,184

FERNALD PROJECT – OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93–1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

-5089

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			5,953	$4,587,163	$105,021	–	$4,692,184
63	T–106,TANK–KCL RUBBER LINED,10,000 GALLONS.	1	EA.	40	$8,000	$706	–	$8,706
64	T–205,T–206,TANKS–STAGES 5&6, RUBBER LINED,12,000 GALLONS.	2	EA.	80	$17,000	$1,411	–	$18,411
65	T–405,TANK–EDTA STORAGE, C.S. RUBBER LINED,15,000 GALLONS.	1	EA.	100	$10,000	$1,764	–	$11,764
66	T–108,TANK–KCL SOAK, RUBBER LINED,15,000 GALLONS.	1	EA.	40	$10,000	$706	–	$10,706
67	T–104,TANK–FILTRATE,CARBON STEEL,15,000 GALLONS.80C.	1	EA.	40	$10,000	$706	–	$10,706
68	INSTRUMENTATION & CONTROL, 15% OF PURCHASED EQUIPMENT COST.	1	LS	1,538	$859,786	$27,130	–	$886,916
69	PROCESS PIPING, 12% OF PURCHASED EQUIPMENT COST.	1	LS	1,230	$687,829	$21,697	–	$709,526
70	ELECTRICAL, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
71	AUXILIARIES, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	13,123	$8,482,540	$231,500	–	$8,714,040
	SUBCONTRACT COSTS			–	–	–	–	–
1	ADDITIVE FEED SYSTEM (PRORATED).(INCL. CEMENT MIXER, 2 TPH)	1	LS	–	–	–	$600,000	$600,000
2	PROCESS VESSEL RADON TREATMENT SYSTEM (PRORATED).	1	LS	–	–	–	–	–
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	–	–	–	$600,000	$600,000
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	13,123	$8,482,540	$231,500	$600,000	$9,314,040

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

-5039

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0%	$1,768,367		$353,700			$353,700
CERCLA $1,500	PER PERSON	2,000				$55,500	$55,500
BOND	1.0%	$6,655,385				$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$332,700	$332,700
OVERHEAD & PROFIT	9.0%	$8,513,685				$766,200	$766,200
EMISSION MODELING	0.50%	$6,655,385		$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50%	$6,655,385		$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0%	$2,145,267		$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0%	$10,461,800					$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0%	$6,655,385		$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0%	$10,880,300					$108,800
PROJ.MGMT.FERMCO	8.0%	$10,880,300					$870,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0%	$7,244,300					$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 4 A REMOVAL,CHEMICAL EXTRACTION, STABILIZATION,ON-PROPERTY DISPOSAL.(SILO 1 & 2)
OPERATION AND MAINTENANCE COSTS-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

A PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	CRAFT LABOR	381,077	MHRS	381,077	-	$12,910,889	-	$12,910,889
2	SUPERVISORY LABOR.	5,803	MHRS	5,803	-	$389,265	-	$389,265
3	PROCESS WATER.	77,672,000	GALS	-	$1,553,440	-	-	$1,553,440
4	LOW PRESSURE STEAM.	-	-	-	INCLUDED	-	-	-
5	WASTE WATER DISCHARGE.	-	-	-	INCLUDED	-	-	-
6	ELECTRICITY-FOR CHEMICAL EXTRACTION MACHINERY, CEMENT STABILIZATION UNIT	18,050,000	KWH	-	$825,066	-	-	$825,066
7	NALMET 8154	5,720	TONS	-	$7,092,800	-	-	$7,092,800
8	DIAMMONIUM EDTA	780	TONS	-	$1,185,980	-		$1,185,980
9	KCL (AS POTASSIUM MURIATE)	2,430	TONS	-	$194,400	-		$194,400
10	HCL (AS 32% SOLUTION)	15,300	TONS	-	$3,396,600	-		$3,396,600
11	NH3 (AS 29% NH3)	4,500	TONS	-	$1,417,343	-		$1,417,343
12	FLYASH	1,560	TONS	-	$18,720	-		$18,720
13	CEMENT	5,530	TONS		$364,980			$364,980
14	CLINOPTILOLITE	525	TONS		$14,385			$14,385
15	BLAST FURNACE SLAG.	3,230	TONS		$96,900			$96,900
	SUBTOTAL OPERATIONS			386,880	$16,160,613	$13,300,154	-	$29,460,767

ALTERNATIVE 5A.1

VITRIFICATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 5A.1: REMOVAL, CHEMICAL EXTRACTION, STABILIZATION W/VITRIFICATION, OFF-SITE DISPOSAL AT NTS

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-6A	SITE PREPARATION	$780,500	$676,400	$1,456,900
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-9A	CHEMICAL EXTRACTION EQUIPMENT	$10,154,300	$7,246,700	$17,401,000
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	TRANSPORTATION	$2,349,800		$2,349,800
–	DISPOSAL	$3,458,100		$3,458,100
–	PACKAGING (6,404 PKGS. @ $955/PKG.)	$1,690,700	$4,425,200	$6,115,900
TOTAL CAPITAL		$26,784,600	$21,573,800	$48,358,400
RISK BUDGET (11.0%)		$2,946,300	$2,373,100	$5,319,400
SUBTOTAL		$29,730,900	$23,946,900	$53,677,800
CONTINGENCY (20.0%)		$5,946,200	$4,789,400	$10,735,600
TOTAL ESTIMATED INSTALLED COST		$35,677,100	$28,736,300	$64,413,400
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$29,188,100
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$81,870,100

663

File: SUM5A1VI.WK3

5089

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-6 A -5039
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	4,148		$68,485		$243,764	$312,200
	SUBCONCTRACTOR COSTS	5,386			$468,274		$468,300
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,534	17.00	$68,500	$468,300	$243,800	$780,500
SUPERVISION & SUPPRT LABOR	28.0%			$19,000			$19,000
SMALL TOOLS	$1.50					$14,300	$14,300
CONSUMABLES	$1.50					$14,300	$14,300
EQUIPMENT RENTAL	$3.00					$28,600	$28,600
TEMP. FACILITIES	4.0%			$1,000		$1,800	$2,800
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,700	$4,1[illegible]
SAFETY	7.0%			$1,700		$3,100	$4,8[illegible]
HEALTH PHYSICS	20.0% $91,800			$18,400			$18,400
CERCLA $1,500	PER PERSON 2,000					$7,200	$7,200
BOND	1.0% $780,500					$7,800	$7,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$15,600	$15,600
OVERHEAD & PROFIT	9.0% $918,000					$82,600	$82,600
EMISSION MODELING	0.50% $780,500			$1,400		$2,500	$3,900
PSAR/FSAR(SAFE RPT)	0.50% $780,500			$1,400		$2,500	$3,900
PAYRL BRD.&BENFT.	52.0% $113,000			$58,800			$58,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$171,800		$427,200	$1,067,200
CONSTR. MGMT.	4.0% $1,067,200						$42,700
SUB-TOTAL 3							$1,109,900
SOIL/WATER/AIR	1.0% $780,500			$2,700		$5,100	$7,800
HOME OFFICE EXP.	1.0% $1,109,900						$11,100
PROJ.MGMT.FERMCO	8.0% $1,109,900						$88,800
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III	3.0%			$213,400
SUB-TOTAL 4	OFFICE COSTS						$1,431,000
SALES TAX	6.0% $432,300						$25,900
SUB-TOTAL 5							$1,456,900
RISK BUDGET	11.0%						$160,300
SUB-TOTAL 6							$1,617,200
CONTINGENCY	20.0%						$323,400
TOTAL ESTIMATED INSTALLED COST							$1,940,600

EST.FILE #: 3098-6.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
14	TRANSFORMER,120 KVA,480 VAC 3 PHASE, TO 240/120 VAC 1 PHASE.	1	EA	125	$3,300	$2,064	-	$5,364
	SUBTOTAL.	1	LS	3,460	$235,579	$57,126	-	$292,705

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRY FORWARD	1	LS	3,460	$235,579	$57,126	-	$292,705
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
17	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
-	SEWER:	-	-	-	-	-	-	
18	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
19	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	
20	STEAM BOILER, ELECTRIC, 141,500 BTUH, 150 #/HR, 30 PSIG.	1	EA	60	$5,000	$991	-	$5,991
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	4,148	$243,764	$68,485	-	$312,249

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$468,274	$468,274
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,534	$243,764	$68,485	$468,274	$780,523

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

5039

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0% $234,800			$47,000			$47,000
CERCLA $1,500	PER PERSON 2,000					$8,900	$8,900
BOND	1.0% $1,008,500					$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$24,300	$24,300
OVERHEAD & PROFIT	9.0% $1,250,400					$112,500	$112,500
EMISSION MODELING	0.50% $1,008,500			$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50% $1,008,500			$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0% $285,400			$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0% $1,521,500						$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0% $1,008,500			$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0% $1,582,400						$15,800
PROJ.MGMT.FERMCO	8.0% $1,582,400						$126,600
ENGINEERING	20.0% Title I 7.0% Title II	10.0%		Title III	3.0%		$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0% $572,100						$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3098-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING - PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

6098

6998

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

EST FILE #: 3096-9 A
CLIENT: US DOE
PROJECT TITLE: CHEMICAL EXTRACTION / VITRIFICATION EQUIPMENT

-5089

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY AND EQUIPMENT COSTS	17,123		$302,060		$9,572,284	$9,874,300
	SUBCONTRACTOR COSTS				$280,000		$280,000
SUB-TOTAL 1	DIRECT FIELD COSTS	17,123	AVG. 17.64	$302,100	$280,000	$9,572,300	$10,154,300
SUPERVISION & SUPPRT LABOR	28.0%			$85,000			$85,000
SMALL TOOLS	$1.50					$25,700	$25,700
CONSUMABLES	$1.50					$25,700	$25,700
EQUIPMENT RENTAL	$3.00					$51,400	$51,400
TEMP. FACILITIES	4.0%			$4,200		$7,900	$12,10
TEMP. UTILITIES	1.0%			$1,100		$2,000	$3,10
JOB CLEAN-UP	6.0%			$6,300		$11,800	$18,100
SAFETY	7.0%			$7,400		$13,700	$21,100
HEALTH PHYSICS	20.0%	$406,100		$81,200			$81,200
CERCLA	$1,500	PER PERSON	2,000			$12,800	$12,800
BOND	1.0%	$10,154,300				$101,500	$101,500
GEN CONTR MARKUP	5.0%	LBR	5.0% MAT			$493,700	$493,700
OVERHEAD & PROFIT	9.0%	$11,085,700				$997,700	$997,700
EMISSION MODELING	0.50%	$10,154,300		$17,800		$33,000	$50,800
PSAR/FSAR(SAFE RPT)	0.50%	$10,154,300		$17,800		$33,000	$50,800
PAYRL BRD.&BENFT.	52.0%	$522,900		$271,900			$271,900
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$794,800		$11,382,200	$12,456,900
CONSTR. MGMT.	4.0%	$12,456,900					$498,300
SUB-TOTAL 3							$12,955,200
SOIL/WATER/AIR	1.0%	$10,154,300		$35,500		$66,000	$101,500
HOME OFFICE EXP.	1.0%	$12,955,200					$129,600
PROJ.MGMT.FERMCO	8.0%	$12,955,200					$1,036,400
ENGINEERING	20.0% Title I	7.0% Title II	10.0% Title III		3.0%		$2,491,400
SUB-TOTAL 4	OFFICE COSTS						$16,714,100
SALES TAX	6.0%	$11,448,200					$686,900
SUB-TOTAL 5							$17,401,000
RISK BUDGET	11.0%						$1,914,100
SUB-TOTAL 6							$19,315,100
CONTINGENCY	20.0%						$3,863,000
TOTAL ESTIMATED INSTALLED COST							$23,178,100

670

EST.FILE #: 3096-9.

SILO 1. & 2.

CHEMICAL EXTRACTION/NITRIFICATION EQUIPMENT.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CHEMICAL EXTRACTION,-EQUIPMENT CAPITAL COST ESTIMATE							
1	M-201,M-202,AGITATORS-STAGES 1 &2,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	56	$40,000	$988		$40,988
2	M-301-M-306,AGITATORS-STAGES 1 &6,RINSE TANK C.S.RUBBER LINED	6	EA.	168	$120,000	$2,964		$122,964
3	M-203-M204,AGITATORS-STAGES 3 &4,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
4	M-205-M-206,AGITATORS-STAGES 5 &6,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
5	M-403,AGITATOR EDTA CRYSTALLIZER,C.S.RUBBER LINED.	1	EA.	24	$15,000	$423		$15,423
6	M-404,AGITATOR EDTA DISSOLVER,C.S.RUBBER LINED.	1	EA.	32	$18,000	$564		$18,564
7	M-503,AGITATOR-FLASH MIX TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
8	M-504,AGITATOR-FLOCCULATION TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
9	M-105,AGITATORS-KCL MIX TANK,C.S.RUBBER LINED	1	EA.	24	$18,000	$423		$18,423
10	M-108,AGITATOR-KCL SOAK TANK C.S. RUBBER LINED.	1	EA.	40	$50,000	$706		$50,706
11	M-106,AGITATOR-KCL TANK C.S.RUBBER LINED.	1	EA.	36	$40,000	$635		$40,635
12	F-201-F-206,BELT FILTERS-STAGES 1-6, 304 S.S.,3'X9'.	6	EA.	1,200	$1,110,000	$21,168		$1,131,168
13	F-106,BELT FILTER-KCL/SOLIDS,316L S.S.BELT FILTER.	1	EA.	200	$185,000	$3,528		$188,528
14	F-501,BELT FILTER-SLUDGE, BELT FILTER PRESS	1	EA.	200	$140,000	$3,528		$143,528
15	F-101,BELT FILTER-SLURRY, BELT FILTER,3'X10'.	1	EA.	200	$185,000	$3,528		$188,528
16	F-301-F-306,CENTRIFUGES- STAGES 1-6,304 S.S.CENTRIFUGES	6	EA.	600	$600,000	$10,584		$610,584
17	T-505,CLARIFIER, EPOXY COATED STEEL	1	EA.	80	$20,000	$1,411		$21,411
18	M-505,CLARIFIER RAKE, EPOXY COATED STEEL.	1	EA.	4	$0	$71		$71
19	C-101,CONVEYOR-ADDITIVES	1	EA.	40	$11,306	$706		$12,012
20	D-501,DRYER-SLUDGE, GAS FIRED COUNTER CURRENT DRYER.	1	EA.	200	$550,000	$3,528		$553,528
21	F-401,FILTER-FILTER, 3'X6' BELT FILTER ACID PROOF.	1	EA.	200	$185,000	$3,528		$188,528
22	H-101,HOPPER-ADDITIVES	1	EA.	80	$5,000	$1,411		$6,411
23	H-101,HOPPER-KCL,C.S.RUBBER LINED, 5,000 LBS.	1	EA.	80	$5,000	$1,411		$6,411
24	P-201-P-206,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
25	P-301-P-306,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
26	P-505,PUMP-CLARIFIER SLUDGE PUMP,POSITIVE DISPLACEMENT,	1	EA.	25	$2,200	$441		$2,641
-	LINED, 0.7 GPM.	-	-	-	-	-		-
27	P-404,PUMP-EDTA CIRCULATING,CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
28	P-405, PUMP-EDTA FEED CENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
29	P-403, PUMP EDTA,SLURRY, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
30	P-104, PUMP FILTRATECENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
	SUBTOTAL THIS PAGE.			4,305	$3,466,506	$75,942	-	$3,542,448

-5089

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FERNALD PROJECT – OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93–1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			4,305	$3,466,506	$75,942	–	$3,542,448
31	P–402,PUMP–HCL,PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	–	$2,441
32	P–106,PUMP–KCL, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
33	P–105,'PUMP–KCL MIX TANK PUMP, CENTRIFUGAL, RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
34	P–108,PUMP–KCL SOLIDS SLURRY PUMP,CENTRIFUGAL,RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
35	P–502,PUMP–NALMET PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	–	$2,441
36	P–501,PUMP–NaOH,PLASTIC METERING, 0.25 gpm.	1	EA.	25	$1,500	$441	–	$1,941
37	P–401,PUMP–NH3, PLASTIC METERING, 0.7 GPM.	1	EA.	25	$2,000	$441	–	$2,441
38	P–101,PUMP–SLURRY,CENTRIFUGAL RUBBER LINED,32 GPM.	1	EA.	40	$4,000	$706	–	$4,706
39	P–207,PUMP–STRONG EXTRACT, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	–	$4,706
40	P–406,PUMP–WEAK CENTRATE, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	–	$4,706
41	S–402,SCRUBBER–HCL,FIBERGLAS, 1,000CFM.	1	EA.	48	$8,800	$847	–	$9,647
42	S–401,SCRUBBER–NH3, FIBERGLASS, 250 CFM.	1	EA.	48	$12,400	$847	–	$13,247
43	SI–103,STEAM INJECTORS–STAGES 5&6 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
44	SI–105,STEAM INJECTORS–EDTA TANKS	2	EA.	40	$3,460	$706	–	$4,166
45	SI–101,STEAM INJECTORS–STAGES 1&2 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
46	SI–104,STEAM INJECTORS–STAGES 1–6 RINSE TANKS	6	EA.	120	$10,380	$2,117	–	$12,497
47	SI–102,STEAM INJECTORS–STAGES 3&4 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
48	B–101,BOILER FOR STEAM INJECTION,ROUGH ESTIMATE OF SIZING,225,000 LBS.	1	EA.	400	$930,000	$7,056	–	$937,056
49	T–502,TANK–NALMET,FIBERGLASS,3,000 GALLONS.	1	EA.	20	$4,948	$353	–	$5,301
50	T–402,TANK–HCL STORAGE,FIBERGLASS,7,500 GALLONS.	1	EA.	40	$6,426	$706	–	$7,132
51	T–401,TANK–NH3 STORAGE,FIBERGLASS,10,000 GALLONS.	1	EA.	40	$7,063	$706	–	$7,769
52	T–503,TANK–FLASH MIX,PLASTIC, 30 GALLONS.	1	EA.	4	$300	$71	–	$371
53	T–504,TANK–FLOCCULATION, PLASTIC, 300 GALLONS.	1	EA.	8	$1,000	$141	–	$1,141
54	T–501,TANK–NaOH, STEEL, 1,000 GALLONS.	1	EA.	20	$3,000	$353	–	$3,353
55	T–403,TANK–EDTA CRYSTALLIZER TANK,CARBON STEEL,RUBBER LINED,1,000 GAL.	1	EA.	20	$3,000	$353	–	$3,353
56	T–105,TANK–KCL MIX, RUBBER LINED, 2,000 GALLONS.	1	EA.	40	$5,000	$706	–	$5,706
57	T–301–T–306,TANKS–STAGES 1–6 RINSE,RUBBER LINED,3,000 GALLONS.	6	EA.	100	$36,000	$1,764	–	$37,764
58	T–201,T–202,TANKS–STAGES 1 & 2 EXTRACTION,RUBBER LINED,3,000 GALS.	2	EA.	40	$12,000	$706	–	$12,706
59	T–404,TANK–EDTA DISSOLVER, CARBON STEEL, RUBBER LINED, 5,000 GALS.	1	EA.	40	$7,000	$706	–	$7,706
60	T–203,T–204,TANKS–STAGES 3&4 EXTRACTION, RUBBER LINED,6,000 GALLONS.	2	EA.	80	$14,000	$1,411	–	$15,411
61	T–207,TANK,STRONG EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	–	$7,706
62	T–406,TANK WEAK EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	–	$7,706
	SUBTOTAL THIS PAGE.			5,953	$4,587,163	$105,021	–	$4,692,184

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FERNALD PROJECT – OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93–1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			5,953	$4,587,163	$105,021	–	$4,692,184
63	T–106,TANK–KCL RUBBER LINED,10,000 GALLONS.	1	EA.	40	$8,000	$706	–	$8,706
64	T–205,T–206,TANKS–STAGES 5&6, RUBBER LINED,12,000 GALLONS.	2	EA.	80	$17,000	$1,411	–	$18,411
65	T–405,TANK–EDTA STORAGE, C.S. RUBBER LINED,15,000 GALLONS.	1	EA.	100	$10,000	$1,764	–	$11,764
66	T–108,TANK–KCL SOAK, RUBBER LINED,15,000 GALLONS.	1	EA.	40	$10,000	$706	–	$10,706
67	T–104,TANK–FILTRATE,CARBON STEEL,15,000 GALLONS.80C.	1	EA.	40	$10,000	$706	–	$10,706
70	I–501,VITRIFIER,OFF–GAS TREATMENT SYSTEM.,1.05 TON PER DAY.	1	EA.	3,200	$871,795	$56,448	–	$928,243
–	OFF–GAS TREATMENT SYSTEM.	1	EA.	800	$217,949	$14,112	–	$232,061
71	INSTRUMENTATION & CONTROL, 15% OF PURCHASED EQUIPMENT COST.	1	LS	1,538	$859,786	$27,130	–	$886,916
72	PROCESS PIPING, 12% OF PURCHASED EQUIPMENT COST.	1	LS	1,230	$687,829	$21,697	–	$709,526
73	ELECTRICAL, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
74	AUXILIARIES, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	17,123	$9,572,284	$302,060	–	$9,874,344
	SUBCONTRACT COSTS							
1	ADDITIVE FEED SYSTEM (PRORATED).	1	LS	–	–	–	–	–
2	PROCESS VESSEL RADON TREATMENT SYSTEM (PRORATED).	1	LS	–	–	–	$280,000	$280,000
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	–	–	–	$280,000	$280,000
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	17,123	$9,572,284	$302,060	$280,000	$10,154,344

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-7 B
CLIENT: US D
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,2
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,20
HEALTH PHYSICS	20.0% $1,768,367			$353,700			$353,7
CERCLA $1,500	PER PERSON 2,000					$55,500	$55,500
BOND	1.0% $6,655,385					$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$332,700	$332,700
OVERHEAD & PROFIT	9.0% $8,513,685					$766,200	$766,200
EMISSION MODELING	0.50% $6,655,385			$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50% $6,655,385			$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0% $2,145,267			$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0% $10,461,800						$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0% $6,655,385			$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0% $10,880,300						$108,800
PROJ.MGMT.FERMCO	8.0% $10,880,300						$870,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0% $7,244,300						$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

06/10/93

I. T.PROJECT NO.:409194

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ALTERNATIVE # 5A.1 REMOVAL,CHEMICAL EXTRACTION,STABILIZATION,OFF-SITE DISPOSAL TO NTS.(SILO 1 & 2)
OPERATION AND MAINTENANCE COSTS-VITRIFICATION OPTION.

FY 93-1 DOLLARS

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	CRAFT LABOR	381,077	MHRS	381,077	-	$12,910,889	-	$12,910,889
2	SUPERVISORY LABOR.	5,803	MHRS	5,803	-	$389,265	-	$389,265
3	PROCESS WATER.	76,084,000	GALS	-	$1,521,680	-	-	$1,521,680
4	LOW PRESSURE STEAM.	-	-	-	INCLUDED	-	-	-
5	WASTE WATER DISCHARGE.	-	-	-	INCLUDED	-	-	-
6	ELECTRICITY-FOR CHEMICAL EXTRACTION MACHINERY, VITRIFICATION UNIT.	15,582,000	KWH	-	$712,253	-	-	$712,253
7	NALMET 8154	5,720	TONS	-	$7,092,800	-	-	$7,092,800
8	DIAMMONIUM EDTA	780	TONS	-	$1,185,980	-	-	$1,185,980
9	KCL (AS POTASSIUM MURIATE)	2,430	TONS	-	$194,400	-	-	$194,400
10	HCL (AS 32% SOLUTION)	15,300	TONS	-	$3,396,600	-	-	$3,396,600
11	NH3 (AS 29% NH3)	4,500	TONS	-	$1,417,343	-	-	$1,417,343
12	FLYASH	10,420	TONS	-	$125,040	-	-	$125,040
13	SODAASH	1,560	TONS	-	$241,800	-	-	$241,800
	SUBTOTAL OPERATIONS			386,880	$15,887,896	$13,300,154	-	$29,188,050

675

5089

5039

ALTERNATIVE 5A.1

CEMENT STABILIZATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 5A.1: REMOVAL, CHEMICAL EXTRACTION, CEMENT STABILIZATION, OFF-SITE DISPOSAL AT NTS

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-6A	SITE PREPARATION	$780,500	$676,400	$1,456,900
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-30A	CHEMICAL EXTRACTION EQUIPMENT	$9,314,000	$6,476,200	$15,790,200
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	TRANSPORTATION	$4,199,100		$4,199,100
–	DISPOSAL	$6,667,900		$6,667,900
–	PACKAGING (12,348 PKGS. @ $955/PKG.)	$3,259,900	$8,532,500	$11,792,400
TOTAL CAPITAL		$32,572,600	$24,910,600	$57,483,200
RISK BUDGET (11.0%)		$3,583,000	$2,740,200	$6,323,200
SUBTOTAL		$36,155,600	$27,650,800	$63,806,400
CONTINGENCY (20.0%)		$7,231,100	$5,530,200	$12,761,300
TOTAL ESTIMATED INSTALLED COST		$43,386,700	$33,181,000	$76,567,700
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$29,460,800
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$92,739,600

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File: SUM5A1CE.WK3

060089

EST FILE #: 3096-6 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	4,148		$68,485		$243,764	$312,200
	SUBCONCTRACTOR COSTS	5,386			$468,274		$468,300
SUB-TOTAL 1	DIRECT FIELD COSTS	9,534	AVG. 17.00	$68,500	$468,300	$243,800	$780,500
SUPERVISION & SUPPRT LABOR	28.0%			$19,000			$19,000
SMALL TOOLS	$1.50					$14,300	$14,300
CONSUMABLES	$1.50					$14,300	$14,300
EQUIPMENT RENTAL	$3.00					$28,600	$28,600
TEMP. FACILITIES	4.0%			$1,000		$1,800	$2,800
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,700	$4,10
SAFETY	7.0%			$1,700		$3,100	$4,80
HEALTH PHYSICS	20.0% $91,800			$18,400			$18,400
CERCLA $1,500	PER PERSON 2,000					$7,200	$7,200
BOND	1.0% $780,500					$7,800	$7,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$15,600	$15,600
OVERHEAD & PROFIT	9.0% $918,000					$82,600	$82,600
EMISSION MODELING	0.50% $780,500			$1,400		$2,500	$3,900
PSAR/FSAR(SAFE RPT)	0.50% $780,500			$1,400		$2,500	$3,900
PAYRL BRD.&BENFT.	52.0% $113,000			$58,800			$58,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$171,800		$427,200	$1,067,200
CONSTR. MGMT.	4.0% $1,067,200						$42,700
SUB-TOTAL 3							$1,109,900
SOIL/WATER/AIR	1.0% $780,500			$2,700		$5,100	$7,800
HOME OFFICE EXP.	1.0% $1,109,900						$11,100
PROJ.MGMT.FERMCO	8.0% $1,109,900						$88,800
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$213,400
SUB-TOTAL 4	OFFICE COSTS						$1,431,000
SALES TAX	6.0% $432,300						$25,900
SUB-TOTAL 5							$1,456,900
RISK BUDGET	11.0%						$160,300
SUB-TOTAL 6							$1,617,200
CONTINGENCY	20.0%						$323,400
TOTAL ESTIMATED INSTALLED COST							$1,940,600

EST.FILE #: 3096-6.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
14	TRANSFORMER,120 KVA,480 VAC 3 PHASE, TO 240/120 VAC 1 PHASE.	1	EA	125	$3,300	$2,064	-	$5,364
	SUBTOTAL.	1	LS	3,460	$235,579	$57,126	-	$292,705

679

5089

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRY FORWARD	1	LS	3,460	$235,579	$57,126	-	$292,705
							-	
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
17	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
							-	
-	SEWER:	-	-	-	-	-	-	
18	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
19	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	
20	STEAM BOILER, ELECTRIC, 141,500 BTUH, 150 #/HR, 30 PSIG.	1	EA	60	$5,000	$991	-	$5,991
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	4,148	$243,764	$68,485	-	$312,249

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$468,274	$468,274
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,534	$243,764	$68,485	$468,274	$780,523

6039

FERMCO
ESTIMATING SERVICES 5039
SUMMARY SHEET

EST FILE #: 3096-5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0% $234,800			$47,000			$47,000
CERCLA $1,500	PER PERSON 2,000					$8,900	$8,900
BOND	1.0% $1,008,500					$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$24,300	$24,300
OVERHEAD & PROFIT	9.0% $1,250,400					$112,500	$112,500
EMISSION MODELING	0.50% $1,008,500			$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50% $1,008,500			$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0% $285,400			$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0% $1,521,500						$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0% $1,008,500			$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0% $1,582,400						$15,800
PROJ.MGMT.FERMCO	8.0% $1,582,400						$126,600
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0% $572,100						$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

-5089

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY- CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	120	$5,000	$2,280		$7,280
		1	LS	9,476	$311,466	$174,822	-	$486,288

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

-5089

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-30 A -5039
CLIENT: US DOE
PROJECT TITLE: CHEMICAL EXTRACTION / CEMENT STABILIZATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY & EQUIPMENT COSTS	13,123		$231,500		$8,482,540	$8,714,000
	SUBCONTRACTOR COSTS				$600,000		$600,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	13,123	17.64	$231,500	$600,000	$8,482,500	$9,314,000
SUPERVISION & SUPPRT LABOR	28.0%			$65,000			$65,000
SMALL TOOLS	$1.50					$19,700	$19,700
CONSUMABLES	$1.50					$19,700	$19,700
EQUIPMENT RENTAL	$3.00					$39,400	$39,400
TEMP. FACILITIES	4.0%			$3,200		$6,000	$9,200
TEMP. UTILITIES	1.0%			$800		$1,500	$2,300
JOB CLEAN-UP	6.0%			$4,900		$9,000	$13,900
SAFETY	7.0%			$5,700		$10,500	$16,200
HEALTH PHYSICS	20.0% $311,100			$62,200			$62,200
CERCLA $1,500	PER PERSON 2,000					$9,800	$9,800
BOND	1.0% $9,314,000					$93,100	$93,100
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$435,700	$435,700
OVERHEAD & PROFIT	9.0% $10,100,200			-		$909,000	$909,000
EMISSION MODELING	0.50% $9,314,000			$16,300		$30,300	$46,600
PSAR/FSAR(SAFE RPT)	0.50% $9,314,000			$16,300		$30,300	$46,600
PAYRL BRD.&BENFT.	52.0% $405,900			$211,100			$211,100
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$617,000		$10,096,500	$11,313,500
CONSTR. MGMT.	4.0% $11,313,500						$452,500
SUB-TOTAL 3							$11,766,000
SOIL/WATER/AIR	1.0% $9,314,000			$32,600		$60,500	$93,100
HOME OFFICE EXP.	1.0% $11,766,000						$117,700
PROJ.MGMT.FERMCO	8.0% $11,766,000						$941,300
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$2,262,700
SUB-TOTAL 4	OFFICE COSTS						$15,180,800
SALES TAX	6.0% $10,157,000						$609,400
SUB-TOTAL 5							$15,790,200
RISK BUDGET	11.0%						$1,736,900
SUB-TOTAL 6							$17,527,100
CONTINGENCY	20.0%						$3,505,400
TOTAL ESTIMATED INSTALLED COST							$21,032,500

08/24/93

EST.FILE #:3096-30.

CHEMICAL EXTRACTION/CEMENT STABILIZATION EQUIPMENT.

FY 93-1 DOLLARS

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CHEMICAL EXTRACTION,-EQUIPMENT CAPITAL COST ESTIMATE.							
1	M-201,M-202,AGITATORS-STAGES 1 &2,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	56	$40,000	$988		$40,988
2	M-301-M-306,AGITATORS-STAGES 1 &6,RINSE TANK C.S.RUBBER LINED	6	EA.	168	$120,000	$2,964		$122,964
3	M-203-M204,AGITATORS-STAGES 3 &4,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
4	M-205-M-206,AGITATORS-STAGES 5 &6,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
5	M-403,AGITATOR EDTA CRYSTALLIZER,C.S.RUBBER LINED.	1	EA.	24	$15,000	$423		$15,423
6	M-404,AGITATOR EDTA DISSOLVER,C.S.RUBBER LINED.	1	EA.	32	$18,000	$564		$18,564
7	M-503,AGITATOR-FLASH MIX TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
8	M-504,AGITATOR-FLOCCULATION TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
9	M-105,AGITATORS-KCL MIX TANK,C.S.RUBBER LINED	1	EA.	24	$18,000	$423		$18,423
10	M-108,AGITATOR-KCL SOAK TANK C.S. RUBBER LINED.	1	EA.	40	$50,000	$706		$50,706
11	M-106,AGITATOR-KCL TANK C.S.RUBBER LINED.	1	EA.	36	$40,000	$635		$40,635
12	F-201-F-206,BELT FILTERS-STAGES 1-6, 304 S.S.,3'X9'.	6	EA.	1,200	$1,110,000	$21,168		$1,131,168
13	F-106,BELT FILTER-KCL/SOLIDS,316L S.S.BELT FILTER.	1	EA.	200	$185,000	$3,528		$188,528
14	F-501,BELT FILTER-SLUDGE, BELT FILTER PRESS	1	EA.	200	$140,000	$3,528		$143,528
15	F-101,BELT FILTER-SLURRY, BELT FILTER,3'X10'.	1	EA.	200	$185,000	$3,528		$188,528
16	F-301-F-306,CENTRIFUGES- STAGES 1-6,304 S.S.CENTRIFUGES	6	EA.	600	$600,000	$10,584		$610,584
17	T-505,CLARIFIER, EPOXY COATED STEEL	1	EA.	80	$20,000	$1,411		$21,411
18	M-505,CLARIFIER RAKE, EPOXY COATED STEEL.	1	EA.	4	$0	$71		$71
19	C-101,CONVEYOR-ADDITIVES	1	EA.	40	$11,306	$706		$12,012
20	D-501,DRYER-SLUDGE, GAS FIRED COUNTER CURRENT DRYER.	1	EA.	200	$550,000	$3,528		$553,528
21	F-401,FILTER-FILTER, 3'X6' BELT FILTER ACID PROOF.	1	EA.	200	$185,000	$3,528		$188,528
22	H-101,HOPPER-ADDITIVES	1	EA.	80	$5,000	$1,411		$6,411
23	H-101,HOPPER-KCL,C.S.RUBBER LINED, 5;000 LBS.	1	EA.	80	$5,000	$1,411		$6,411
24	P-201-P-206,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
25	P-301-P-306,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
26	P-505,PUMP-CLARIFIER SLUDGE PUMP,POSITIVE DISPLACEMENT,	1	EA.	25	$2,200	$441		$2,641
-	LINED, 0.7 GPM.	-	-	-	-	-		-
27	P-404,PUMP-EDTA CIRCULATING,CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
28	P-405, PUMP-EDTA FEED CENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
29	P-403, PUMP EDTA,SLURRY, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
30	P-104, PUMP FILTRATECENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
	SUBTOTAL THIS PAGE.			4,305	$3,466,506	$75,942	-	$3,542,[illegible]

985

50039

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A- REMOVAL,STABILIZATION,ON-PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	CARRYFORWARD			4,305	$3,466,506	$75,942	-	$3,542,448
31	P-402,PUMP-HCL,PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	-	$2,441
32	P-106,PUMP-KCL, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
33	P-105,'PUMP-KCL MIX TANK PUMP, CENTRIFUGAL, RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
34	P-108,PUMP-KCL SOLIDS SLURRY PUMP,CENTRIFUGAL,RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
35	P-502,PUMP-NALMET PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	-	$2,441
36	P-501,PUMP-NaOH,PLASTIC METERING, 0.25 gpm.	1	EA.	25	$1,500	$441	-	$1,941
37	P-401,PUMP-NH3, PLASTIC METERING, 0.7 GPM.	1	EA.	25	$2,000	$441	-	$2,441
38	P-101,PUMP-SLURRY,CENTRIFUGAL RUBBER LINED,32 GPM.	1	EA.	40	$4,000	$706	-	$4,706
39	P-207,PUMP-STRONG EXTRACT, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	-	$4,706
40	P-406,PUMP-WEAK CENTRATE, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	-	$4,706
41	S-402,SCRUBBER-HCL,FIBERGLAS, 1,000CFM.	1	EA.	48	$8,800	$847	-	$9,647
42	S-401,SCRUBBER-NH3, FIBERGLASS, 250 CFM.	1	EA.	48	$12,400	$847	-	$13,247
43	SI-103,STEAM INJECTORS-STAGES 5&6 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
44	SI-105,STEAM INJECTORS-EDTA TANKS	2	EA.	40	$3,460	$706	-	$4,166
45	SI-101,STEAM INJECTORS-STAGES 1&2 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
46	SI-104,STEAM INJECTORS-STAGES 1-6 RINSE TANKS	6	EA.	120	$10,380	$2,117	-	$12,497
47	SI-102,STEAM INJECTORS-STAGES 3&4 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
48	B-101,BOILER FOR STEAM INJECTION,ROUGH ESTIMATE OF SIZING,225,000 LBS.	1	EA.	400	$930,000	$7,056	-	$937,056
49	T-502,TANK-NALMET,FIBERGLASS,3,000 GALLONS.	1	EA.	20	$4,948	$353	-	$5,301
50	T-402,TANK-HCL STORAGE,FIBERGLASS,7,500 GALLONS.	1	EA.	40	$6,426	$706	-	$7,132
51	T-401,TANK-NH3 STORAGE,FIBERGLASS,10,000 GALLONS.	1	EA.	40	$7,063	$706	-	$7,769
52	T-503,TANK-FLASH MIX,PLASTIC, 30 GALLONS.	1	EA.	4	$300	$71	-	$371
53	T-504,TANK-FLOCCULATION, PLASTIC, 300 GALLONS.	1	EA.	8	$1,000	$141	-	$1,141
54	T-501,TANK-NaOH, STEEL, 1,000 GALLONS.	1	EA.	20	$3,000	$353	-	$3,353
55	T-403,TANK-EDTA CRYSTALLIZER TANK,CARBON STEEL,RUBBER LINED,1,000 GAL.	1	EA.	20	$3,000	$353	-	$3,353
56	T-105,TANK-KCL MIX, RUBBER LINED, 2,000 GALLONS.	1	EA.	40	$5,000	$706	-	$5,706
57	T-301-T-306,TANKS-STAGES 1-6 RINSE,RUBBER LINED,3,000 GALLONS.	6	EA.	100	$36,000	$1,764	-	$37,764
58	T-201,T-202,TANKS-STAGES 1 & 2 EXTRACTION,RUBBER LINED,3,000 GALS.	2	EA.	40	$12,000	$706	-	$12,706
59	T-404,TANK-EDTA DISSOLVER, CARBON STEEL, RUBBER LINED, 5,000 GALS.	1	EA.	40	$7,000	$706	-	$7,706
60	T-203,T-204,TANKS-STAGES 3&4 EXTRACTION, RUBBER LINED,6,000 GALLONS.	2	EA.	80	$14,000	$1,411	-	$15,411
61	T-207,TANK,STRONG EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	-	$7,706
62	T-406,TANK WEAK EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	-	$7,706
	SUBTOTAL THIS PAGE.			5,953	$4,587,163	$105,021	-	$4,692,184

-5080

939

FERNALD PROJECT – OU4

08/24/93

I. T.PROJECT NO.:409194

ESTIMATOR: F.H.GASLIGHTWALA

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

PROJ.ENGR: JOE PACELLI

SUMMARY OF CAPITAL COSTS.

PROJ. MGR: SUSAN RHYNE.

FY 93–1 DOLLARS

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			5,953	$4,587,163	$105,021	–	$4,692,184
63	T–106,TANK–KCL RUBBER LINED,10,000 GALLONS.	1	EA.	40	$8,000	$706	–	$8,706
64	T–205,T–206,TANKS–STAGES 5&6, RUBBER LINED,12,000 GALLONS.	2	EA.	80	$17,000	$1,411	–	$18,411
65	T–405,TANK–EDTA STORAGE, C.S. RUBBER LINED,15,000 GALLONS.	1	EA.	100	$10,000	$1,764	–	$11,764
66	T–108,TANK–KCL SOAK, RUBBER LINED,15,000 GALLONS.	1	EA.	40	$10,000	$706	–	$10,706
67	T–104,TANK–FILTRATE,CARBON STEEL,15,000 GALLONS.80C.	1	EA.	40	$10,000	$706	–	$10,706
68	INSTRUMENTATION & CONTROL, 15% OF PURCHASED EQUIPMENT COST.	1	LS	1,538	$859,786	$27,130	–	$886,916
69	PROCESS PIPING, 12% OF PURCHASED EQUIPMENT COST.	1	LS	1,230	$687,829	$21,697	–	$709,526
70	ELECTRICAL, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
71	AUXILIARIES, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	13,123	$8,482,540	$231,500	–	$8,714,040
	SUBCONTRACT COSTS			–	–	–	–	–
1	ADDITIVE FEED SYSTEM (PRORATED).(INCL. CEMENT MIXER, 2 TPH)	1	LS	–	–	–	$600,000	$600,000
2	PROCESS VESSEL RADON TREATMENT SYSTEM (PRORATED).	1	LS	–	–	–	–	–
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	–	–	–	$600,000	$600,000
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	13,123	$8,482,540	$231,500	$600,000	$9,314,040

687

-5088

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,28[illegible]
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,2[illegible]
HEALTH PHYSICS	20.0%	$1,768,367		$353,700			$353,7[illegible]
CERCLA $1,500	PER PERSON	2,000				$55,500	$55,500
BOND	1.0%	$6,655,385				$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$332,700	$332,700
OVERHEAD & PROFIT	9.0%	$8,513,685				$766,200	$766,200
EMISSION MODELING	0.50%	$6,655,385		$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50%	$6,655,385		$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0%	$2,145,267		$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0%	$10,461,800					$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0%	$6,655,385		$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0%	$10,880,300					$108,800
PROJ.MGMT.FERMCO	8.0%	$10,880,300					$870,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0%	$7,244,300					$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE #5 A.1 REMOVAL,CHEMICAL EXTRACTION,STABILIZATION,OFF-SITE DISPOSAL TO NTS.(SILO 1 & 2)
OPERATION & MAINTENANCE COSTS-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	CRAFT LABOR	381,077	MHRS	381,077	-	$12,910,889	-	$12,910,889
2	SUPERVISORY LABOR.	5,803	MHRS	5,803	-	$389,265	-	$389,265
3	PROCESS WATER.	77,672,000	GALS	-	$1,553,440	-	-	$1,553,440
4	LOW PRESSURE STEAM.	-	-	-	INCLUDED	-	-	-
5	WASTE WATER DISCHARGE.	-	-	-	INCLUDED	-	-	-
6	ELECTRICITY-FOR CHEMICAL EXTRACTION MACHINERY, CEMENT STABILIZATION UNIT	18,050,000	KWH	-	$825,066	-	-	$825,066
7	NALMET 8154	5,720	TONS	-	$7,092,800	-	-	$7,092,800
8	DIAMMONIUM EDTA	780	TONS	-	$1,185,980	-		$1,185,980
9	KCL (AS POTASSIUM MURIATE)	2,430	TONS	-	$194,400	-		$194,400
10	HCL (AS 32% SOLUTION)	15,300	TONS	-	$3,396,600	-		$3,396,600
11	NH3 (AS 29% NH3)	4,500	TONS	-	$1,417,343	-		$1,417,343
12	FLYASH	1,560	TONS	-	$18,720	-		$18,720
13	CEMENT	5,530	TONS		$364,980			$364,980
14	CLINOPTILOLITE	525	TONS		$14,385			$14,385
15	BLAST FURNACE SLAG.	3,230	TONS		$96,900			$96,900
	SUBTOTAL OPERATIONS			386,880	$16,160,613	$13,300,154	-	$29,460,767

689

I-5089

ALTERNATIVE 5A.2

VITRIFICATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 5A.2: REMOVAL, CHEMICAL EXTRACTION, STABILIZATION W/VITRIFICATION, OFF-SITE DISPOSAL AT FACILITY 300 MILES FROM FEMP

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-6A	SITE PREPARATION	$780,500	$676,400	$1,456,900
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-9A	CHEMICAL EXTRACTION EQUIPMENT	$10,154,300	$7,246,700	$17,401,000
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	TRANSPORTATION	$228,400		$228,400
–	DISPOSAL VAULT	$2,489,900	$4,236,200	$6,726,100
–	PACKAGING (6,404 PKGS. @ $955/PKG.)	$1,690,700	$4,425,200	$6,115,900
TOTAL CAPITAL		$23,695,000	$25,810,000	$49,505,000
RISK BUDGET (11.0%)		$2,606,500	$2,839,100	$5,445,600
SUBTOTAL		$26,301,500	$28,649,100	$54,950,600
CONTINGENCY (20.0%)		$5,260,300	$5,729,800	$10,990,100
TOTAL ESTIMATED INSTALLED COST		$31,561,800	$34,378,900	$65,940,700
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$29,188,100
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$83,206,000

691

I-5039

File: SUM5A2VI.WK3

5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-6 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	4,148		$68,485		$243,764	$312,200
	SUBCONCTRACTOR COSTS	5,386			$468,274		$468,300
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,534	17.00	$68,500	$468,300	$243,800	$780,500
SUPERVISION & SUPPRT LABOR	28.0%			$19,000			$19,000
SMALL TOOLS	$1.50					$14,300	$14,300
CONSUMABLES	$1.50					$14,300	$14,300
EQUIPMENT RENTAL	$3.00					$28,600	$28,600
TEMP. FACILITIES	4.0%			$1,000		$1,800	$2,800
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,700	$4,10
SAFETY	7.0%			$1,700		$3,100	$4,80
HEALTH PHYSICS	20.0% $91,800			$18,400			$18,400
CERCLA	$1,500 PER PERSON 2,000					$7,200	$7,200
BOND	1.0% $780,500					$7,800	$7,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$15,600	$15,600
OVERHEAD & PROFIT	9.0% $918,000					$82,600	$82,600
EMISSION MODELING	0.50% $780,500			$1,400		$2,500	$3,900
PSAR/FSAR(SAFE RPT)	0.50% $780,500			$1,400		$2,500	$3,900
PAYRL BRD.&BENFT.	52.0% $113,000			$58,800			$58,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$171,800		$427,200	$1,067,200
CONSTR. MGMT.	4.0% $1,067,200						$42,700
SUB-TOTAL 3							$1,109,900
SOIL/WATER/AIR	1.0% $780,500			$2,700		$5,100	$7,800
HOME OFFICE EXP.	1.0% $1,109,900						$11,100
PROJ.MGMT.FERMCO	8.0% $1,109,900						$88,800
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$213,400
SUB-TOTAL 4	OFFICE COSTS						$1,431,000
SALES TAX	6.0% $432,300						$25,900
SUB-TOTAL 5							$1,456,900
RISK BUDGET	11.0%						$160,300
SUB-TOTAL 6							$1,617,200
CONTINGENCY	20.0%						$323,400
TOTAL ESTIMATED INSTALLED COST							$1,940,600

EST.FILE #: 3096-6.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
14	TRANSFORMER,120 KVA,480 VAC 3 PHASE, TO 240/120 VAC 1 PHASE.	1	EA	125	$3,300	$2,064	-	$5,364
	SUBTOTAL.	1	LS	3,460	$235,579	$57,126	-	$292,705

050030

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRY FORWARD	1	LS	3,460	$235,579	$57,126	-	$292,705
							-	
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
17	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
							-	
-	SEWER:	-	-	-	-	-	-	
18	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
19	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	
20	STEAM BOILER, ELECTRIC, 141,500 BTUH, 150 #/HR, 30 PSIG.	1	EA	60	$5,000	$991	-	$5,991
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	4,148	$243,764	$68,485	-	$312,249

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$468,274	$468,274
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,534	$243,764	$68,485	$468,274	$780,523

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

5039

EST FILE #: 3096-5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0%	$234,800		$47,000			$47,000
CERCLA $1,500	PER PERSON	2,000				$8,900	$8,900
BOND	1.0%	$1,008,500				$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$24,300	$24,300
OVERHEAD & PROFIT	9.0%	$1,250,400				$112,500	$112,500
EMISSION MODELING	0.50%	$1,008,500		$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50%	$1,008,500		$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0%	$285,400		$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0%	$1,521,500					$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0%	$1,008,500		$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0%	$1,582,400					$15,800
PROJ.MGMT.FERMCO	8.0%	$1,582,400					$126,600
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0%	$572,100					$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET.	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-9 A
CLIENT: US DOE
PROJECT TITLE: CHEMICAL EXTRACTION / VITRIFICATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY AND EQUIPMENT COSTS	17,123		$302,060		$9,572,284	$9,874,300
	SUBCONTRACTOR COSTS				$280,000		$280,000
SUB-TOTAL 1	DIRECT FIELD COSTS	17,123	AVG. 17.64	$302,100	$280,000	$9,572,300	$10,154,300
SUPERVISION & SUPPRT LABOR	28.0%			$85,000			$85,000
SMALL TOOLS	$1.50					$25,700	$25,700
CONSUMABLES	$1.50					$25,700	$25,700
EQUIPMENT RENTAL	$3.00					$51,400	$51,400
TEMP. FACILITIES	4.0%			$4,200		$7,900	$12,1[illegible]
TEMP. UTILITIES	1.0%			$1,100		$2,000	$3,1[illegible]
JOB CLEAN-UP	6.0%			$6,300		$11,800	$18,100
SAFETY	7.0%			$7,400		$13,700	$21,100
HEALTH PHYSICS	20.0%	$406,100		$81,200			$81,200
CERCLA $1,500	PER PERSON	2,000				$12,800	$12,800
BOND	1.0%	$10,154,300				$101,500	$101,500
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$493,700	$493,700
OVERHEAD & PROFIT	9.0%	$11,085,700				$997,700	$997,700
EMISSION MODELING	0.50%	$10,154,300		$17,800		$33,000	$50,800
PSAR/FSAR(SAFE RPT)	0.50%	$10,154,300		$17,800		$33,000	$50,800
PAYRL BRD.&BENFT.	52.0%	$522,900		$271,900			$271,900
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$794,800		$11,382,200	$12,456,900
CONSTR. MGMT.	4.0%	$12,456,900					$498,300
SUB-TOTAL 3							$12,955,200
SOIL/WATER/AIR	1.0%	$10,154,300		$35,500		$66,000	$101,500
HOME OFFICE EXP.	1.0%	$12,955,200					$129,600
PROJ.MGMT.FERMCO	8.0%	$12,955,200					$1,036,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$2,491,400
SUB-TOTAL 4	OFFICE COSTS						$16,714,100
SALES TAX	6.0%	$11,448,200					$686,900
SUB-TOTAL 5							$17,401,000
RISK BUDGET	11.0%						$1,914,100
SUB-TOTAL 6							$19,315,100
CONTINGENCY	20.0%						$3,863,000
TOTAL ESTIMATED INSTALLED COST							$23,178,100

EST.FILE #: 3096-9.

SILO 1. & 2.

CHEMICAL EXTRACTION/VITRIFICATION EQUIPMENT.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CHEMICAL EXTRACTION,-EQUIPMENT CAPITAL COST ESTIMATE							
1	M-201,M-202,AGITATORS-STAGES 1 &2,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	56	$40,000	$988		$40,988
2	M-301-M-306,AGITATORS-STAGES 1 &6,RINSE TANK C.S.RUBBER LINED	6	EA.	168	$120,000	$2,964		$122,964
3	M-203-M204,AGITATORS-STAGES 3 &4,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
4	M-205-M-206,AGITATORS-STAGES 5 &6,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
5	M-403,AGITATOR EDTA CRYSTALLIZER,C.S.RUBBER LINED.	1	EA.	24	$15,000	$423		$15,423
6	M-404,AGITATOR EDTA DISSOLVER,C.S.RUBBER LINED.	1	EA.	32	$18,000	$564		$18,564
7	M-503,AGITATOR-FLASH MIX TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
8	M-504,AGITATOR-FLOCCULATION TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
9	M-105,AGITATORS-KCL MIX TANK,C.S.RUBBER LINED	1	EA.	24	$18,000	$423		$18,423
10	M-108,AGITATOR-KCL SOAK TANK C.S. RUBBER LINED.	1	EA.	40	$50,000	$706		$50,706
11	M-106,AGITATOR-KCL TANK C.S.RUBBER LINED.	1	EA.	36	$40,000	$635		$40,635
12	F-201-F-206,BELT FILTERS-STAGES 1-6, 304 S.S.,3'X9'.	6	EA.	1,200	$1,110,000	$21,168		$1,131,168
13	F-106,BELT FILTER-KCL/SOLIDS,316L S.S.BELT FILTER.	1	EA.	200	$185,000	$3,528		$188,528
14	F-501,BELT FILTER-SLUDGE, BELT FILTER PRESS	1	EA.	200	$140,000	$3,528		$143,528
15	F-101,BELT FILTER-SLURRY, BELT FILTER,3'X10'.	1	EA.	200	$185,000	$3,528		$188,528
16	F-301-F-306,CENTRIFUGES- STAGES 1-6,304 S.S.CENTRIFUGES	6	EA.	600	$600,000	$10,584		$610,584
17	T-505,CLARIFIER, EPOXY COATED STEEL	1	EA.	80	$20,000	$1,411		$21,411
18	M-505,CLARIFIER RAKE, EPOXY COATED STEEL.	1	EA.	4	$0	$71		$71
19	C-101,CONVEYOR-ADDITIVES	1	EA.	40	$11,306	$706		$12,012
20	D-501,DRYER-SLUDGE, GAS FIRED COUNTER CURRENT DRYER.	1	EA.	200	$550,000	$3,528		$553,528
21	F-401,FILTER-FILTER, 3'X6' BELT FILTER ACID PROOF.	1	EA.	200	$185,000	$3,528		$188,528
22	H-101,HOPPER-ADDITIVES	1	EA.	80	$5,000	$1,411		$6,411
23	H-101,HOPPER-KCL,C.S.RUBBER LINED, 5,000 LBS.	1	EA.	80	$5,000	$1,411		$6,411
24	P-201-P-206,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
25	P-301-P-306,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
26	P-505,PUMP-CLARIFIER SLUDGE PUMP,POSITIVE DISPLACEMENT,	1	EA.	25	$2,200	$441		$2,641
-	LINED, 0.7 GPM.	-	-	-	-	-		-
27	P-404,PUMP-EDTA CIRCULATING,CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
28	P-405, PUMP-EDTA FEED CENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
29	P-403, PUMP EDTA,SLURRY, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
30	P-104, PUMP FILTRATECENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
	SUBTOTAL THIS PAGE.			4,305	$3,466,506	$75,942	-	$3,542,448

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A- REMOVAL,STABILIZATION,ON-PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	CARRYFORWARD			4,305	$3,466,506	$75,942	-	$3,542,448
31	P-402,PUMP-HCL,PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	-	$2,441
32	P-106,PUMP-KCL, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
33	P-105,'PUMP-KCL MIX TANK PUMP, CENTRIFUGAL, RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
34	P-108,PUMP-KCL SOLIDS SLURRY PUMP,CENTRIFUGAL,RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	-	$4,706
35	P-502,PUMP-NALMET PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	-	$2,441
36	P-501,PUMP-NaOH,PLASTIC METERING, 0.25 gpm.	1	EA.	25	$1,500	$441	-	$1,941
37	P-401,PUMP-NH3, PLASTIC METERING, 0.7 GPM.	1	EA.	25	$2,000	$441	-	$2,441
38	P-101,PUMP-SLURRY,CENTRIFUGAL RUBBER LINED,32 GPM.	1	EA.	40	$4,000	$706	-	$4,706
39	P-207,PUMP-STRONG EXTRACT, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	-	$4,706
40	P-406,PUMP-WEAK CENTRATE, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	-	$4,706
41	S-402,SCRUBBER-HCL,FIBERGLAS, 1,000CFM.	1	EA.	48	$8,800	$847	-	$9,647
42	S-401,SCRUBBER-NH3, FIBERGLASS, 250 CFM.	1	EA.	48	$12,400	$847	-	$13,247
43	SI-103,STEAM INJECTORS-STAGES 5&6 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
44	SI-105,STEAM INJECTORS-EDTA TANKS	2	EA.	40	$3,460	$706	-	$4,166
45	SI-101,STEAM INJECTORS-STAGES 1&2 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
46	SI-104,STEAM INJECTORS-STAGES 1-6 RINSE TANKS	6	EA.	120	$10,380	$2,117	-	$12,497
47	SI-102,STEAM INJECTORS-STAGES 3&4 EXTRACTION TANK	2	EA.	40	$3,460	$706	-	$4,166
48	B-101,BOILER FOR STEAM INJECTION,ROUGH ESTIMATE OF SIZING,225,000 LBS.	1	EA.	400	$930,000	$7,056	-	$937,056
49	T-502,TANK-NALMET,FIBERGLASS,3,000 GALLONS.	1	EA.	20	$4,948	$353	-	$5,301
50	T-402,TANK-HCL STORAGE,FIBERGLASS,7,500 GALLONS.	1	EA.	40	$6,426	$706	-	$7,132
51	T-401,TANK-NH3 STORAGE,FIBERGLASS,10,000 GALLONS.	1	EA.	40	$7,063	$706	-	$7,769
52	T-503,TANK-FLASH MIX,PLASTIC, 30 GALLONS.	1	EA.	4	$300	$71	-	$371
53	T-504,TANK-FLOCCULATION, PLASTIC, 300 GALLONS.	1	EA.	8	$1,000	$141	-	$1,141
54	T-501,TANK-NaOH, STEEL, 1,000 GALLONS.	1	EA.	20	$3,000	$353	-	$3,353
55	T-403,TANK-EDTA CRYSTALLIZER TANK,CARBON STEEL,RUBBER LINED,1,000 GAL.	1	EA.	20	$3,000	$353	-	$3,353
56	T-105,TANK-KCL MIX, RUBBER LINED, 2,000 GALLONS.	1	EA.	40	$5,000	$706	-	$5,706
57	T-301-T-306,TANKS-STAGES 1-6 RINSE,RUBBER LINED,3,000 GALLONS.	6	EA.	100	$36,000	$1,764	-	$37,764
58	T-201,T-202,TANKS-STAGES 1 & 2 EXTRACTION,RUBBER LINED,3,000 GALS.	2	EA.	40	$12,000	$706	-	$12,706
59	T-404,TANK-EDTA DISSOLVER, CARBON STEEL, RUBBER LINED, 5,000 GALS.	1	EA.	40	$7,000	$706	-	$7,706
60	T-203,T-204,TANKS-STAGES 3&4 EXTRACTION, RUBBER LINED,6,000 GALLONS.	2	EA.	80	$14,000	$1,411	-	$15,411
61	T-207,TANK,STRONG EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	-	$7,706
62	T-406,TANK WEAK EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	-	$7,706
	SUBTOTAL THIS PAGE.			5,953	$4,587,163	$105,021	-	$4,692,184

F-5089

700

FERNALD PROJECT – OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93–1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			5,953	$4,587,163	$105,021	–	$4,692,184
63	T–106,TANK–KCL RUBBER LINED,10,000 GALLONS.	1	EA.	40	$8,000	$706	–	$8,706
64	T–205,T–206,TANKS–STAGES 5&6, RUBBER LINED,12,000 GALLONS.	2	EA.	80	$17,000	$1,411	–	$18,411
65	T–405,TANK–EDTA STORAGE, C.S. RUBBER LINED,15,000 GALLONS.	1	EA.	100	$10,000	$1,764	–	$11,764
66	T–108,TANK–KCL SOAK, RUBBER LINED,15,000 GALLONS.	1	EA.	40	$10,000	$706	–	$10,706
67	T–104,TANK–FILTRATE,CARBON STEEL,15,000 GALLONS.80C.	1	EA.	40	$10,000	$706	–	$10,706
70	I–501,VITRIFIER,OFF–GAS TREATMENT SYSTEM.,1.05 TON PER DAY.	1	EA.	3,200	$871,795	$56,448	–	$928,243
–	OFF–GAS TREATMENT SYSTEM.	1	EA.	800	$217,949	$14,112	–	$232,061
71	INSTRUMENTATION & CONTROL, 15% OF PURCHASED EQUIPMENT COST.	1	LS	1,538	$859,786	$27,130	–	$886,916
72	PROCESS PIPING, 12% OF PURCHASED EQUIPMENT COST.	1	LS	1,230	$687,829	$21,697	–	$709,526
73	ELECTRICAL, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
74	AUXILIARIES, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	17,123	$9,572,284	$302,060	–	$9,874,344
	SUBCONTRACT COSTS							
1	ADDITIVE FEED SYSTEM (PRORATED).	1	LS	–	–	–	–	–
2	PROCESS VESSEL RADON TREATMENT SYSTEM (PRORATED).	1	LS	–	–	–	$280,000	$280,000
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	–	–	–	$280,000	$280,000
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	17,123	$9,572,284	$302,060	$280,000	$10,154,344

EST FILE #: 0096-[redacted]5039
CLIENT: US DO[redacted]
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

ESTIMATOR: COSSMAN / WALTERS
LOCATION: FERNALD
DATE: 24-Aug-93

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,[illegible]
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	AVG. 17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0%	$1,768,367		$353,700			$353,7[illegible]
CERCLA	$1,500 PER PERSON	2,000				$55,500	$55,5[illegible]
BOND	1.0%	$6,655,385				$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$332,700	$332,700
OVERHEAD & PROFIT	9.0%	$8,513,685				$766,200	$766,200
EMISSION MODELING	0.50%	$6,655,385		$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50%	$6,655,385		$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0%	$2,145,267		$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0%	$10,461,800					$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0%	$6,655,385		$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0%	$10,880,300					$108,800
PROJ.MGMT.FERMCO	8.0%	$10,880,300					$870,400
ENGINEERING	20.0% Title I	7.0% Title II	10.0% Title III	3.0%			$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0%	$7,244,300					$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

06/10/93

I. T.PROJECT NO.:409194

ESTIMATOR: F.H.GASLIGHTWALA

ALTERNATIVE # 5A.2 REMOVAL,CHEMICAL,EXTRACTION,STABILIZATION,OFF-SITE DISPOSAL TO FACILITY WITHIN 300 MILES OF FEMP. (SILO 1 & 2),OPERATION & MAINTENANCE COSTS-VITRIFICATION OPTION.

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

FY 93-1 DOLLARS

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	CRAFT LABOR	381,077	MHRS	381,077	-	$12,910,889	-	$12,910,889
2	SUPERVISORY LABOR.	5,803	MHRS	5,803	-	$389,265	-	$389,265
3	PROCESS WATER.	76,084,000	GALS	-	$1,521,680	-	-	$1,521,680
4	LOW PRESSURE STEAM.	-	-	-	INCLUDED	-	-	-
5	WASTE WATER DISCHARGE.	-	-	-	INCLUDED	-	-	-
6	ELECTRICITY-FOR CHEMICAL EXTRACTION MACHINERY, VITRIFICATION UNIT.	15,582,000	KWH	-	$712,253	-	-	$712,253
7	NALMET 8154	5,720	TONS	-	$7,092,800	-	-	$7,092,800
8	DIAMMONIUM EDTA	780	TONS	-	$1,185,980	-	-	$1,185,980
9	KCL (AS POTASSIUM MURIATE)	2,430	TONS	-	$194,400	-	-	$194,400
10	HCL (AS 32% SOLUTION)	15,300	TONS	-	$3,396,600	-	-	$3,396,600
11	NH3 (AS 29% NH3)	4,500	TONS	-	$1,417,343	-	-	$1,417,343
12	FLYASH	10,420	TONS	-	$125,040	-	-	$125,040
13	SODAASH	1,560	TONS	-	$241,800	-	-	$241,800
	SUBTOTAL OPERATIONS			386,880	$15,887,896	$13,300,154	-	$29,188,050

5039

ALTERNATIVE 5A.2

CEMENT STABILIZATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 3
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 5A.2: REMOVAL, CHEMICAL EXTRACTION, CEMENT STABILIZATION, OFF-SITE DISPOSAL AT FACILITY 300 MILES FROM FEMP

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-6A	SITE PREPARATION	$780,500	$676,400	$1,456,900
3096-5B	WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
3096-30A	CHEMICAL EXTRACTION EQUIPMENT	$9,314,000	$6,476,200	$15,790,200
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
-	TRANSPORTATION	$407,900		$407,900
-	DISPOSAL VAULT	$4,797,200	$8,168,200	$12,965,400
-	PACKAGING (12,348 PKGS. @ $955/PKG.)	$3,259,900	$8,532,500	$11,792,400
TOTAL CAPITAL		$26,910,700	$33,078,800	$59,989,500
RISK BUDGET (11.0%)		$2,960,200	$3,638,700	$6,598,900
SUBTOTAL		$29,870,900	$36,717,500	$66,588,400
CONTINGENCY (20.0%)		$5,974,200	$7,343,500	$13,317,700
TOTAL ESTIMATED INSTALLED COST		$35,845,100	$44,061,000	$79,906,100
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$29,460,800
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$95,659,600

715

File: SUM5A2CE.WK3

EST FILE #: 3096-5039
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	4,148		$68,485		$243,764	$312,200
	SUBCONCTRACTOR COSTS	5,386			$468,274		$468,300
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,534	17.00	$68,500	$468,300	$243,800	$780,500
SUPERVISION & SUPPRT LABOR	28.0%			$19,000			$19,000
SMALL TOOLS	$1.50					$14,300	$14,300
CONSUMABLES	$1.50					$14,300	$14,300
EQUIPMENT RENTAL	$3.00					$28,600	$28,600
TEMP. FACILITIES	4.0%			$1,000		$1,800	$2,800
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,400		$2,700	$4,10[illegible]
SAFETY	7.0%			$1,700		$3,100	$4,8[illegible]
HEALTH PHYSICS	20.0% $91,800			$18,400			$18,40[illegible]
CERCLA $1,500	PER PERSON 2,000					$7,200	$7,200
BOND	1.0% $780,500					$7,800	$7,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$15,600	$15,600
OVERHEAD & PROFIT	9.0% $918,000					$82,600	$82,600
EMISSION MODELING	0.50% $780,500			$1,400		$2,500	$3,900
PSAR/FSAR(SAFE RPT)	0.50% $780,500			$1,400		$2,500	$3,900
PAYRL BRD.&BENFT.	52.0% $113,000			$58,800			$58,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$171,800		$427,200	$1,067,200
CONSTR. MGMT.	4.0% $1,067,200						$42,700
SUB-TOTAL 3							$1,109,900
SOIL/WATER/AIR	1.0% $780,500			$2,700		$5,100	$7,800
HOME OFFICE EXP.	1.0% $1,109,900						$11,100
PROJ.MGMT.FERMCO	8.0% $1,109,900						$88,800
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$213,400
SUB-TOTAL 4	OFFICE COSTS						$1,431,000
SALES TAX	6.0% $432,300						$25,900
SUB-TOTAL 5							$1,456,900
RISK BUDGET	11.0%						$160,300
SUB-TOTAL 6							$1,617,200
CONTINGENCY	20.0%						$323,400
TOTAL ESTIMATED INSTALLED COST							$1,940,600

EST.FILE #: 3096-6.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
14	TRANSFORMER,120 KVA,480 VAC 3 PHASE, TO 240/120 VAC 1 PHASE.	1	EA	125	$3,300	$2,064	-	$5,364
	SUBTOTAL.	1	LS	3,460	$235,579	$57,126	-	$292,705

F 50030

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRY FORWARD	1	LS	3,460	$235,579	$57,126	-	$292,705
							-	
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
17	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
							-	
-	SEWER:	-	-	-	-	-	-	
18	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
19	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	
20	STEAM BOILER, ELECTRIC, 141,500 BTUH, 150 #/HR, 30 PSIG.	1	EA	60	$5,000	$991	-	$5,991
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	4,148	$243,764	$68,485	-	$312,249

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$468,274	$468,274
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,534	$243,764	$68,485	$468,274	$780,523

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

E-5039

EST FILE #: 3096-5 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	4,052		$71,766		$117,285	$189,100
	H V A C COSTS	5,424		$103,056		$194,181	$297,200
	SUBCONCTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,852	14.75	$174,800	$522,200	$311,500	$1,008,500
SUPERVISION & SUPPRT LABOR	28.0%			$49,000			$49,000
SMALL TOOLS	$1.50					$17,800	$17,800
CONSUMABLES	$1.50					$17,800	$17,800
EQUIPMENT RENTAL	$3.00					$35,600	$35,600
TEMP. FACILITIES	4.0%			$2,400		$4,500	$6,900
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,700		$6,800	$10,500
SAFETY	7.0%			$4,300		$8,000	$12,300
HEALTH PHYSICS	20.0%	$234,800		$47,000			$47,000
CERCLA $1,500	PER PERSON	2,000				$8,900	$8,900
BOND	1.0%	$1,008,500				$10,100	$10,100
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$24,300	$24,300
OVERHEAD & PROFIT	9.0%	$1,250,400				$112,500	$112,500
EMISSION MODELING	0.50%	$1,008,500		$1,800		$3,300	$5,100
PSAR/FSAR(SAFE RPT)	0.50%	$1,008,500		$1,800		$3,300	$5,100
PAYRL BRD.&BENFT.	52.0%	$285,400		$148,400			$148,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$433,800		$565,500	$1,521,500
CONSTR. MGMT.	4.0%	$1,521,500					$60,900
SUB-TOTAL 3							$1,582,400
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0%	$1,008,500		$3,500		$6,600	$10,100
HOME OFFICE EXP.	1.0%	$1,582,400					$15,800
PROJ.MGMT.FERMCO	8.0%	$1,582,400					$126,600
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III	3.0%		$304,300
SUB-TOTAL 4	OFFICE COSTS						$2,039,200
SALES TAX	6.0%	$572,100					$34,300
SUB-TOTAL 5							$3,123,500
RISK BUDGET	11.0%						$343,600
SUB-TOTAL 6							$3,467,100
CONTINGENCY	20.0%						$693,400
TOTAL ESTIMATED INSTALLED COST							$4,160,500

EST.FILE #: 3096-5.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$1,310
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$2,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$9,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$2,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$60,155
9	WALLS FOR SHIELDING - PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$39,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$23,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$5,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$5,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$18,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$29,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$153,064
-	PROCESS AREA VENTILATION SYSTEM, RADON.	1	EA	96	$900	$1,824		$2,724
17	RADON GAS MONITOR	-	-	-	-	-		-
18	BLOWER,1,000 CFM,1"SP.	3	EA	32	$21,000	$608		$21,608
19	DEHUMIDIFICATION VESSELS,DRIRITE,1,000 CFM.	2	EA	16	$3,000	$304		$3,304
20	CARBON VESSELS, 1,000 CFM	2	EA	64	$21,800	$1,216		$23,016
21	HEPA FILTERS, 1,000 CFM CAPACITY.	2	EA	64	$21,800	$1,216		$23,016
22	DUCTWORK,10"DIAMETER,w/ DAMPERS, FITTINGS, 200 FT LONG..	2	EA	16	$2,600	$304		$2,904
23	DAMPER 1,000 CFM.	2,700	LBS	332	$5,061	$6,308		$11,369
24	ALLOWANCE FOR CONTROLS TO SWITCH FROM GENERAL VENTILATION TO RADON.	1	EA	16	$400	$304		$704
		1	LS	120	$5,000	$2,280		$7,280
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	9,476	$311,466	$174,822	-	$486,288

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	–	–	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	–	–	$432,000	$432,000
–	(30 FT EAVES, FULLY INSULATED, HVAC).	–	–	–	–	–	–	–
3	PARTITIONS–ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	–	–	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	–	–	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,852	$311,466	$174,822	$522,208	$1,008,496

EST FILE # 3096-30 A -5039
CLIENT: US DOE
PROJECT TITLE: CHEMICAL EXTRACTION / CEMENT STABILIZATION EQUIPMENT

PERMCO
ESTIMATING SERVICES
SUMMARY SHEET

ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD
DATE 24-Aug-93

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	MACHINERY & EQUIPMENT COSTS	13,123		$231,500		$8,482,540	$8,714,000
	SUBCONTRACTOR COSTS				$600,000		$600,000
SUB-TOTAL 1	DIRECT FIELD COSTS	13,123	AVG. 17.64	$231,500	$600,000	$8,482,500	$9,314,000
SUPERVISION & SUPPRT LABOR	28.0%						
SMALL TOOLS	$1.50			$65,000			$65,000
CONSUMABLES	$1.50					$19,700	$19,700
EQUIPMENT RENTAL	$3.00					$19,700	$19,700
TEMP. FACILITIES	4.0%					$39,400	$39,400
TEMP. UTILITIES	1.0%			$3,200		$6,000	$9,200
JOB CLEAN-UP	6.0%			$800		$1,500	$2,300
SAFETY	7.0%			$4,900		$9,000	$13,900
HEALTH PHYSICS	20.0% $311,100			$5,700		$10,500	$16,200
CERCLA $1,500	PER PERSON 2,000			$62,200			$62,200
BOND	1.0% $9,314,000					$9,800	$9,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$93,100	$93,100
OVERHEAD & PROFIT	9.0% $10,100,200					$435,700	$435,700
EMISSION MODELING	0.50% $9,314,000					$909,000	$909,000
PSAR/FSAR(SAFE RPT)	0.50% $9,314,000			$16,300		$30,300	$46,600
PAYRL BRD.&BENFT.	52.0% $405,900			$16,300		$30,300	$46,600
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$211,100			$211,100
				$617,000		$10,096,500	$11,313,500
CONSTR. MGMT.	4.0% $11,313,500						$452,500
SUB-TOTAL 3							$11,766,000
SOIL/WATER/AIR	1.0% $9,314,000						
HOME OFFICE EXP.	1.0% $11,766,000			$32,600		$60,500	$93,100
PROJ.MGMT.FERMCO	8.0% $11,766,000						$117,700
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$941,300
SUB-TOTAL 4	OFFICE COSTS						$2,262,700
							$15,180,800
SALES TAX	6.0% $10,157,000						$609,400
SUB-TOTAL 5							$15,790,200
RISK BUDGET	11.0%						$1,736,900
SUB-TOTAL 6							$17,527,100
CONTINGENCY	20.0%						$3,505,400
TOTAL ESTIMATED INSTALLED COST							$21,032,500

08/24/93

EST.FILE #:3096-30.

CHEMICAL EXTRACTION/CEMENT STABILIZATION EQUIPMENT.

FY 93-1 DOLLARS

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CHEMICAL EXTRACTION,-EQUIPMENT CAPITAL COST ESTIMATE.							
1	M-201,M-202,AGITATORS-STAGES 1 &2,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	56	$40,000	$988		$40,988
2	M-301-M-306,AGITATORS-STAGES 1 &6,RINSE TANK C.S.RUBBER LINED	6	EA.	168	$120,000	$2,964		$122,964
3	M-203-M204,AGITATORS-STAGES 3 &4,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
4	M-205-M-206,AGITATORS-STAGES 5 &6,EXTRACTION TANK C.S.RUBBER LINED	2	EA.	64	$50,000	$1,129		$51,129
5	M-403,AGITATOR EDTA CRYSTALLIZER,C.S.RUBBER LINED.	1	EA.	24	$15,000	$423		$15,423
6	M-404,AGITATOR EDTA DISSOLVER,C.S.RUBBER LINED.	1	EA.	32	$18,000	$564		$18,564
7	M-503,AGITATOR-FLASH MIX TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
8	M-504,AGITATOR-FLOCCULATION TANK, PLASTIC.	1	EA.	24	$1,500	$423		$1,923
9	M-105,AGITATORS-KCL MIX TANK,C.S.RUBBER LINED	1	EA.	24	$18,000	$423		$18,423
10	M-108,AGITATOR-KCL SOAK TANK C.S. RUBBER LINED.	1	EA.	40	$50,000	$706		$50,706
11	M-106,AGITATOR-KCL TANK C.S.RUBBER LINED.	1	EA.	36	$40,000	$635		$40,635
12	F-201-F-206,BELT FILTERS-STAGES 1-6, 304 S.S.,3'X9'.	6	EA.	1,200	$1,110,000	$21,168		$1,131,168
13	F-106,BELT FILTER-KCL/SOLIDS,316L S.S.BELT FILTER.	1	EA.	200	$185,000	$3,528		$188,528
14	F-501,BELT FILTER-SLUDGE, BELT FILTER PRESS	1	EA.	200	$140,000	$3,528		$143,528
15	F-101,BELT FILTER-SLURRY, BELT FILTER,3'X10'.	1	EA.	200	$185,000	$3,528		$188,528
16	F-301-F-306,CENTRIFUGES- STAGES 1-6,304 S.S.CENTRIFUGES	6	EA.	600	$600,000	$10,584		$610,584
17	T-505,CLARIFIER, EPOXY COATED STEEL	1	EA.	80	$20,000	$1,411		$21,411
18	M-505,CLARIFIER RAKE, EPOXY COATED STEEL.	1	EA.	4	$0	$71		$71
19	C-101,CONVEYOR-ADDITIVES	1	EA.	40	$11,306	$706		$12,012
20	D-501,DRYER-SLUDGE, GAS FIRED COUNTER CURRENT DRYER.	1	EA.	200	$550,000	$3,528		$553,528
21	F-401,FILTER-FILTER, 3'X6' BELT FILTER ACID PROOF.	1	EA.	200	$185,000	$3,528		$188,528
22	H-101,HOPPER-ADDITIVES	1	EA.	80	$5,000	$1,411		$6,411
23	H-101,HOPPER-KCL,C.S.RUBBER LINED, 5,000 LBS.	1	EA.	80	$5,000	$1,411		$6,411
24	P-201-P-206,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
25	P-301-P-306,PUMPS-STAGES 1-6 SLURRY,CENTRIFUGAL,RUBBER	6	EA.	240	$24,000	$4,234		$28,234
-	LINED, 50 GPM.	-	-	-	-	-		-
26	P-505,PUMP-CLARIFIER SLUDGE PUMP,POSITIVE DISPLACEMENT,	1	EA.	25	$2,200	$441		$2,641
-	LINED, 0.7 GPM.	-	-	-	-	-		-
27	P-404,PUMP-EDTA CIRCULATING,CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
28	P-405, PUMP-EDTA FEED CENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
29	P-403, PUMP EDTA,SLURRY, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706		$4,706
30	P-104, PUMP FILTRATECENTRIFUGAL RUBBER LINED,30 GPM.	1	EA.	40	$4,000	$706		$4,706
	SUBTOTAL THIS PAGE.			4,305	$3,466,506	$75,942	-	$3,542,448

713

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FERNALD PROJECT – OU4

08/24/93

I. T.PROJECT NO.:409194

ESTIMATOR: F.H.GASLIGHTWALA

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

PROJ.ENGR: JOE PACELLI

SUMMARY OF CAPITAL COSTS.

PROJ. MGR: SUSAN RHYNE.

FY 93–1 DOLLARS

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			4,305	$3,466,506	$75,942	–	$3,542,448
31	P–402,PUMP–HCL,PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	–	$2,441
32	P–106,PUMP–KCL, CENTRIFUGAL RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
33	P–105,'PUMP–KCL MIX TANK PUMP, CENTRIFUGAL, RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
34	P–108,PUMP–KCL SOLIDS SLURRY PUMP,CENTRIFUGAL,RUBBER LINED,50 GPM.	1	EA.	40	$4,000	$706	–	$4,706
35	P–502,PUMP–NALMET PLASTIC METERING, 0.5 GPM.	1	EA.	25	$2,000	$441	–	$2,441
36	P–501,PUMP–NaOH,PLASTIC METERING, 0.25 gpm.	1	EA.	25	$1,500	$441	–	$1,941
37	P–401,PUMP–NH3, PLASTIC METERING, 0.7 GPM.	1	EA.	25	$2,000	$441	–	$2,441
38	P–101,PUMP–SLURRY,CENTRIFUGAL RUBBER LINED,32 GPM.	1	EA.	40	$4,000	$706	–	$4,706
39	P–207,PUMP–STRONG EXTRACT, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	–	$4,706
40	P–406,PUMP–WEAK CENTRATE, CENTRIFUGAL RUBBER LINED, 30 GPM.	1	EA.	40	$4,000	$706	–	$4,706
41	S–402,SCRUBBER–HCL,FIBERGLAS, 1,000CFM.	1	EA.	48	$8,800	$847	–	$9,647
42	S–401,SCRUBBER–NH3, FIBERGLASS, 250 CFM.	1	EA.	48	$12,400	$847	–	$13,247
43	SI–103,STEAM INJECTORS–STAGES 5&6 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
44	SI–105,STEAM INJECTORS–EDTA TANKS	2	EA.	40	$3,460	$706	–	$4,166
45	SI–101,STEAM INJECTORS–STAGES 1&2 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
46	SI–104,STEAM INJECTORS–STAGES 1–6 RINSE TANKS	6	EA.	120	$10,380	$2,117	–	$12,497
47	SI–102,STEAM INJECTORS–STAGES 3&4 EXTRACTION TANK	2	EA.	40	$3,460	$706	–	$4,166
48	B–101,BOILER FOR STEAM INJECTION,ROUGH ESTIMATE OF SIZING,225,000 LBS.	1	EA.	400	$930,000	$7,056	–	$937,056
49	T–502,TANK–NALMET,FIBERGLASS,3,000 GALLONS.	1	EA.	20	$4,948	$353	–	$5,301
50	T–402,TANK–HCL STORAGE,FIBERGLASS,7,500 GALLONS.	1	EA.	40	$6,426	$706	–	$7,132
51	T–401,TANK–NH3 STORAGE,FIBERGLASS,10,000 GALLONS.	1	EA.	40	$7,063	$706	–	$7,769
52	T–503,TANK–FLASH MIX,PLASTIC, 30 GALLONS.	1	EA.	4	$300	$71	–	$371
53	T–504,TANK–FLOCCULATION, PLASTIC, 300 GALLONS.	1	EA.	8	$1,000	$141	–	$1,141
54	T–501,TANK–NaOH, STEEL, 1,000 GALLONS.	1	EA.	20	$3,000	$353	–	$3,353
55	T–403,TANK–EDTA CRYSTALLIZER TANK,CARBON STEEL,RUBBER LINED,1,000 GAL.	1	EA.	20	$3,000	$353	–	$3,353
56	T–105,TANK–KCL MIX, RUBBER LINED, 2,000 GALLONS.	1	EA.	40	$5,000	$706	–	$5,706
57	T–301–T–306,TANKS–STAGES 1–6 RINSE,RUBBER LINED,3,000 GALLONS.	6	EA.	100	$36,000	$1,764	–	$37,764
58	T–201,T–202,TANKS–STAGES 1 & 2 EXTRACTION,RUBBER LINED,3,000 GALS.	2	EA.	40	$12,000	$706	–	$12,706
59	T–404,TANK–EDTA DISSOLVER, CARBON STEEL, RUBBER LINED, 5,000 GALS.	1	EA.	40	$7,000	$706	–	$7,706
60	T–203,T–204,TANKS–STAGES 3&4 EXTRACTION, RUBBER LINED,6,000 GALLONS.	2	EA.	80	$14,000	$1,411	–	$15,411
61	T–207,TANK,STRONG EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	–	$7,706
62	T–406,TANK WEAK EXTRACT,C.S.RUBBER LINED,8,000 GALLONS.	1	EA.	40	$7,000	$706	–	$7,706
	SUBTOTAL THIS PAGE.			5,953	$4,587,163	$105,021	–	$4,692,184

714

5039

FERNALD PROJECT – OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2A– REMOVAL,STABILIZATION,ON–PROPERTY DISPOSAL.(SILO 1 & 2 CONTENTS).

SUMMARY OF CAPITAL COSTS.

FY 93–1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN–HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
–	CARRYFORWARD			5,953	$4,587,163	$105,021	–	$4,692,184
63	T–106,TANK–KCL RUBBER LINED,10,000 GALLONS.	1	EA.	40	$8,000	$706	–	$8,706
64	T–205,T–206,TANKS–STAGES 5&6, RUBBER LINED,12,000 GALLONS.	2	EA.	80	$17,000	$1,411	–	$18,411
65	T–405,TANK–EDTA STORAGE, C.S. RUBBER LINED,15,000 GALLONS.	1	EA.	100	$10,000	$1,764	–	$11,764
66	T–108,TANK–KCL SOAK, RUBBER LINED,15,000 GALLONS.	1	EA.	40	$10,000	$706	–	$10,706
67	T–104,TANK–FILTRATE,CARBON STEEL,15,000 GALLONS.80C.	1	EA.	40	$10,000	$706	–	$10,706
68	INSTRUMENTATION & CONTROL, 15% OF PURCHASED EQUIPMENT COST.	1	LS	1,538	$859,786	$27,130	–	$886,916
69	PROCESS PIPING, 12% OF PURCHASED EQUIPMENT COST.	1	LS	1,230	$687,829	$21,697	–	$709,526
70	ELECTRICAL, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
71	AUXILIARIES, 20% OF PURCHASED EQUIPMENT COST.	1	LS	2,051	$1,146,381	$36,180	–	$1,182,561
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	13,123	$8,482,540	$231,500	–	$8,714,040
	SUBCONTRACT COSTS			–	–	–	–	–
1	ADDITIVE FEED SYSTEM (PRORATED).(INCL. CEMENT MIXER, 2 TPH)	1	LS	–	–	–	$600,000	$600,000
2	PROCESS VESSEL RADON TREATMENT SYSTEM (PRORATED).	1	LS	–	–	–	–	–
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	–	–	–	$600,000	$600,000
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	13,123	$8,482,540	$231,500	$600,000	$9,314,040

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 30%-7 B
CLIENT: USDOE 5039
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

ESTIMATOR COSSMAN / WALTERS
DATE 24-Aug-93
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,28
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0% $1,768,367			$353,700			$353,700
CERCLA $1,500	PER PERSON 2,000					$55,500	$55,500
BOND	1.0% $6,655,385					$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$332,700	$332,700
OVERHEAD & PROFIT	9.0% $8,513,685					$766,200	$766,200
EMISSION MODELING	0.50% $6,655,385			$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50% $6,655,385			$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0% $2,145,267			$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0% $10,461,800						$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0% $6,655,385			$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0% $10,880,300						$108,800
PROJ.MGMT.FERMCO	8.0% $10,880,300						$870,400
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0% $7,244,300						$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 5A.2 REMOVAL,CHEMICAL,EXTRACTION,STABILIZATION,OFF-SITE DISPOSAL TO FACILITY WITHIN 300 MILES OF FEMP. (SILO 1 & 2),OPERATION & MAINTENANCE COSTS-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	CRAFT LABOR	381,077	MHRS	381,077	-	$12,910,889	-	$12,910,889
2	SUPERVISORY LABOR.	5,803	MHRS	5,803	-	$389,265	-	$389,265
3	PROCESS WATER.	77,672,000	GALS	-	$1,553,440	-	-	$1,553,440
4	LOW PRESSURE STEAM.	-	-	-	INCLUDED	-	-	-
5	WASTE WATER DISCHARGE.	-	-	-	INCLUDED	-	-	-
6	ELECTRICITY-FOR CHEMICAL EXTRACTION MACHINERY, CEMENT STABILIZATION UNIT	18,050,000	KWH	-	$825,066	-	-	$825,066
7	NALMET 8154	5,720	TONS	-	$7,092,800	-	-	$7,092,800
8	DIAMMONIUM EDTA	780	TONS	-	$1,185,980	-		$1,185,980
9	KCL (AS POTASSIUM MURIATE)	2,430	TONS	-	$194,400	-		$194,400
10	HCL (AS 32% SOLUTION)	15,300	TONS	-	$3,396,600	-		$3,396,600
11	NH3 (AS 29% NH3)	4,500	TONS	-	$1,417,343	-		$1,417,343
12	FLYASH	1,560	TONS	-	$18,720	-		$18,720
13	CEMENT	5,530	TONS		$364,980			$364,980
14	CLINOPTILOLITE	525	TONS		$14,385			$14,385
15	BLAST FURNACE SLAG.	3,230	TONS		$96,900			$96,900
	SUBTOTAL OPERATIONS			386,880	$16,160,613	$13,300,154	-	$29,460,767

ALTERNATIVE 6A

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 1
O&M DURING REMEDIATION (YRS): 2
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 6A: REMOVAL, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-8A	SITE PREPARATION	$768,600	$660,000	$1,428,600
–	WASTE PROCESSING	$201,700	$835,100	$1,036,800
3096-7B	HYDRAULIC REMOVAL/TRANSFER SYSTEM	$6,655,400	$7,797,800	$14,453,200
–	DISPOSAL VAULT	$1,405,700	$2,393,200	$3,798,900
–	PACKAGING (5,582 PKGS. @ $955/PKG.)	$1,473,600	$3,857,200	$5,330,800
TOTAL CAPITAL		$10,505,000	$15,543,300	$26,048,300
RISK BUDGET (11.0%)		$1,155,600	$1,709,800	$2,865,400
SUBTOTAL		$11,660,600	$17,253,100	$28,913,700
CONTINGENCY (20.0%)		$2,332,100	$3,450,600	$5,782,700
TOTAL ESTIMATED INSTALLED COST		$13,992,700	$20,703,700	$34,696,400
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$1,948,800
	POST-REMEDIATION			$3,425,400
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$35,619,700

719

-5039

File: SUM6A.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-8 A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CIVIL AND EXCAVATION COSTS	2,750		$45,403		$155,239	$200,600
	ELECTRICAL COSTS	585		$9,659		$77,040	$86,700
	PIPING COSTS	628		$10,368		$3,185	$13,600
	SUBCONCTRACTOR COSTS	5,386			$467,734		$467,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	9,349	16.50	$65,400	$467,700	$235,500	$768,600
SUPERVISION & SUPPRT LABOR	28.0%			$18,000			$18,000
SMALL TOOLS	$1.50					$14,000	$14,000
CONSUMABLES	$1.50					$14,000	$14,000
EQUIPMENT RENTAL	$3.00					$28,000	$28,000
TEMP. FACILITIES	4.0%			$900		$1,700	$2,600
TEMP. UTILITIES	1.0%			$200		$400	$6[illegible]
JOB CLEAN-UP	6.0%			$1,400		$2,600	$4,0[illegible]
SAFETY	7.0%			$1,600		$3,000	$4,600
HEALTH PHYSICS	20.0%	$87,500		$17,500			$17,500
CERCLA $1,500	PER PERSON	2,000				$7,000	$7,000
BOND	1.0%	$768,600				$7,700	$7,700
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$15,100	$15,100
OVERHEAD & PROFIT	9.0%	$901,700				$81,200	$81,200
EMISSION MODELING	0.50%	$768,600		$1,300		$2,500	$3,800
PSAR/FSAR(SAFE RPT)	0.50%	$768,600		$1,300		$2,500	$3,800
PAYRL BRD.&BENFT.	52.0%	$107,600		$56,000			$56,000
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$163,600		$415,200	$1,046,500
CONSTR. MGMT.	4.0%	$1,046,500					$41,900
SUB-TOTAL 3							$1,088,400
SOIL/WATER/AIR	1.0%	$768,600		$2,700		$5,000	$7,700
HOME OFFICE EXP.	1.0%	$1,088,400					$10,900
PROJ.MGMT.FERMCO	8.0%	$1,088,400					$87,100
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$209,300
SUB-TOTAL 4	OFFICE COSTS						$1,403,400
SALES TAX	6.0%	$420,200					$25,200
SUB-TOTAL 5							$1,428,600
RISK BUDGET	11.0%						$157,100
SUB-TOTAL 6							$1,585,700
CONTINGENCY	20.0%						$317,100
TOTAL ESTIMATED INSTALLED COST							$1,902,800

EST.FILE #: 3096-8.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SITE PREPARATION - CAPITAL COSTS							
1	CONTAMINATED BERM PACKING AREA,6"CRUSHED STONE,100'X 100'.	185	CYDS	184	$3,700	$3,038	-	$6,738
-	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
-		-	-	-	-	-	-	-
-	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
7	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
8	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
9	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
10	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
11	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	3	EA	72	$5,520	$1,189	-	$6,709
12	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
-	280 KVA.	-	-	-	-	-	-	-
-		-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
14	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
15	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
16	EXCAVATION & BACKFILL.	93	CYDS	6	-	$99	-	
							-	
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
18	EXCAVATION & BACKFILL.	67	CYDS	4	-	$66	-	$66
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,963	$235,464	$65,430	-	$300,894

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ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	REMOVE EXCESS BERM MATERIAL.(MATERIAL REMOVED FROM AROUND SILOS)	20,000	CYDS	2,620	-	-	$184,000	$184,000
-	TO ALLOW (CONSTRUCTION OF EIE RAIL SYSTEM).	-	-	-	-	-	-	-
2	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
3	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
4	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,234	$13,234
5	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
6	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
7	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
8	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
9	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	5,386	-	-	$467,734	$467,734
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	9,349	$235,464	$65,430	$467,734	$768,628

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-7 B
CLIENT: US DOE
PROJECT TITLE: HYDRAULIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	26,700		$440,687		$1,337,600	$1,778,287
	CONCRETE	4,000		$70,300		$336,300	$406,600
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,939		$51,780		$1,487,960	$1,539,740
	MACHINERY AND EQUIPMENT	948		$18,500		$52,000	$70,500
	PIPING	18,641		$354,080		$708,138	$1,062,218
	ELECTRICAL	3,422		$61,900		$108,600	$170,500
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	4,158		$77,040		$87,780	$164,820
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	73,981	17.79	$1,316,467		$5,338,900	$6,655,385
SUPERVISION & SUPPRT LABOR	28.0%			$369,000			$369,000
SMALL TOOLS	$1.50					$111,000	$111,000
CONSUMABLES	$1.50					$111,000	$111,000
EQUIPMENT RENTAL	$3.00					$221,900	$221,900
TEMP. FACILITIES	4.0%			$18,400		$34,200	$52,600
TEMP. UTILITIES	1.0%			$4,600		$8,600	$13,200
JOB CLEAN-UP	6.0%			$27,600		$51,300	$78,900
SAFETY	7.0%			$32,300		$59,900	$92,200
HEALTH PHYSICS	20.0% $1,768,367			$353,700			$353,700
CERCLA $1,500	PER PERSON 2,000					$55,500	$55,500
BOND	1.0% $6,655,385					$66,600	$66,600
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$332,700	$332,700
OVERHEAD & PROFIT	9.0% $8,513,685					$766,200	$766,200
EMISSION MODELING	0.50% $6,655,385			$11,600		$21,600	$33,200
PSAR/FSAR(SAFE RPT)	0.50% $6,655,385			$11,600		$21,600	$33,200
PAYRL BRD.&BENFT.	52.0% $2,145,267			$1,115,500			$1,115,500
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,260,800		$7,201,000	$10,461,800
CONSTR. MGMT.	4.0% $10,461,800						$418,500
SUB-TOTAL 3							$10,880,300
SOIL/WATER/AIR	1.0% $6,655,385			$23,300		$43,300	$66,600
HOME OFFICE EXP.	1.0% $10,880,300						$108,800
PROJ.MGMT.FERMCO	8.0% $10,880,300						$870,400
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$2,092,400
SUB-TOTAL 4	OFFICE COSTS						$14,018,500
SALES TAX	6.0% $7,244,300						$434,700
SUB-TOTAL 5							$14,453,200
RISK BUDGET	11.0%						$1,589,900
SUB-TOTAL 6							$16,043,100
CONTINGENCY	20.0%						$3,208,600
TOTAL ESTIMATED INSTALLED COST							$19,251,700

ALTERNATIVE 1B

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 1.5
O&M DURING REMEDIATION (YRS): 0.2
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 1B: IN-SITU CONTAINMENT

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-15B	IN-SITU CONTAINMENT	$3,168,900	$5,663,700	$8,832,600
	TOTAL CAPITAL	$3,168,900	$5,663,700	$8,832,600
	RISK BUDGET (11.0%)	$348,600	$623,000	$971,600
	SUBTOTAL	$3,517,500	$6,286,700	$9,804,200
	CONTINGENCY (20.0%)	$703,500	$1,257,300	$1,960,800
	TOTAL ESTIMATED INSTALLED COST	$4,221,000	$7,544,000	$11,765,000
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$126,300
	POST-REMEDIATION			$2,562,000
	TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)			$11,938,900

File: SUM1B.WK3

5089

EST FILE #: 3096-[illegible]B-
CLIENT: US DOE
PROJECT TITLE: ALTERNATIVE IB-IN-SITU CONTAINMENT

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	INSTALLTION CAP COSTS	50,590		$835,241		$459,206	$1,294,400
	PADDYS RUN RELOCATION COSTS	21,907		$361,684		$253,465	$615,100
	CAPPING SECURITY COSTS	3,556		$58,710		$80,710	$139,400
	ANCILLARY ITEM COSTS	2,939		$48,523		$58,882	$107,400
	SUBCONTRACTOR COSTS	19,414			$1,012,614		$1,012,600
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	98,406	16.50	$1,304,200	$1,012,600	$852,300	$3,168,900
SUPERVISION & SUPPRT LABOR	28.0%			$365,000			$365,000
SMALL TOOLS	$1.50					$147,600	$147,600
CONSUMABLES	$1.50					$147,600	$147,600
EQUIPMENT RENTAL	$3.00					$295,200	$295,200
TEMP. FACILITIES	4.0%			$18,300		$33,900	$52,20[illegible]
TEMP. UTILITIES	1.0%			$4,600		$8,500	$13,1[illegible]
JOB CLEAN-UP	6.0%			$27,400		$50,900	$78,300
SAFETY	7.0%			$32,000		$59,300	$91,300
HEALTH PHYSICS	20.0%	$1,751,500		$350,300			$350,300
CERCLA $1,500	PER PERSON	2,000				$73,800	$73,800
BOND	1.0%	$3,168,900				$31,700	$31,700
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$107,800	$107,800
OVERHEAD & PROFIT	9.0%	$4,922,800				$443,100	$443,100
EMISSION MODELING	0.50%	$3,168,900		$5,500		$10,300	$15,800
PSAR/FSAR(SAFE RPT)	0.50%	$3,168,900		$5,500		$10,300	$15,800
PAYRL BRD.&BENFT.	52.0%	$2,112,800		$1,098,700			$1,098,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,211,500		$2,272,300	$6,496,200
CONSTR. MGMT.	4.0%	$6,496,200					$259,800
SUB-TOTAL 3							$6,756,000
SOIL/WATER/AIR	1.0%	$3,168,900		$11,100		$20,600	$31,700
HOME OFFICE EXP.	1.0%	$6,756,000					$67,600
PROJ.MGMT.FERMCO	8.0%	$6,756,000					$540,500
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$1,299,200
SUB-TOTAL 4	OFFICE COSTS						$8,695,000
SALES TAX	6.0%	$2,292,900					$137,600
SUB-TOTAL 5							$8,832,600
RISK BUDGET	11.0%						$971,600
SUB-TOTAL 6							$9,804,200
CONTINGENCY	20.0%						$1,960,800
TOTAL ESTIMATED INSTALLED COST							$11,765,000

EST.FILE #:3096-15.

ALTERNATIVE # 1B- IN-SITU CONTAINMENT.(SILO 3).

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	INSTALLATION OF CAP- CAPITAL COST.							
1	SOIL FILL AROUND SILOS,90 COMPACTION,12"LIFT,10 MILES HAUL DIST.	71,200	CYD	24,920	$242,080	$411,429	-	$653,509
2	DRAIN TILE,4"-1/2 SINGLE WALL (DRAINAGE LAYER)	1,490	LFT	317	$3,427	$5,234	-	$8,661
3	PUSH PIPE-4",PLASTIC FILTER TYPE,SLOTTED (LEACHATE COLLECTION).	160	LFT	16	$480	$264	-	$744
4	PVC PIPE-4",PLASTIC TYPE. (LEACHATE COLLECTION).	440	LFT	44	$211	$726	-	$937
5	MANHOLES HDPE LINED, 6'DIA X 28' DEEP	4	EA	96	$11,300	$1,585	-	$12,885
6	CLAY LAYER, 98% COMPACTION,8-6" LIFTS,10 MI HAUL DIST.,E-7 PERM.	27,365	CYD	12,314	$93,041	$203,304	-	$296,345
7	DRAINAGE LAYER,2'LAYER GRADED AGGR.FILTER,BLANKET,15 MILES HAUL	13,091	CYD	3,888	$44,640	$64,191	-	$108,831
8	VEGETATION LAYER 2'LAYER,85% COMPACTION,2-12"LIFTS.,10 MILE HAUL.	13,241	CYD	5,958	$45,019	$98,367	-	$143,386
9	SEEDING, FERTILIZER & MULCHING	23,050	SYD	1,106	$3,458	$18,260	-	$21,718
10	GEOTEXTILE	201,900	SFT	1,163	$10,095	$19,201	-	$29,296
11	H.D.P.E. LINER TEXTURED, 40 MIL THICK.	21,820	SYD	768	$5,455	$12,680	-	$18,135
	SUBTOTAL CAP COSTS.	1	LS	50,590	$459,206	$835,241	-	$1,294,447

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6805-7

	PADDY'S RUN RELOCATION – CAPITAL COSTS.							
1	BORROW FILL FOR PADDY'S RUN(10 MILES ROUNDTRIP)(85% COMPACTION).	69,158	CYD	20,540	$235,829	$339,115	–	$574,944
2	FILTER FABRIC – OF COMPATIBLE MATERIAL	51,120	SFT	294	$2,556	$4,854	–	$7,410
3	SEED FERTILIZE & MULCH AROUND PADDY'S RUN	15,560	SYD	747	$2,334	$12,333	–	$14,667
4	RIPRAP (TWO LAYERS, STONE DIAMETER, 4")	1,262	CYD	326	$12,746	$5,382	–	$18,128
	SUBTOTAL PADDY'S RUN COSTS.	1	LS	21,907	$253,465	$361,684	–	$615,149
	CAPPING SECURITY COSTS							
1	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	22	EA	704	$28,424	$11,623	–	$40,047
2	POWER LINES FOR LIGHTS, 12 AWG	9,000	FT	2,601	$31,049	$42,943	–	$73,992
3	ADMINISTRATION BUILDING w/LIGHT & HEATER.250 SFT SHOP BUILT.	1	EA	16	$18,000	$264	–	$18,264
4	CONCRETE PAD FOR ADMINISTRATION BUILDING.	1	LS	23	$1,737	$380	–	$2,117
5	ELECTRICAL POWER ALLOWANCE FOR ADMINISTRATION BUILDING.	1	LS	32	$500	$528	–	$1,028
6	THREE PERMANENT SURVEY MARKERS REFERENCED TO USGS ~ NGS MONUME	1	LS	180	$1,000	$2,972	–	$3,972
	SUBTOTAL CAPPING SECURITY.	1	LS	3,556	$80,710	$58,710	–	$139,420
	ANCILILLIARY ITEMS/GROUT PLANT– CAPITAL COSTS.							
1	GLOVE BAG.	20	EA	4	$2,000	$66	–	$2,066
2	TEMPORARY LIGHTING	24	EA.	768	$31,008	$12,680	–	$43,688
3	POWER LINES FOR LIGHTS, 12 AWG	7,500	FT	2,167	$25,874	$35,777	–	$61,651
	SUBTOTAL GROUT PLANT/ITEMS CAPITAL COSTS.	1	LS	2,939	$58,882	$48,523	–	$107,405
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	78,992	$852,263	$1,304,158	–	$2,156,421

FERNALD PROJECT

I. T.PROJECT NO.:409194

ALTERNATIVE # 1B- IN-SITU CONTAINMENT.(SILO 3),POST REMEDIATION COSTS.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	POST REMEDIATION O. & M. COSTS.	-	-	-	-	-	-	-
1	REPLACEMENT WELLS.(FOR 16 WELLS)	1	LS	-	-	-	$203,200	$203,200
2	CERCLA 5- YEAR REEVALUATION.	6	EA	4,000	-	$300,000	-	$300,000
3	RADIATION MONITORING ANNUALLY. FOR 30 YEARS.	30	EA	2,400	-	$81,312	$1,000	$82,312
4	GROUND WATER MONITORING FOR 30 YEARS.	30	EA	9,600	-	$325,248	-	$325,248
5	AIR MONITORING FOR AMBIENT AIR. DITTO.	30	EA	-	-	-	-	$13,838
6	ANALYTICAL WATER SAMPLES FOR RADIONUCLIDES.	800	EA	4,800	-	-	$1,443,200	$1,443,200
7	ANALYTICAL WATER SAMPLES FOR HSL/METALS.	800	EA	4,800	-	-	INCL.IN ABOVE.	-
8	ANNUAL INSPECTION.	1	LS	140	-	-	$3,828	$3,828
9	MOWING COSTS.	4.50	ACRES	216	-	-	$18,093	$18,093
10	REFERTILIZATION.	4.50	ACRES	996	-	-	$48,277	$48,277
11	ANNUAL INSPECTION.	4.50	ACRES	630	-	-	$17,225	$17,225
12	EROSION CONTROL.	4.50	ACRES	810	-	-	$6,881	$6,881
13	REPAIRS RESULTING FROM SHRINK/WELL OR FROZEN/THAW FORCES.	4.50	ACRES	1,161	-	-	$6,881	$6,881
14	ALLOW ROUTINE MAINTENANCE FOR SECURITY ITEMS FOR 30 YEARS.	1	LS	720	$60,000	$27,360	$20,000	$107,360
	O. & M. COSTS ALT. #1B-POST REMEDIATION. (SILO 3.)	1	LS	30,273	$60,000	$733,920	$1,768,585	$2,562,505

-5038

ALTERNATIVE 2B

VITRIFICATION

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 1
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 2B: REMOVAL, STABILIZATION W/VITRIFICATION, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-24A	SITE PREPARATION	$579,500	$528,700	$1,108,200
3096-29A	WASTE PROCESSING	$915,300	$971,000	$1,886,300
3096-13A	VITRIFICATION	$2,593,400	$1,460,700	$4,054,100
3096-1B	PNEUMATIC REMOVAL/TRANSFER SYSTEM	$4,571,600	$4,744,400	$9,316,000
-	DISPOSAL VAULT	$498,100	$848,000	$1,346,100
-	PACKAGING (1,282 PKGS. @ $955/PKG.)	$338,400	$885,900	$1,224,300
TOTAL CAPITAL		$9,496,300	$9,438,700	$18,935,000
RISK BUDGET (11.0%)		$1,044,600	$1,038,300	$2,082,900
SUBTOTAL		$10,540,900	$10,477,000	$21,017,900
CONTINGENCY (20.0%)		$2,108,200	$2,095,400	$4,203,600
TOTAL ESTIMATED INSTALLED COST		$12,649,100	$12,572,400	$25,221,500
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$4,923,000
POST-REMEDIATION				$3,162,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$27,971,300

731

-5039

File: SUM2BVIT.WK3

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 309[redacted]A-5039
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	2,566		$42,365		$151,539	$193,900
	ELECTRICAL COSTS	561		$9,262		$75,200	$84,500
	PIPING COSTS	650		$10,731		$5,475	$16,200
	SUBCONTRACTOR COSTS	2,777			$284,880		$284,900
SUB-TOTAL 1	DIRECT FIELD COSTS	6,554		$62,400	$284,900	$232,200	$579,500
SUPERVISION & SUPPRT LABOR	28.0%			$17,000			$17,000
SMALL TOOLS	$1.50					$9,800	$9,800
CONSUMABLES	$1.50					$9,800	$9,800
EQUIPMENT RENTAL	$3.00					$19,700	$19,700
TEMP. FACILITIES	4.0%			$900		$1,600	$2,500
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,300		$2,400	$3,700
SAFETY	7.0%			$1,500		$2,800	$4,300
HEALTH PHYSICS	20.0% $83,300			$16,700			$16,700
CERCLA $1,500	PER PERSON 2,000					$4,900	$4,900
BOND	1.0% $579,500					$5,800	$5,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$14,700	$14,700
OVERHEAD & PROFIT	9.0% $689,000					$62,000	$62,000
EMISSION MODELING	0.50% $579,500			$1,000		$1,900	$2,900
PSAR/FSAR(SAFE RPT)	0.50% $579,500			$1,000		$1,900	$2,900
PAYRL BRD.&BENFT.	52.0% $102,000			$53,000			$53,000
SUBTOTAL 2	INDIRECT CONSTRUCTION SUPPORT			$155,000		$369,900	$809,800
CONSTR. MGMT.	4.0% $809,800						$32,400
SUB-TOTAL 3							$842,200
SOIL/WATER/AIR	1.0% $579,500			$2,000		$3,800	$5,800
HOME OFFICE EXP.	1.0% $842,200						$8,400
PROJ.MGMT.FERMCO	8.0% $842,200						$67,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%		Title III	3.0%		$162,000
SUB-TOTAL 4	OFFICE COSTS						$1,085,800
SALES TAX	6.0% $373,700						$22,400
SUB-TOTAL 5							$1,108,200
RISK BUDGET	11.0%						$121,900
SUB-TOTAL 6							$1,230,100
CONTINGENCY	20.0%						$246,000
TOTAL ESTIMATED INSTALLED COST							$1,476,100

08/24/93

EST.FILE #:3096-24A.

SITE PREPARATION.

FY 93-1 DOLLARS

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	SITE PREPARATION - CAPITAL COSTS							
1	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
7	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
8	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
9	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
10	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
11	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
12	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	2	EA	48	$3,680	$792	-	$4,472
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
14	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE, 280 KVA.	300	FT	90	$6,000	$1,486	-	$7,486
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
-	SEWER:	-	-	-	-	-	-	-
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
-	COMPRESSED AIR:	-	-	-	-	-	-	-
18	AIR COMPRESSOR, 5 HP w/ 50 GALLON RECEIVER AND DRYER.	1	EA	32	$2,290	$528	-	$2,818
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,777	$232,214	$62,358	-	$294,572

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRY FORWARD	1	LS	3,777	$232,214	$62,358	-	$294,572
	SUBCONTRACT COSTS							
1	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
2	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
3	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
4	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
5	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
6	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
7	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
8	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
9	EXCAVATION & BACKFILL.	160	CYDS	11	-	$254	$606	$860
10								
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,777	-	254	284,880	$285,134
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	6,554	$232,214	$62,612	$284,880	$579,706

EST FILE #: 3096-29[redacted] 5039
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	8,816		$162,282		$230,805	$393,100
	SUBCONTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,192	18.00	$162,300	$522,200	$230,800	$915,300
SUPERVISION & SUPPRT LABOR	28.0%			$45,000			$45,000
SMALL TOOLS	$1.50					$16,800	$16,800
CONSUMABLES	$1.50					$16,800	$16,800
EQUIPMENT RENTAL	$3.00					$33,600	$33,600
TEMP. FACILITIES	4.0%			$2,300		$4,200	$6,500
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,400		$6,300	$9,700
SAFETY	7.0%			$4,000		$7,400	$11,400
HEALTH PHYSICS	20.0%	$217,600		$43,500			$43,500
CERCLA $1,500	PER PERSON	2,000				$8,400	$8,400
BOND	1.0%	$915,300				$9,200	$9,200
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$19,600	$19,600
OVERHEAD & PROFIT	9.0%	$1,137,500				$102,400	$102,400
EMISSION MODELING	0.50%	$915,300		$1,600		$3,000	$4,600
PSAR/FSAR(SAFE RPT)	0.50%	$915,300		$1,600		$3,000	$4,600
PAYRL BRD.&BENFT.	52.0%	$264,300		$137,400			$137,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$401,700		$462,600	$1,386,500
CONSTR. MGMT.	4.0%	$1,386,500					$55,500
SUB-TOTAL 3							$1,442,000
SOIL/WATER/AIR	1.0%	$915,300		$3,200		$5,900	$9,100
HOME OFFICE EXP.	1.0%	$1,442,000					$14,400
PROJ.MGMT.FERMCO	8.0%	$1,442,000					$115,400
ENGINEERING 20.0%	Title I	7.0%	Title II	10.0%	Title III	3.0%	$277,300
SUB-TOTAL 4	OFFICE COSTS						$1,858,200
SALES TAX	6.0%	$468,500					$28,100
SUB-TOTAL 5							$1,886,300
RISK BUDGET	11.0%						$207,500
SUB-TOTAL 6							$2,093,800
CONTINGENCY	20.0%						$418,800
TOTAL ESTIMATED INSTALLED COST							$2,512,600

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

EST.FILE #:3096-29.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$2,010
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$4,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$12,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$7,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$70,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$41,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$25,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$10,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$6,265
		-	-	-	-	-	-	-
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	2	EA	96	$16,600	$1,824		$20,424
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$28,000	$1,824		$31,824
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	38,160	LBS	4,476	$68,020	$85,044		$163,064
16	DAMPER 40,000 CFM.	1	EA	96	$900	$1,824		$3,724
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,816	$230,805	$162,282	-	$393,087

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,192	$230,805	$162,282	$522,208	$915,295

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-13 A
CLIENT: US DOE
PROJECT TITLE: VITRIFICATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	VITRIFICATION EQUIPMENT COSTS	866		$15,274		$194,972	$210,200
	RADON TREATMENT SYSTEM COSTS	375		$6,614		$17,932	$24,500
	OFF-GAS SYSTEM COSTS	880		$15,521		$103,136	$118,700
	SUBCONTRACTOR COSTS (ADJ. TO CURRENT COST)	1,380			$2,240,000		$2,240,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	3,501	16.50	$37,400	$2,240,000	$316,000	$2,593,400
SUPERVISION & SUPPRT LABOR	28.0%			$10,000			$10,000
SMALL TOOLS	$1.50					$5,300	$5,300
CONSUMABLES	$1.50					$5,300	$5,300
EQUIPMENT RENTAL	$3.00					$10,500	$10,500
TEMP. FACILITIES	4.0%			$500		$1,000	$1,500
TEMP. UTILITIES	1.0%			$100		$200	$300
JOB CLEAN-UP	6.0%			$800		$1,500	$2,300
SAFETY	7.0%			$900		$1,700	$2,60(
HEALTH PHYSICS	20.0% $49,700			$9,900			$9,900
CERCLA $1,500	PER PERSON 2,000					$2,600	$2,600
BOND	1.0% $2,593,400					$25,900	$25,900
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$17,700	$17,700
OVERHEAD & PROFIT	9.0% $2,687,300					$241,900	$241,900
EMISSION MODELING	0.50% $2,593,400			$4,500		$8,400	$12,900
PSAR/FSAR(SAFE RPT)	0.50% $2,593,400			$4,500		$8,400	$12,900
PAYRL BRD.&BENFT.	52.0% $68,600			$35,700			$35,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$104,300		$646,400	$2,990,700
CONSTR. MGMT.	4.0% $2,990,700						$119,600
SUB-TOTAL 3							$3,110,300
SOIL/WATER/AIR	1.0% $2,593,400			$9,100		$16,900	$26,000
HOME OFFICE EXP.	1.0% $3,110,300						$31,100
PROJ.MGMT.FERMCO	8.0% $3,110,300						$248,800
ENGINEERING 20.0%	Title I 7.0% Title II	10.0%	Title III		3.0%		$598,100
SUB-TOTAL 4	OFFICE COSTS						$4,014,300
SALES TAX	6.0% $663,300						$39,800
SUB-TOTAL 5							$4,054,100
RISK BUDGET	11.0%						$446,000
SUB-TOTAL 6							$4,500,100
CONTINGENCY	20.0%						$900,000
TOTAL ESTIMATED INSTALLED COST							$5,400,100

FERMCO
ESTIMATING SERVICES 5039
SUMMARY SHEET

EST FILE #: 3096-1 B
CLIENT: US DOE
PROJECT TITLE: PNEUMATIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	10,700		$176,808		$680,350	$857,158
	CONCRETE	1,200		$22,000		$116,500	$138,500
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,510		$44,230		$1,432,960	$1,477,190
	MACHINERY AND EQUIPMENT	1,113		$22,200		$144,600	$166,800
	PIPING	737		$13,310		$50,820	$64,130
	ELECTRICAL	6,578		$118,900		$203,800	$322,700
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	2,079		$38,520		$43,890	$82,410
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	38,090	17.80	$678,148		$3,893,500	$4,571,608
SUPERVISION & SUPPRT LABOR	28.0%			$190,000			$190,000
SMALL TOOLS	$1.50					$57,100	$57,100
CONSUMABLES	$1.50					$57,100	$57,100
EQUIPMENT RENTAL	$3.00					$114,300	$114,300
TEMP. FACILITIES	4.0%			$9,500		$17,600	$27,100
TEMP. UTILITIES	1.0%			$2,400		$4,400	$6,800
JOB CLEAN-UP	6.0%			$14,200		$26,400	$40,600
SAFETY	7.0%			$16,600		$30,900	$47,500
HEALTH PHYSICS	20.0%	$910,848		$182,200			$182,200
CERCLA $1,500	PER PERSON	2,000				$28,600	$28,600
BOND	1.0%	$4,571,608				$45,700	$45,700
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$228,600	$228,600
OVERHEAD & PROFIT	9.0%	$5,597,208				$503,700	$503,700
EMISSION MODELING	0.50%	$4,571,608		$8,000		$14,900	$22,900
PSAR/FSAR(SAFE RPT)	0.50%	$4,571,608		$8,000		$14,900	$22,900
PAYRL BRD.&BENFT.	52.0%	$1,109,048		$576,700			$576,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,685,700		$5,037,700	$6,723,400
CONSTR. MGMT.	4.0%	$6,723,400					$268,900
SUB-TOTAL 3							$6,992,300
SOIL/WATER/AIR	1.0%	$4,571,608		$16,000		$29,700	$45,700
HOME OFFICE EXP.	1.0%	$6,992,300					$69,900
PROJ.MGMT.FERMCO	8.0%	$6,992,300					$559,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$1,344,700
SUB-TOTAL 4	OFFICE COSTS						$9,012,000
SALES TAX	6.0%	$5,067,400					$304,000
SUB-TOTAL 5							$9,316,000
RISK BUDGET	11.0%						$1,024,800
SUB-TOTAL 6							$10,340,800
CONTINGENCY	20.0%						$2,068,200
TOTAL ESTIMATED INSTALLED COST							$12,409,000

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2B REMOVAL,STABILIZATION,ON-PROPERTY DISPOSAL.(SILO # 3)
OPERATION & MAINTENANCE COSTS.-VITRIFICATION OPTION.
WASTE REMOVAL/ PROCESSING.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	SILICA	1,330,560	LBS	-	$25,281	-	-	$25,281
2	ALUMINA	1,227,744	LBS	-	$672,190	-	-	$672,190
3	BORATE	737,856	LBS	-	$202,910	-	-	$202,910
4	ELECTRICITY	7,232,243	KWHR	-	$330,586	-	-	$330,586
5	CRAFT LABOR.	105,882	HRS	105,882	-	$3,587,282	-	$3,587,282
6	SUPERVISION LABOR.	1,561	HRS	1,561	-	$104,712	-	$104,712
	SUBTOTAL OPERATION & MAINTENACE COSTS.-VITRIFICATION OPTION	1	LS	107,443	$1,230,967	$3,691,994	-	$4,922,961

ALTERNATIVE 2B

CEMENT STABILIZATION

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 1
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 2B: REMOVAL, CEMENT STABILIZATION, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-24A	SITE PREPARATION	$579,500	$528,700	$1,108,200
3096-29A	WASTE PROCESSING	$915,300	$971,000	$1,886,300
3096-3A	CEMENT STABILIZATION	$2,253,700	$2,473,400	$4,727,100
3096-1B	PNEUMATIC REMOVAL/TRANSFER SYSTEM	$4,571,600	$4,744,400	$9,316,000
–	DISPOSAL VAULT	$1,925,800	$3,279,100	$5,204,900
–	PACKAGING (4,957 PKGS. @ $955/PKG.)	$1,308,600	$3,425,300	$4,733,900
TOTAL CAPITAL		$11,554,500	$15,421,900	$26,976,400
RISK BUDGET (11.0%)		$1,271,000	$1,696,400	$2,967,400
SUBTOTAL		$12,825,500	$17,118,300	$29,943,800
CONTINGENCY (20.0%)		$2,565,100	$3,423,700	$5,988,800
TOTAL ESTIMATED INSTALLED COST		$15,390,600	$20,542,000	$35,932,600
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$4,923,000
POST-REMEDIATION				$3,207,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$37,358,600

740

File: SUM2BCEM.WK3

-5039

E-5039

PERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-24.A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	2,566		$42,365		$151,539	$193,900
	ELECTRICAL COSTS	561		$9,262		$75,200	$84,500
	PIPING COSTS	650		$10,731		$5,475	$16,200
	SUBCONTRACTOR COSTS	2,777			$284,880		$284,900
SUB-TOTAL 1	DIRECT FIELD COSTS	6,554		$62,400	$284,900	$232,200	$579,500
SUPERVISION & SUPPRT LABOR	28.0%			$17,000			$17,000
SMALL TOOLS	$1.50					$9,800	$9,800
CONSUMABLES	$1.50					$9,800	$9,800
EQUIPMENT RENTAL	$3.00					$19,700	$19,700
TEMP. FACILITIES	4.0%			$900		$1,600	$2,500
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,300		$2,400	$3,700
SAFETY	7.0%			$1,500		$2,800	$4,300
HEALTH PHYSICS	20.0%	$83,300		$16,700			$16,700
CERCLA $1,500	PER PERSON	2,000				$4,900	$4,900
BOND	1.0%	$579,500				$5,800	$5,800
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$14,700	$14,700
OVERHEAD & PROFIT	9.0%	$689,000				$62,000	$62,000
EMISSION MODELING	0.50%	$579,500		$1,000		$1,900	$2,900
PSAR/FSAR(SAFE RPT)	0.50%	$579,500		$1,000		$1,900	$2,900
PAYRL BRD.&BENFT.	52.0%	$102,000		$53,000			$53,000
SUBTOTAL 2	INDIRECT CONSTRUCTION SUPPORT			$155,000		$369,900	$809,800
CONSTR. MGMT.	4.0%	$809,800					$32,400
SUB-TOTAL 3							$842,200
SOIL/WATER/AIR	1.0%	$579,500		$2,000		$3,800	$5,800
HOME OFFICE EXP.	1.0%	$842,200					$8,400
PROJ.MGMT.FERMCO	8.0%	$842,200					$67,400
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$162,000
SUB-TOTAL 4	OFFICE COSTS						$1,085,800
SALES TAX	6.0%	$373,700					$22,400
SUB-TOTAL 5							$1,108,200
RISK BUDGET	11.0%						$121,900
SUB-TOTAL 6							$1,230,100
CONTINGENCY	20.0%						$246,000
TOTAL ESTIMATED INSTALLED COST							$1,476,100

EST.FILE #:3096-24A.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	SITE PREPARATION - CAPITAL COSTS							
1	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
7	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
8	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
9	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
10	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
11	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
12	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	2	EA	48	$3,680	$792	-	$4,472
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
14	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE, 280 KVA.	300	FT	90	$6,000	$1,486	-	$7,486
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
-	SEWER:	-	-	-	-	-	-	-
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
-	COMPRESSED AIR:	-	-	-	-	-	-	-
18	AIR COMPRESSOR, 5 HP w/ 50 GALLON RECEIVER AND DRYER.	1	EA	32	$2,290	$528	-	$2,818
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,777	$232,214	$62,358	-	$294,572

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRYFORWARD	1	LS	3,777	$232,214	$62,358	-	$294,572
	SUBCONTRACT COSTS							
1	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
2	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
3	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
4	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
5	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
6	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
7	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
8	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
9	EXCAVATION & BACKFILL.	160	CYDS	11	-	$254	$606	$860
10								
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,777	-	254	284,880	$285,134
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	6,554	$232,214	$62,612	$284,880	$579,706

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-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-29 A
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	8,816		$162,282		$230,805	$393,100
	SUBCONTRACTOR COSTS	2,376			$522,208		$522,200
SUB-TOTAL 1	DIRECT FIELD COSTS	11,192	AVG. 18.00	$162,300	$522,200	$230,800	$915,300
SUPERVISION & SUPPRT LABOR	28.0%			$45,000			$45,000
SMALL TOOLS	$1.50					$16,800	$16,800
CONSUMABLES	$1.50					$16,800	$16,800
EQUIPMENT RENTAL	$3.00					$33,600	$33,600
TEMP. FACILITIES	4.0%			$2,300		$4,200	$6,500
TEMP. UTILITIES	1.0%			$600		$1,100	$1,70
JOB CLEAN-UP	6.0%			$3,400		$6,300	$9,70
SAFETY	7.0%			$4,000		$7,400	$11,400
HEALTH PHYSICS	20.0% $217,600			$43,500			$43,500
CERCLA $1,500	PER PERSON 2,000					$8,400	$8,400
BOND	1.0% $915,300					$9,200	$9,200
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$19,600	$19,600
OVERHEAD & PROFIT	9.0% $1,137,500					$102,400	$102,400
EMISSION MODELING	0.50% $915,300			$1,600		$3,000	$4,600
PSAR/FSAR(SAFE RPT)	0.50% $915,300			$1,600		$3,000	$4,600
PAYRL BRD.&BENFT.	52.0% $264,300			$137,400			$137,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$401,700		$462,600	$1,386,500
CONSTR. MGMT.	4.0% $1,386,500						$55,500
SUB-TOTAL 3							$1,442,000
SOIL/WATER/AIR	1.0% $915,300			$3,200		$5,900	$9,100
HOME OFFICE EXP.	1.0% $1,442,000						$14,400
PROJ.MGMT.FERMCO	8.0% $1,442,000						$115,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III	3.0%			$277,300
SUB-TOTAL 4	OFFICE COSTS						$1,858,200
SALES TAX	6.0% $468,500						$28,100
SUB-TOTAL 5							$1,886,300
RISK BUDGET	11.0%						$207,500
SUB-TOTAL 6							$2,093,800
CONTINGENCY	20.0%						$418,800
TOTAL ESTIMATED INSTALLED COST							$2,512,600

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

EST.FILE #:3096-29.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$2,010
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$4,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$12,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$7,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$70,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$41,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$25,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$10,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$6,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	2	EA	96	$16,600	$1,824		$20,424
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$28,000	$1,824		$31,824
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	38,160	LBS	4,476	$68,020	$85,044		$163,064
16	DAMPER 40,000 CFM.	1	EA	96	$900	$1,824		$3,724
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,816	$230,805	$162,282	-	$393,087

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,192	$230,805	$162,282	$522,208	$915,295

EST FILE #: 3096-3 A[redacted] -5039

CLIENT: US DOE [redacted]

PROJECT TITLE: CEMENT STABILIZATION EQUIPMENT

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CEMENT STABILIZATION EQUIPMENT COSTS (CURRENT COST ESTIMATE)	15,543		$450,747	$585,971	$1,217,017	$2,253,7[illegible]
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	15,543	18.00	$450,700	$586,000	$1,217,000	$2,253,700
SUPERVISION & SUPPRT LABOR	28.0%			$126,200			$126,200
SMALL TOOLS	$1.50					$23,300	$23,300
CONSUMABLES	$1.50					$23,300	$23,300
EQUIPMENT RENTAL	$3.00					$46,600	$46,600
TEMP. FACILITIES	4.0%			$6,300		$11,700	$18,000
TEMP. UTILITIES	1.0%			$1,600		$2,900	$4,500
JOB CLEAN-UP	6.0%			$9,500		$17,600	$27,100
SAFETY	7.0%			$11,000		$20,500	$31,5[illegible]
HEALTH PHYSICS	20.0%	$605,300		$121,100			$121,1[illegible]
CERCLA $1,500	PER PERSON	2,000				$11,700	$11,700
BOND	1.0%	$2,253,700				$22,500	$22,500
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$83,400	$83,400
OVERHEAD & PROFIT	9.0%	$2,792,900				$251,400	$251,400
EMISSION MODELING	0.50%	$2,253,700		$3,900		$7,300	$11,200
PSAR/FSAR(SAFE RPT)	0.50%	$2,253,700		$3,900		$7,300	$11,200
PAYRL BRD.&BENFT.	52.0%	$734,200		$381,800			$381,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,116,000		$1,746,500	$3,448,500
CONSTR. MGMT.	4.0%	$3,448,500					$137,900
SUB-TOTAL 3							$3,586,400
SOIL/WATER/AIR	1.0%	$2,253,700		$7,900		$14,600	$22,500
HOME OFFICE EXP.	1.0%	$3,586,400					$35,900
PROJ.MGMT.FERMCO	8.0%	$3,586,400					$286,900
ENGINEERING	20.0% Title I	7.0% Title II	10.0%	Title III	3.0%		$689,700
SUB-TOTAL 4	OFFICE COSTS						$4,621,400
SALES TAX	6.0%	$1,761,100					$105,700
SUB-TOTAL 5							$4,727,100
RISK BUDGET	11.0%						$520,000
SUB-TOTAL 6							$5,247,100
CONTINGENCY	20.0%						$1,049,400
TOTAL ESTIMATED INSTALLED COST							$6,296,500

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-1 B
CLIENT: US DOE
PROJECT TITLE: PNEUMATIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	10,700		$176,808		$680,350	$857,158
	CONCRETE	1,200		$22,000		$116,500	$138,500
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,510		$44,230		$1,432,960	$1,477,190
	MACHINERY AND EQUIPMENT	1,113		$22,200		$144,600	$166,800
	PIPING	737		$13,310		$50,820	$64,130
	ELECTRICAL	6,578		$118,900		$203,800	$322,700
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	2,079		$38,520		$43,890	$82,410
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	38,090	17.80	$678,148		$3,893,500	$4,571,608
SUPERVISION & SUPPRT LABOR	28.0%			$190,000			$190,000
SMALL TOOLS	$1.50					$57,100	$57,100
CONSUMABLES	$1.50					$57,100	$57,100
EQUIPMENT RENTAL	$3.00					$114,300	$114,300
TEMP. FACILITIES	4.0%			$9,500		$17,600	$27,100
TEMP. UTILITIES	1.0%			$2,400		$4,400	$6,800
JOB CLEAN-UP	6.0%			$14,200		$26,400	$40,600
SAFETY	7.0%			$16,600		$30,900	$47,500
HEALTH PHYSICS	20.0%	$910,848		$182,200			$182,200
CERCLA $1,500	PER PERSON	2,000				$28,600	$28,600
BOND	1.0%	$4,571,608				$45,700	$45,700
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$228,600	$228,600
OVERHEAD & PROFIT	9.0%	$5,597,208				$503,700	$503,700
EMISSION MODELING	0.50%	$4,571,608		$8,000		$14,900	$22,900
PSAR/FSAR(SAFE RPT)	0.50%	$4,571,608		$8,000		$14,900	$22,900
PAYRL BRD.&BENFT.	52.0%	$1,109,048		$576,700			$576,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,685,700		$5,037,700	$6,723,400
CONSTR. MGMT.	4.0%	$6,723,400					$268,900
SUB-TOTAL 3							$6,992,300
SOIL/WATER/AIR	1.0%	$4,571,608		$16,000		$29,700	$45,700
HOME OFFICE EXP.	1.0%	$6,992,300					$69,900
PROJ.MGMT.FERMCO	8.0%	$6,992,300					$559,400
ENGINEERING 20.0%	Title I	7.0%	Title II	10.0%	Title III	3.0%	$1,344,700
SUB-TOTAL 4	OFFICE COSTS						$9,012,000
SALES TAX	6.0%	$5,067,400					$304,000
SUB-TOTAL 5							$9,316,000
RISK BUDGET	11.0%						$1,024,800
SUB-TOTAL 6							$10,340,800
CONTINGENCY	20.0%						$2,068,200
TOTAL ESTIMATED INSTALLED COST							$12,409,000

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 2B- REMOVAL,STABILIZATION, ON-PROPERTY DISPOSAL.(SILO #3)
OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	974,484	GALS	-	$19,490	-	-	$19,490
2	BLAST FURNACE SLAG.	3,501,792	LBS	-	$52,527	-	-	$52,527
3	CEMENT	3,501,792	LBS	-	$115,559	-	-	$115,559
4	ELECTRICITY	3,858,593	KWHR	-	$176,376	-	-	$176,376
5	CRAFT LABOR.	105,882	HRS	105,882	-	$3,587,282	-	$3,587,282
6	SUPERVISION LABOR.	1,561	HRS	1,561	-	$104,712	-	$104,712
	SUBTOTAL OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION	1	LS	107,443	$363,952	$3,691,994	-	$4,055,946

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ALTERNATIVE 3B.1

VITRIFICATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 1
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3B.1: REMOVAL, STABILIZATION W/VITRIFICATION, OFF-SITE DISPOSAL AT NTS

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-24A	SITE PREPARATION	$579,500	$528,700	$1,108,200
3096-29B	WASTE PROCESSING	$1,602,600	$1,333,700	$2,936,300
3096-13A	VITRIFICATION	$2,593,400	$1,460,700	$4,054,100
3096-1B	PNEUMATIC REMOVAL/TRANSFER SYSTEM	$4,571,600	$4,744,400	$9,316,000
-	TRANSPORTATION	$646,900		$646,900
-	DISPOSAL	$692,300		$692,300
-	PACKAGING (1,282 PKGS. @ $955/PKG.)	$338,400	$885,900	$1,224,300
TOTAL CAPITAL		$11,024,700	$8,953,400	$19,978,100
RISK BUDGET (11.0%)		$1,212,700	$984,900	$2,197,600
SUBTOTAL		$12,237,400	$9,938,300	$22,175,700
CONTINGENCY (20.0%)		$2,447,500	$1,987,700	$4,435,200
TOTAL ESTIMATED INSTALLED COST		$14,684,900	$11,926,000	$26,610,900
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$4,923,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$27,878,700

749

5039

File: SUM3B1VI.WK3

EST FILE #: 3096-24.A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

PERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	2,566		$42,365		$151,539	$193,900
	ELECTRICAL COSTS	561		$9,262		$75,200	$84,500
	PIPING COSTS	650		$10,731		$5,475	$16,200
	SUBCONTRACTOR COSTS	2,777			$284,880		$284,900
SUB-TOTAL 1	DIRECT FIELD COSTS	6,554		$62,400	$284,900	$232,200	$579,500
SUPERVISION & SUPPRT LABOR	28.0%			$17,000			$17,000
SMALL TOOLS	$1.50					$9,800	$9,800
CONSUMABLES	$1.50					$9,800	$9,800
EQUIPMENT RENTAL	$3.00					$19,700	$19,700
TEMP. FACILITIES	4.0%			$900		$1,600	$2,500
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,300		$2,400	$3,700
SAFETY	7.0%			$1,500		$2,800	$4,300
HEALTH PHYSICS	20.0%	$83,300		$16,700			$16,700
CERCLA $1,500	PER PERSON	2,000				$4,900	$4,900
BOND	1.0%	$579,500				$5,800	$5,800
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$14,700	$14,700
OVERHEAD & PROFIT	9.0%	$689,000				$62,000	$62,000
EMISSION MODELING	0.50%	$579,500		$1,000		$1,900	$2,900
PSAR/FSAR(SAFE RPT)	0.50%	$579,500		$1,000		$1,900	$2,900
PAYRL BRD.&BENFT.	52.0%	$102,000		$53,000			$53,000
SUBTOTAL 2	INDIRECT CONSTRUCTION SUPPORT			$155,000		$369,900	$809,800
CONSTR. MGMT.	4.0%	$809,800					$32,400
SUB-TOTAL 3							$842,200
SOIL/WATER/AIR	1.0%	$579,500		$2,000		$3,800	$5,800
HOME OFFICE EXP.	1.0%	$842,200					$8,400
PROJ.MGMT.FERMCO	8.0%	$842,200					$67,400
ENGINEERING 20.0%	Title I 7.0%	Title II	10.0%	Title III	3.0%		$162,000
SUB-TOTAL 4	OFFICE COSTS						$1,085,800
SALES TAX	6.0%	$373,700					$22,400
SUB-TOTAL 5							$1,108,200
RISK BUDGET	11.0%						$121,900
SUB-TOTAL 6							$1,230,100
CONTINGENCY	20.0%						$246,000
TOTAL ESTIMATED INSTALLED COST							$1,476,100

08/24/93

EST.FILE #:3096-24A.

SITE PREPARATION.

FY 93-1 DOLLARS

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	SITE PREPARATION - CAPITAL COSTS							
1	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
7	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
8	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
9	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
10	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
11	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
12	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	2	EA	48	$3,680	$792	-	$4,472
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
14	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE,	300	FT	90	$6,000	$1,486	-	$7,486
	280 KVA.	-	-	-	-	-	-	-
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
-	COMPRESSED AIR:	-	-	-	-	-	-	-
18	AIR COMPRESSOR, 5 HP w/ 50 GALLON RECEIVER AND DRYER.	1	EA	32	$2,290	$528	-	$2,818
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,777	$232,214	$62,358	-	$294,572

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRYFORWARD	1	LS	3,777	$232,214	$62,358	-	$294,572
	SUBCONTRACT COSTS							
1	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
2	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
3	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
4	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
5	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
6	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
7	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
8	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
9	EXCAVATION & BACKFILL.	160	CYDS	11	-	$254	$606	$860
10								
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,777	-	254	284,880	$285,134
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	6,554	$232,214	$62,612	$284,880	$579,706

EST FILE #: 3096-[illegible]-B -5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	8,816		$162,282		$230,805	$393,10[illegible]
	SUBCONTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,192	18.00	$162,300	$522,200	$230,800	$915,300
SUPERVISION & SUPPRT LABOR	28.0%			$45,000			$45,000
SMALL TOOLS	$1.50					$16,800	$16,800
CONSUMABLES	$1.50					$16,800	$16,800
EQUIPMENT RENTAL	$3.00					$33,600	$33,600
TEMP. FACILITIES	4.0%			$2,300		$4,200	$6,500
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,400		$6,300	$9,700
SAFETY	7.0%			$4,000		$7,400	$11,4[illegible]
HEALTH PHYSICS	20.0% $217,600			$43,500			$43,5[illegible]
CERCLA $1,500	PER PERSON 2,000					$8,400	$8,400
BOND	1.0% $915,300					$9,200	$9,200
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$19,600	$19,600
OVERHEAD & PROFIT	9.0% $1,137,500					$102,400	$102,400
EMISSION MODELING	0.50% $915,300			$1,600		$3,000	$4,600
PSAR/FSAR(SAFE RPT)	0.50% $915,300			$1,600		$3,000	$4,600
PAYRL BRD.&BENFT.	52.0% $264,300			$137,400			$137,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$401,700		$462,600	$1,386,500
CONSTR. MGMT.	4.0% $1,386,500						$55,500
SUB-TOTAL 3							$1,442,000
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0% $915,300			$3,200		$5,900	$9,100
HOME OFFICE EXP.	1.0% $1,442,000						$14,400
PROJ.MGMT.FERMCO	8.0% $1,442,000						$115,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$277,300
SUB-TOTAL 4	OFFICE COSTS						$1,858,200
SALES TAX	6.0% $468,500						$28,100
SUB-TOTAL 5							$2,936,300
RISK BUDGET	11.0%						$323,000
SUB-TOTAL 6							$3,259,300
CONTINGENCY	20.0%						$651,900
TOTAL ESTIMATED INSTALLED COST							$3,911,200

753

EST.FILE #:3096-29.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$2,010
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$4,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$12,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$7,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$70,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$41,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$25,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$10,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$6,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$20,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$31,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$163,064
		1	EA	96	$900	$1,824		$3,724
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,816	$230,805	$162,282	-	$393,087

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,192	$230,805	$162,282	$522,208	$915,295

-5039

5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST.FILE #: 3096-15X
CLIENT: US DOE
PROJECT TITLE: VITRIFICATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	VITRIFICATION EQUIPMENT COSTS	866		$15,274		$194,972	$210,200
	RADON TREATMENT SYSTEM COSTS	375		$6,614		$17,932	$24,500
	OFF-GAS SYSTEM COSTS	880		$15,521		$103,136	$118,700
	SUBCONTRACTOR COSTS (ADJ. TO CURRENT COST)	1,380			$2,240,000		$2,240,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	3,501	16.50	$37,400	$2,240,000	$316,000	$2,593,400
SUPERVISION & SUPPRT LABOR	28.0%			$10,000			$10,000
SMALL TOOLS	$1.50					$5,300	$5,300
CONSUMABLES	$1.50					$5,300	$5,300
EQUIPMENT RENTAL	$3.00					$10,500	$10,500
TEMP. FACILITIES	4.0%			$500		$1,000	$1,500
TEMP. UTILITIES	1.0%			$100		$200	$3[illegible]
JOB CLEAN-UP	6.0%			$800		$1,500	$2[illegible]
SAFETY	7.0%			$900		$1,700	$2,600
HEALTH PHYSICS	20.0% $49,700			$9,900			$9,900
CERCLA $1,500	PER PERSON 2,000					$2,600	$2,600
BOND	1.0% $2,593,400					$25,900	$25,900
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$17,700	$17,700
OVERHEAD & PROFIT	9.0% $2,687,300					$241,900	$241,900
EMISSION MODELING	0.50% $2,593,400			$4,500		$8,400	$12,900
PSAR/FSAR(SAFE RPT)	0.50% $2,593,400			$4,500		$8,400	$12,900
PAYRL BRD.&BENFT.	52.0% $68,600			$35,700			$35,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$104,300		$646,400	$2,990,700
CONSTR. MGMT.	4.0% $2,990,700						$119,600
SUB-TOTAL 3							$3,110,300
SOIL/WATER/AIR	1.0% $2,593,400			$9,100		$16,900	$26,000
HOME OFFICE EXP.	1.0% $3,110,300						$31,100
PROJ.MGMT.FERMCO	8.0% $3,110,300						$248,800
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$598,100
SUB-TOTAL 4	OFFICE COSTS						$4,014,300
SALES TAX	6.0% $663,300						$39,800
SUB-TOTAL 5							$4,054,100
RISK BUDGET	11.0%						$446,000
SUB-TOTAL 6							$4,500,100
CONTINGENCY	20.0%						$900,000
TOTAL ESTIMATED INSTALLED COST							$5,400,100

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-1 B
CLIENT: US DOE
PROJECT TITLE: PNEUMATIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	10,700		$176,808		$680,350	$857,158
	CONCRETE	1,200		$22,000		$116,500	$138,500
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,510		$44,230		$1,432,960	$1,477,190
	MACHINERY AND EQUIPMENT	1,113		$22,200		$144,600	$166,800
	PIPING	737		$13,310		$50,820	$64,130
	ELECTRICAL	6,578		$118,900		$203,800	$322,700
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	2,079		$38,520		$43,890	$82,410
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	38,090	17.80	$678,148		$3,893,500	$4,571,608
SUPERVISION & SUPPRT LABOR	28.0%			$190,000			$190,000
SMALL TOOLS	$1.50					$57,100	$57,100
CONSUMABLES	$1.50					$57,100	$57,100
EQUIPMENT RENTAL	$3.00					$114,300	$114,300
TEMP. FACILITIES	4.0%			$9,500		$17,600	$27,100
TEMP. UTILITIES	1.0%			$2,400		$4,400	$6,800
JOB CLEAN-UP	6.0%			$14,200		$26,400	$40,600
SAFETY	7.0%			$16,600		$30,900	$47,500
HEALTH PHYSICS	20.0%	$910,848		$182,200			$182,200
CERCLA $1,500	PER PERSON	2,000				$28,600	$28,600
BOND	1.0%	$4,571,608				$45,700	$45,700
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$228,600	$228,600
OVERHEAD & PROFIT	9.0%	$5,597,208				$503,700	$503,700
EMISSION MODELING	0.50%	$4,571,608		$8,000		$14,900	$22,900
PSAR/FSAR(SAFE RPT)	0.50%	$4,571,608		$8,000		$14,900	$22,900
PAYRL BRD.&BENFT.	52.0%	$1,109,048		$576,700			$576,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,685,700		$5,037,700	$6,723,400
CONSTR. MGMT.	4.0%	$6,723,400					$268,900
SUB-TOTAL 3							$6,992,300
SOIL/WATER/AIR	1.0%	$4,571,608		$16,000		$29,700	$45,700
HOME OFFICE EXP.	1.0%	$6,992,300					$69,900
PROJ.MGMT.FERMCO	8.0%	$6,992,300					$559,400
ENGINEERING	20.0% Title I	7.0% Title II	10.0%	Title III	3.0%		$1,344,700
SUB-TOTAL 4	OFFICE COSTS						$9,012,000
SALES TAX	6.0%	$5,067,400					$304,000
SUB-TOTAL 5							$9,316,000
RISK BUDGET	11.0%						$1,024,800
SUB-TOTAL 6							$10,340,800
CONTINGENCY	20.0%						$2,068,200
TOTAL ESTIMATED INSTALLED COST							$12,409,000

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3B.1 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL TO NTS.(SILO # 3.)
OPERATION & MAINTENANCE COSTS.-VITRIFICATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWAL

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	SILICA	1,330,560	LBS	-	$25,281	-	-	$25,281
2	ALUMINA	1,227,744	LBS	-	$672,190	-	-	$672,190
3	BORATE	737,856	LBS	-	$202,910	-	-	$202,910
4	ELECTRICITY	7,232,243	KWHR	-	$330,586	-	-	$330,586
5	CRAFT LABOR.	105,882	HRS	105,882	-	$3,587,282	-	$3,587,282
6	SUPERVISION LABOR.	1,561	HRS	1,561	-	$104,712	-	$104,712
	SUBTOTAL OPERATION & MAINTENACE COSTS.-VITRIFICATION OPTION	1	LS	107,443	$1,230,967	$3,691,994	-	$4,922,961

ALTERNATIVE 3B.1

CEMENT STABILIZATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 1
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3B.1: REMOVAL, CEMENT STABILIZATION, OFF-SITE DISPOSAL AT NTS

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-24A	SITE PREPARATION	$579,500	$528,700	$1,108,200
3096-29B	WASTE PROCESSING	$1,602,600	$1,333,700	$2,936,300
3096-3A	CEMENT STABILIZATION	$2,253,700	$2,473,400	$4,727,100
3096-1B	PNEUMATIC REMOVAL/TRANSFER SYSTEM	$4,571,600	$4,744,400	$9,316,000
-	TRANSPORTATION	$1,625,600		$1,625,600
-	DISPOSAL	$2,676,800		$2,676,800
-	PACKAGING (4,957 PKGS. @ $955/PKG.)	$1,308,600	$3,425,300	$4,733,900
TOTAL CAPITAL		$14,618,400	$12,505,500	$27,123,900
RISK BUDGET (11.0%)		$1,608,000	$1,375,600	$2,983,600
SUBTOTAL		$16,226,400	$13,881,100	$30,107,500
CONTINGENCY (20.0%)		$3,245,300	$2,776,200	$6,021,500
TOTAL ESTIMATED INSTALLED COST		$19,471,700	$16,657,300	$36,129,000
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$4,056,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$35,393,200

758

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File: SUM3B1CE.WK3

-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-24.A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	2,566		$42,365		$151,539	$193,900
	ELECTRICAL COSTS	561		$9,262		$75,200	$84,500
	PIPING COSTS	650		$10,731		$5,475	$16,200
	SUBCONTRACTOR COSTS	2,777			$284,880		$284,900
SUB-TOTAL 1	DIRECT FIELD COSTS	6,554		$62,400	$284,900	$232,200	$579,500
SUPERVISION & SUPPRT LABOR	28.0%			$17,000			$17,000
SMALL TOOLS	$1.50					$9,800	$9,800
CONSUMABLES	$1.50					$9,800	$9,800
EQUIPMENT RENTAL	$3.00					$19,700	$19,700
TEMP. FACILITIES	4.0%			$900		$1,600	$2,500
TEMP. UTILITIES	1.0%			$200		$400	$600
JOB CLEAN-UP	6.0%			$1,300		$2,400	$3,700
SAFETY	7.0%			$1,500		$2,800	$4,300
HEALTH PHYSICS	20.0%	$83,300		$16,700			$16,700
CERCLA	$1,500	PER PERSON	2,000			$4,900	$4,900
BOND	1.0%	$579,500				$5,800	$5,800
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$14,700	$14,700
OVERHEAD & PROFIT	9.0%	$689,000				$62,000	$62,000
EMISSION MODELING	0.50%	$579,500		$1,000		$1,900	$2,900
PSAR/FSAR(SAFE RPT)	0.50%	$579,500		$1,000		$1,900	$2,900
PAYRL BRD.&BENFT.	52.0%	$102,000		$53,000			$53,000
SUBTOTAL 2	INDIRECT CONSTRUCTION SUPPORT			$155,000		$369,900	$809,800
CONSTR. MGMT.	4.0%	$809,800					$32,400
SUB-TOTAL 3							$842,200
SOIL/WATER/AIR	1.0%	$579,500		$2,000		$3,800	$5,800
HOME OFFICE EXP.	1.0%	$842,200					$8,400
PROJ.MGMT.FERMCO	8.0%	$842,200					$67,400
ENGINEERING	20.0% Title I	7.0% Title II	10.0%	Title III	3.0%		$162,000
SUB-TOTAL 4	OFFICE COSTS						$1,085,800
SALES TAX	6.0%	$373,700					$22,400
SUB-TOTAL 5							$1,108,200
RISK BUDGET	11.0%						$121,900
SUB-TOTAL 6							$1,230,100
CONTINGENCY	20.0%						$246,000
TOTAL ESTIMATED INSTALLED COST							$1,476,100

EST.FILE #:3096-24A.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	SITE PREPARATION - CAPITAL COSTS							
1	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
7	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
8	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
9	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
10	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
11	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
12	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	2	EA	48	$3,680	$792	-	$4,472
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
14	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE, 280 KVA.	300	FT	90	$6,000	$1,486	-	$7,486
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
-	SEWER:	-	-	-	-	-	-	-
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
-	COMPRESSED AIR:	-	-	-	-	-	-	-
18	AIR COMPRESSOR, 5 HP w/ 50 GALLON RECEIVER AND DRYER.	1	EA	32	$2,290	$528	-	$2,818
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,777	$232,214	$62,358	-	$294,572

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRYFORWARD	1	LS	3,777	$232,214	$62,358	-	$294,572
	SUBCONTRACT COSTS							
1	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
2	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
3	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
4	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
5	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
6	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
7	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
8	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
9	EXCAVATION & BACKFILL.	160	CYDS	11	-	$254	$606	$860
10								
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,777	-	254	284,880	$285,134
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	6,554	$232,214	$62,612	$284,880	$579,706

760

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-29 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	8,816		$162,282		$230,805	$393,100
	SUBCONTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,192	18.00	$162,300	$522,200	$230,800	$915,300
SUPERVISION & SUPPRT LABOR	28.0%			$45,000			$45,000
SMALL TOOLS	$1.50					$16,800	$16,800
CONSUMABLES	$1.50					$16,800	$16,800
EQUIPMENT RENTAL	$3.00					$33,600	$33,600
TEMP. FACILITIES	4.0%			$2,300		$4,200	$6,500
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,400		$6,300	$9,700
SAFETY	7.0%			$4,000		$7,400	$11,[illegible]
HEALTH PHYSICS	20.0% $217,600			$43,500			$43,5[illegible]
CERCLA $1,500	PER PERSON 2,000					$8,400	$8,400
BOND	1.0% $915,300					$9,200	$9,200
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$19,600	$19,600
OVERHEAD & PROFIT	9.0% $1,137,500					$102,400	$102,400
EMISSION MODELING	0.50% $915,300			$1,600		$3,000	$4,600
PSAR/FSAR(SAFE RPT)	0.50% $915,300			$1,600		$3,000	$4,600
PAYRL BRD.&BENFT.	52.0% $264,300			$137,400			$137,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$401,700		$462,600	$1,386,500
CONSTR. MGMT.	4.0% $1,386,500						$55,500
SUB-TOTAL 3							$1,442,000
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0% $915,300			$3,200		$5,900	$9,100
HOME OFFICE EXP.	1.0% $1,442,000						$14,400
PROJ.MGMT.FERMCO	8.0% $1,442,000						$115,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$277,300
SUB-TOTAL 4	OFFICE COSTS						$1,858,200
SALES TAX	6.0% $468,500						$28,100
SUB-TOTAL 5							$2,936,300
RISK BUDGET	11.0%						$323,000
SUB-TOTAL 6							$3,259,300
CONTINGENCY	20.0%						$651,900
TOTAL ESTIMATED INSTALLED COST							$3,911,200

08/24/93

EST.FILE #:3096-29.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$2,010
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$4,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$12,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$7,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$70,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$41,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$25,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$10,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$6,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$20,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$31,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$163,064
		1	EA	96	$900	$1,824		$3,724
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,816	$230,805	$162,282	-	$393,087

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,192	$230,805	$162,282	$522,208	$915,295

-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-3 A
CLIENT: US DOE
PROJECT TITLE: CEMENT STABILIZATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CEMENT STABILIZATION EQUIPMENT COSTS (CURRENT COST ESTIMATE)	15,543		$450,747	$585,971	$1,217,017	$2,253,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	15,543	18.00	$450,700	$586,000	$1,217,000	$2,253,700
SUPERVISION & SUPPRT LABOR	28.0%			$126,200			$126,200
SMALL TOOLS	$1.50					$23,300	$23,300
CONSUMABLES	$1.50					$23,300	$23,300
EQUIPMENT RENTAL	$3.00					$46,600	$46,600
TEMP. FACILITIES	4.0%			$6,300		$11,700	$18,000
TEMP. UTILITIES	1.0%			$1,600		$2,900	$4,500
JOB CLEAN-UP	6.0%			$9,500		$17,600	$27,[illegible]
SAFETY	7.0%			$11,000		$20,500	$31,5[illegible]
HEALTH PHYSICS	20.0% $605,300			$121,100			$121,100
CERCLA $1,500	PER PERSON 2,000					$11,700	$11,700
BOND	1.0% $2,253,700					$22,500	$22,500
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$83,400	$83,400
OVERHEAD & PROFIT	9.0% $2,792,900					$251,400	$251,400
EMISSION MODELING	0.50% $2,253,700			$3,900		$7,300	$11,200
PSAR/FSAR(SAFE RPT)	0.50% $2,253,700			$3,900		$7,300	$11,200
PAYRL BRD.&BENFT.	52.0% $734,200			$381,800			$381,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,116,000		$1,746,500	$3,448,500
CONSTR. MGMT.	4.0% $3,448,500						$137,900
SUB-TOTAL 3							$3,586,400
SOIL/WATER/AIR	1.0% $2,253,700			$7,900		$14,600	$22,500
HOME OFFICE EXP.	1.0% $3,586,400						$35,900
PROJ.MGMT.FERMCO	8.0% $3,586,400						$286,900
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$689,700
SUB-TOTAL 4	OFFICE COSTS						$4,621,400
SALES TAX	6.0% $1,761,100						$105,700
SUB-TOTAL 5							$4,727,100
RISK BUDGET	11.0%						$520,000
SUB-TOTAL 6							$5,247,100
CONTINGENCY	20.0%						$1,049,400
TOTAL ESTIMATED INSTALLED COST							$6,296,500

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-1 B
CLIENT: US DOE
PROJECT TITLE: PNEUMATIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	10,700		$176,808		$680,350	$857,158
	CONCRETE	1,200		$22,000		$116,500	$138,500
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,510		$44,230		$1,432,960	$1,477,190
	MACHINERY AND EQUIPMENT	1,113		$22,200		$144,600	$166,800
	PIPING	737		$13,310		$50,820	$64,130
	ELECTRICAL	6,578		$118,900		$203,800	$322,700
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	2,079		$38,520		$43,890	$82,410
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	38,090	17.80	$678,148		$3,893,500	$4,571,608
SUPERVISION & SUPPRT LABOR	28.0%			$190,000			$190,000
SMALL TOOLS	$1.50					$57,100	$57,100
CONSUMABLES	$1.50					$57,100	$57,100
EQUIPMENT RENTAL	$3.00					$114,300	$114,300
TEMP. FACILITIES	4.0%			$9,500		$17,600	$27,100
TEMP. UTILITIES	1.0%			$2,400		$4,400	$6,800
CLEAN-UP	6.0%			$14,200		$26,400	$40,600
SAFETY	7.0%			$16,600		$30,900	$47,500
HEALTH PHYSICS	20.0% $910,848			$182,200			$182,200
CERCLA $1,500	PER PERSON 2,000					$28,600	$28,600
BOND	1.0% $4,571,608					$45,700	$45,700
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$228,600	$228,600
OVERHEAD & PROFIT	9.0% $5,597,208					$503,700	$503,700
EMISSION MODELING	0.50% $4,571,608			$8,000		$14,900	$22,900
PSAR/FSAR(SAFE RPT)	0.50% $4,571,608			$8,000		$14,900	$22,900
PAYRL BRD.&BENFT.	52.0% $1,109,048			$576,700			$576,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,685,700		$5,037,700	$6,723,400
CONSTR. MGMT.	4.0% $6,723,400						$268,900
SUB-TOTAL 3							$6,992,300
SOIL/WATER/AIR	1.0% $4,571,608			$16,000		$29,700	$45,700
HOME OFFICE EXP.	1.0% $6,992,300						$69,900
PROJ.MGMT.FERMCO	8.0% $6,992,300						$559,400
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$1,344,700
SUB-TOTAL 4	OFFICE COSTS						$9,012,000
SALES TAX	6.0% $5,067,400						$304,000
SUB-TOTAL 5							$9,316,000
RISK BUDGET	11.0%						$1,024,800
SUB-TOTAL 6							$10,340,800
CONTINGENCY	20.0%						$2,068,200
TOTAL ESTIMATED INSTALLED COST							$12,409,000

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3B.1 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL TO NTS. (SILO # 3)
OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHT[illegible]

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	974,484	GALS	-	$19,490	-	-	$19,490
2	BLAST FURNACE SLAG.	3,501,792	LBS	-	$52,527	-	-	$52,527
3	CEMENT	3,501,792	LBS	-	$115,559	-	-	$115,559
4	ELECTRICITY	3,858,593	KWHR	-	$176,376	-	-	$176,376
5	CRAFT LABOR.	105,882	HRS	105,882	-	$3,587,282	-	$3,587,282
6	SUPERVISION LABOR.	1,561	HRS	1,561	-	$104,712	-	$104,712
	SUBTOTAL OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION	1	LS	107,443	$363,952	$3,691,994	-	$4,055,946

ALTERNATIVE 3B.2

VITRIFICATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 1
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3B.2: REMOVAL, STABILIZATION W/VITRIFICATION, OFF-SITE DISPOSAL 300 MILES FROM FEMP

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-24A	SITE PREPARATION	$579,500	$528,700	$1,108,200
3096-29B	WASTE PROCESSING	$1,602,600	$1,333,700	$2,936,300
3096-13A	VITRIFICATION	$2,593,400	$1,460,700	$4,054,100
3096-1B	PNEUMATIC REMOVAL/TRANSFER SYSTEM	$4,571,600	$4,744,400	$9,316,000
–	TRANSPORTATION	$62,800		$62,800
–	DISPOSAL	$498,100	$848,000	$1,346,100
–	PACKAGING (1,282 PKGS. @ $955/PKG.)	$338,400	$885,900	$1,224,300
TOTAL CAPITAL		$10,246,400	$9,801,400	$20,047,800
RISK BUDGET (11.0%)		$1,127,100	$1,078,200	$2,205,300
SUBTOTAL		$11,373,500	$10,879,600	$22,253,100
CONTINGENCY (20.0%)		$2,274,700	$2,175,900	$4,450,600
TOTAL ESTIMATED INSTALLED COST		$13,648,200	$13,055,500	$26,703,700
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$4,923,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$27,959,800

767

File: SUM3B2VI.WK3

5039

EST FILE #: 3096-24.A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	2,566		$42,365		$151,539	$193,900
	ELECTRICAL COSTS	561		$9,262		$75,200	$84,500
	PIPING COSTS	650		$10,731		$5,475	$16,200
	SUBCONTRACTOR COSTS	2,777			$284,880		$284,900
SUB-TOTAL 1	DIRECT FIELD COSTS	6,554		$62,400	$284,900	$232,200	$579,500
SUPERVISION & SUPPRT LABOR	28.0%						
SMALL TOOLS	$1.50			$17,000			$17,000
CONSUMABLES	$1.50					$9,800	$9,800
EQUIPMENT RENTAL	$3.00					$9,800	$9,800
TEMP. FACILITIES	4.0%					$19,700	$19,700
TEMP. UTILITIES	1.0%			$900		$1,600	$2,50[illegible]
JOB CLEAN-UP	6.0%			$200		$400	$60[illegible]
SAFETY	7.0%			$1,300		$2,400	$3,700
HEALTH PHYSICS	20.0%	$83,300		$1,500		$2,800	$4,300
CERCLA	$1,500	PER PERSON	2,000	$16,700			$16,700
BOND	1.0%	$579,500				$4,900	$4,900
GEN CONTR MARKUP	5.0%	LBR	5.0% MAT			$5,800	$5,800
OVERHEAD & PROFIT	9.0%	$689,000				$14,700	$14,700
EMISSION MODELING	0.50%	$579,500				$62,000	$62,000
PSAR/FSAR(SAFE RPT)	0.50%	$579,500		$1,000		$1,900	$2,900
PAYRL BRD.&BENFT.	52.0%	$102,000		$1,000		$1,900	$2,900
SUBTOTAL 2	INDIRECT CONSTRUCTION SUPPORT			$53,000			$53,000
				$155,000		$369,900	$809,800
CONSTR. MGMT.	4.0%	$809,800					$32,400
SUB-TOTAL 3							$842,200
SOIL/WATER/AIR	1.0%	$579,500		$2,000		$3,800	$5,800
HOME OFFICE EXP.	1.0%	$842,200					$8,400
PROJ.MGMT.FERMCO	8.0%	$842,200					$67,400
ENGINEERING	20.0% Title I	7.0% Title II	10.0% Title III		3.0%		$162,000
SUB-TOTAL 4	OFFICE COSTS						$1,085,800
SALES TAX	6.0%	$373,700					$22,400
SUB-TOTAL 5							$1,108,200
RISK BUDGET	11.0%						$121,900
SUB-TOTAL 6							$1,230,100
CONTINGENCY	20.0%						$246,000
TOTAL ESTIMATED INSTALLED COST							$1,476,100

EST.FILE #:3096-24A.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	SITE PREPARATION - CAPITAL COSTS							
1	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
7	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
8	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
9	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
10	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
11	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
12	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	2	EA	48	$3,680	$792	-	$4,472
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
14	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE, 280 KVA.	300	FT	90	$6,000	$1,486	-	$7,486
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
-	SEWER:	-	-	-	-	-	-	
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
-	COMPRESSED AIR:	-	-	-	-	-	-	-
18	AIR COMPRESSOR, 5 HP w/ 50 GALLON RECEIVER AND DRYER.	1	EA	32	$2,290	$528	-	$2,818
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,777	$232,214	$62,358	-	$294,572

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRYFORWARD	1	LS	3,777	$232,214	$62,358	-	$294,572
	SUBCONTRACT COSTS							
1	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
2	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
3	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
4	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
5	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
6	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
7	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
8	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
9	EXCAVATION & BACKFILL.	160	CYDS	11	-	$254	$606	$860
10								
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,777	-	254	284,880	$285,134
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	6,554	$232,214	$62,612	$284,880	$579,706

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-29 B
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	8,816		$162,282		$230,805	$393,1[illegible]
	SUBCONTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,192	18.00	$162,300	$522,200	$230,800	$915,300
SUPERVISION & SUPPRT LABOR	28.0%			$45,000			$45,000
SMALL TOOLS	$1.50					$16,800	$16,800
CONSUMABLES	$1.50					$16,800	$16,800
EQUIPMENT RENTAL	$3.00					$33,600	$33,600
TEMP. FACILITIES	4.0%			$2,300		$4,200	$6,500
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,400		$6,300	$9,700
SAFETY	7.0%			$4,000		$7,400	$11[illegible]
HEALTH PHYSICS	20.0% $217,600			$43,500			$43,[illegible]
CERCLA $1,500	PER PERSON 2,000					$8,400	$8,400
BOND	1.0% $915,300					$9,200	$9,200
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$19,600	$19,600
OVERHEAD & PROFIT	9.0% $1,137,500					$102,400	$102,400
EMISSION MODELING	0.50% $915,300			$1,600		$3,000	$4,600
PSAR/FSAR(SAFE RPT)	0.50% $915,300			$1,600		$3,000	$4,600
PAYRL BRD.&BENFT.	52.0% $264,300			$137,400			$137,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$401,700		$462,600	$1,386,500
CONSTR. MGMT.	4.0% $1,386,500						$55,500
SUB-TOTAL 3							$1,442,000
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0% $915,300			$3,200		$5,900	$9,100
HOME OFFICE EXP.	1.0% $1,442,000						$14,400
PROJ.MGMT.FERMCO	8.0% $1,442,000						$115,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$277,300
SUB-TOTAL 4	OFFICE COSTS						$1,858,200
SALES TAX	6.0% $468,500						$28,100
SUB-TOTAL 5							$2,936,300
RISK BUDGET	11.0%						$323,000
SUB-TOTAL 6							$3,259,300
CONTINGENCY	20.0%						$651,900
TOTAL ESTIMATED INSTALLED COST							$3,911,200

EST.FILE #:3096-29.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$2,010
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$4,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$12,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$7,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$70,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$41,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$25,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$10,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$6,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$20,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$31,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$163,064
		1	EA	96	$900	$1,824		$3,724
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,816	$230,805	$162,282	-	$393,087

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,192	$230,805	$162,282	$522,208	$915,295

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-13 A
CLIENT: US DOE
PROJECT TITLE: VITRIFICATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	VITRIFICATION EQUIPMENT COSTS	866		$15,274		$194,972	$210,200
	RADON TREATMENT SYSTEM COSTS	375		$6,614		$17,932	$24,500
	OFF-GAS SYSTEM COSTS	880		$15,521		$103,136	$118,700
	SUBCONTRACTOR COSTS (ADJ. TO CURRENT COST)	1,380			$2,240,000		$2,240,000
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	3,501	16.50	$37,400	$2,240,000	$316,000	$2,593,400
SUPERVISION & SUPPRT LABOR	28.0%			$10,000			$10,000
SMALL TOOLS	$1.50					$5,300	$5,300
CONSUMABLES	$1.50					$5,300	$5,300
EQUIPMENT RENTAL	$3.00					$10,500	$10,500
TEMP. FACILITIES	4.0%			$500		$1,000	$1,500
TEMP. UTILITIES	1.0%			$100		$200	$3[illegible]
JOB CLEAN-UP	6.0%			$800		$1,500	$2,3[illegible]
SAFETY	7.0%			$900		$1,700	$2,600
HEALTH PHYSICS	20.0% $49,700			$9,900			$9,900
CERCLA $1,500	PER PERSON 2,000					$2,600	$2,600
BOND	1.0% $2,593,400					$25,900	$25,900
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$17,700	$17,700
OVERHEAD & PROFIT	9.0% $2,687,300					$241,900	$241,900
EMISSION MODELING	0.50% $2,593,400			$4,500		$8,400	$12,900
PSAR/FSAR(SAFE RPT)	0.50% $2,593,400			$4,500		$8,400	$12,900
PAYRL BRD.&BENFT.	52.0% $68,600			$35,700			$35,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$104,300		$646,400	$2,990,700
CONSTR. MGMT.	4.0% $2,990,700						$119,600
SUB-TOTAL 3							$3,110,300
SOIL/WATER/AIR	1.0% $2,593,400			$9,100		$16,900	$26,000
HOME OFFICE EXP.	1.0% $3,110,300						$31,100
PROJ.MGMT.FERMCO	8.0% $3,110,300						$248,800
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$598,100
SUB-TOTAL 4	OFFICE COSTS						$4,014,300
SALES TAX	6.0% $663,300						$39,800
SUB-TOTAL 5							$4,054,100
RISK BUDGET	11.0%						$446,000
SUB-TOTAL 6							$4,500,100
CONTINGENCY	20.0%						$900,000
TOTAL ESTIMATED INSTALLED COST							$5,400,100

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-1 B
CLIENT: US DOE
PROJECT TITLE: PNEUMATIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	10,700		$176,808		$680,350	$857,158
	CONCRETE	1,200		$22,000		$116,500	$138,500
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,510		$44,230		$1,432,960	$1,477,190
	MACHINERY AND EQUIPMENT	1,113		$22,200		$144,600	$166,800
	PIPING	737		$13,310		$50,820	$64,130
	ELECTRICAL	6,578		$118,900		$203,800	$322,700
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	2,079		$38,520		$43,890	$82,410
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	38,090	17.80	$678,148		$3,893,500	$4,571,608
SUPERVISION & SUPPRT LABOR	28.0%			$190,000			$190,000
SMALL TOOLS	$1.50					$57,100	$57,100
CONSUMABLES	$1.50					$57,100	$57,100
EQUIPMENT RENTAL	$3.00					$114,300	$114,300
TEMP. FACILITIES	4.0%			$9,500		$17,600	$27,100
TEMP. UTILITIES	1.0%			$2,400		$4,400	$6,800
JOB CLEAN-UP	6.0%			$14,200		$26,400	$40,600
SAFETY	7.0%			$16,600		$30,900	$47,500
HEALTH PHYSICS	20.0%	$910,848		$182,200			$182,200
CERCLA $1,500	PER PERSON	2,000				$28,600	$28,600
BOND	1.0%	$4,571,608				$45,700	$45,700
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$228,600	$228,600
OVERHEAD & PROFIT	9.0%	$5,597,208				$503,700	$503,700
EMISSION MODELING	0.50%	$4,571,608		$8,000		$14,900	$22,900
PSAR/FSAR(SAFE RPT)	0.50%	$4,571,608		$8,000		$14,900	$22,900
PAYRL BRD.&BENFT.	52.0%	$1,109,048		$576,700			$576,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,685,700		$5,037,700	$6,723,400
CONSTR. MGMT.	4.0%	$6,723,400					$268,900
SUB-TOTAL 3							$6,992,300
SOIL/WATER/AIR	1.0%	$4,571,608		$16,000		$29,700	$45,700
HOME OFFICE EXP.	1.0%	$6,992,300					$69,900
PROJ.MGMT.FERMCO	8.0%	$6,992,300					$559,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$1,344,700
SUB-TOTAL 4	OFFICE COSTS						$9,012,000
SALES TAX	6.0%	$5,067,400					$304,000
SUB-TOTAL 5							$9,316,000
RISK BUDGET	11.0%						$1,024,800
SUB-TOTAL 6							$10,340,800
CONTINGENCY	20.0%						$2,068,200
TOTAL ESTIMATED INSTALLED COST							$12,409,000

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3B.2 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL AT FACILITY,WITHIN 300 MILES OF FEMP.(SILO #3)
OPERATION & MAINTENANCE COSTS.-VITRIFICATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	SILICA	1,330,560	LBS	-	$25,281	-	-	$25,281
2	ALUMINA	1,227,744	LBS	-	$672,190	-	-	$672,190
3	BORATE	737,856	LBS	-	$202,910	-	-	$202,910
4	ELECTRICITY	7,232,243	KWHR	-	$330,586	-	-	$330,586
5	CRAFT LABOR.	105,882	HRS	105,882	-	$3,587,282	-	$3,587,282
6	SUPERVISION LABOR.	1,561	HRS	1,561	-	$104,712	-	$104,712
	SUBTOTAL OPERATION & MAINTENACE COSTS.-VITRIFICATION OPTION	1	LS	107,443	$1,230,967	$3,691,994	-	$4,922,961

5088

774

ALTERNATIVE 3B.2

CEMENT STABILIZATION

DATE: 05-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 3
O&M DURING REMEDIATION (YRS): 1
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3B.2: REMOVAL, CEMENT STABILIZATION, OFF-SITE DISPOSAL 300 MILES FROM FEMP

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-24A	SITE PREPARATION	$579,500	$528,700	$1,108,200
3096-29B	WASTE PROCESSING	$1,602,600	$1,333,700	$2,936,300
3096-3A	CEMENT STABILIZATION	$2,253,700	$2,473,400	$4,727,100
3096-1B	PNEUMATIC REMOVAL/TRANSFER SYSTEM	$4,571,600	$4,744,400	$9,316,000
-	TRANSPORTATION	$165,000		$165,000
-	DISPOSAL	$1,925,800	$3,279,000	$5,204,800
-	PACKAGING (4,957 PKGS. @ $955/PKG.)	$1,308,600	$3,425,300	$4,733,900
TOTAL CAPITAL		$12,406,800	$15,784,500	$28,191,300
RISK BUDGET (11.0%)		$1,364,700	$1,736,300	$3,101,000
SUBTOTAL		$13,771,500	$17,520,800	$31,292,300
CONTINGENCY (20.0%)		$2,754,300	$3,504,200	$6,258,500
TOTAL ESTIMATED INSTALLED COST		$16,525,800	$21,025,000	$37,550,800
OPERATION AND MAINTENANCE (O&M) COSTS				
DURING REMEDIATION				$4,056,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$36,636,800

776

File: SUM3B2CE.WK3

E-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST.FILE #: 3096-24.A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	2,566		$42,365		$151,539	$193,900
	ELECTRICAL COSTS	561		$9,262		$75,200	$84,500
	PIPING COSTS	650		$10,731		$5,475	$16,200
	SUBCONTRACTOR COSTS	2,777			$284,880		$284,900
SUB-TOTAL 1	DIRECT FIELD COSTS	6,554		$62,400	$284,900	$232,200	$579,500
SUPERVISION & SUPPRT LABOR	28.0%			$17,000			$17,000
SMALL TOOLS	$1.50					$9,800	$9,800
CONSUMABLES	$1.50					$9,800	$9,800
EQUIPMENT RENTAL	$3.00					$19,700	$19,700
TEMP. FACILITIES	4.0%			$900		$1,600	$2,500
TEMP. UTILITIES	1.0%			$200		$400	$60
JOB CLEAN-UP	6.0%			$1,300		$2,400	$3,70
SAFETY	7.0%			$1,500		$2,800	$4,300
HEALTH PHYSICS	20.0%	$83,300		$16,700			$16,700
CERCLA $1,500	PER PERSON	2,000				$4,900	$4,900
BOND	1.0%	$579,500				$5,800	$5,800
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$14,700	$14,700
OVERHEAD & PROFIT	9.0%	$689,000				$62,000	$62,000
EMISSION MODELING	0.50%	$579,500		$1,000		$1,900	$2,900
PSAR/FSAR(SAFE RPT)	0.50%	$579,500		$1,000		$1,900	$2,900
PAYRL BRD.&BENFT.	52.0%	$102,000		$53,000			$53,000
SUBTOTAL 2	INDIRECT CONSTRUCTION SUPPORT			$155,000		$369,900	$809,800
CONSTR. MGMT.	4.0%	$809,800					$32,400
SUB-TOTAL 3							$842,200
SOIL/WATER/AIR	1.0%	$579,500		$2,000		$3,800	$5,800
HOME OFFICE EXP.	1.0%	$842,200					$8,400
PROJ.MGMT.FERMCO	8.0%	$842,200					$67,400
ENGINEERING	20.0% Title I	7.0% Title II	10.0%	Title III	3.0%		$162,000
SUB-TOTAL 4	OFFICE COSTS						$1,085,800
SALES TAX	6.0%	$373,700					$22,400
SUB-TOTAL 5							$1,108,200
RISK BUDGET	11.0%						$121,900
SUB-TOTAL 6							$1,230,100
CONTINGENCY	20.0%						$246,000
TOTAL ESTIMATED INSTALLED COST							$1,476,100

EST.FILE #:3096-24A.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	SITE PREPARATION - CAPITAL COSTS							
1	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
7	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
8	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
9	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
10	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
11	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
12	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	2	EA	48	$3,680	$792	-	$4,472
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
14	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE, 280 KVA.	300	FT	90	$6,000	$1,486	-	$7,486
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	-	-	-	-	-	-	-
16	2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
-	SEWER:	100	FT	250	$700	$4,128	-	$4,828
17	BURIED SEWER PIPE 4" CONCRETE.	-	-	-	-	-	-	
-	COMPRESSED AIR:	300	FT	48	$885	$792	-	$1,677
18	AIR COMPRESSOR, 5 HP w/ 50 GALLON RECEIVER AND DRYER.	-	-	-	-	-	-	-
		1	EA	32	$2,290	$528	-	$2,818
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,777	$232,214	$62,358	-	$294,572

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRYFORWARD							
	SUBCONTRACT COSTS	1	LS	3,777	$232,214	$62,358	-	$294,572
1	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
2	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
3	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
4	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
5	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
6	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
7	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
8	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
9	EXCAVATION & BACKFILL.	160	CYDS	11	-	$254	$606	$860
10								
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,777	-	254	284,880	$285,134
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	6,554	$232,214	$62,612	$284,880	$579,706

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-29 B 5039
CLIENT: US DOE
PROJECT TITLE: WASTE PROCESSING FACILITY & TEMPORARY STAGING & STORAGE

DATE 03-Dec-93
ESTIMATOR COSSMAN
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CONCRETE COSTS	8,816		$162,282		$230,805	$393,[illegible]
	SUBCONTRACTOR COSTS	2,376			$522,208		$522,200
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	11,192	18.00	$162,300	$522,200	$230,800	$915,300
SUPERVISION & SUPPRT LABOR	28.0%			$45,000			$45,000
SMALL TOOLS	$1.50					$16,800	$16,800
CONSUMABLES	$1.50					$16,800	$16,800
EQUIPMENT RENTAL	$3.00					$33,600	$33,600
TEMP. FACILITIES	4.0%			$2,300		$4,200	$6,500
TEMP. UTILITIES	1.0%			$600		$1,100	$1,700
JOB CLEAN-UP	6.0%			$3,400		$6,300	$9,700
SAFETY	7.0%			$4,000		$7,400	$11[illegible]
HEALTH PHYSICS	20.0% $217,600			$43,500			$43[illegible]
CERCLA $1,500	PER PERSON 2,000					$8,400	$8,400
BOND	1.0% $915,300					$9,200	$9,200
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$19,600	$19,600
OVERHEAD & PROFIT	9.0% $1,137,500					$102,400	$102,400
EMISSION MODELING	0.50% $915,300			$1,600		$3,000	$4,600
PSAR/FSAR(SAFE RPT)	0.50% $915,300			$1,600		$3,000	$4,600
PAYRL BRD.&BENFT.	52.0% $264,300			$137,400			$137,400
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$401,700		$462,600	$1,386,500
CONSTR. MGMT.	4.0% $1,386,500						$55,500
SUB-TOTAL 3							$1,442,000
TEMPORARY STAGING & STORAGE					$1,050,000		$1,050,000
SOIL/WATER/AIR	1.0% $915,300			$3,200		$5,900	$9,100
HOME OFFICE EXP.	1.0% $1,442,000						$14,400
PROJ.MGMT.FERMCO	8.0% $1,442,000						$115,400
ENGINEERING	20.0% Title I 7.0% Title II 10.0% Title III 3.0%						$277,300
SUB-TOTAL 4	OFFICE COSTS						$1,858,200
SALES TAX	6.0% $468,500						$28,100
SUB-TOTAL 5							$2,936,300
RISK BUDGET	11.0%						$323,000
SUB-TOTAL 6							$3,259,300
CONTINGENCY	20.0%						$651,900
TOTAL ESTIMATED INSTALLED COST							$3,911,200

779

08/24/93

EST.FILE #:3096-29.

WASTE PROCESSING FACILITY.

FY 93-1 DOLLARS

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	WASTE PROCESSING FACILITY - CAPITAL COSTS							
1	FOOTINGS,CONCRETE	110	CYDS	53	$5,060	$931		$5,991
2	FOOTINGS,FORMS	960	SFT	125	$1,056	$2,195		$3,251
3	SLAB,CONCRETE	540	CYDS	281	$24,840	$4,934		$29,774
4	SLAB,FORMS	460	SFT	51	$414	$896		$2,010
5	FOUNDATION,CONCRETE	55	CYDS	26	$2,530	$457		$4,987
6	FOUNDATION,FORMS	2,900	SFT	377	$3,190	$6,620		$12,810
7	CONCRETE FINISHING	1,070	CYDS	128	-	$2,248		$7,248
8	WALLS, FORMS.	17,400	SFT	2,088	$23,490	$36,665		$70,155
9	WALLS FOR SHIELDING-PROCESS AREA,2'THICK..	644	CYDS	393	$32,200	$6,901		$41,101
10	REINFORCING STEEL	39	TONS	390	$16,380	$7,332		$25,712
11	UTILITIES(ALLOWANCE,NO DESIGN PARAMETERS GIVEN)	1	LS	80	$4,000	$1,447		$10,447
12	AIR COMPRESSOR, 10 HP, 100 GALLON RECEIVER	1	EA	60	$4,125	$1,140		$6,265
-	PROCESS AREA VENTILATION SYSTEM, GENERAL.	-	-	-	-	-	-	-
13	BLOWERS, 40,000 CFM, 3" SP	-	-	-	-	-	-	-
14	HEPA FILTERS, 40,000 CFM CAPACITY.	2	EA	96	$16,600	$1,824		$20,424
15	DUCTWORK,60"DIAMETER,w/ DAMPERS, FITTINGS, 300 FT LONG..	2	EA	96	$28,000	$1,824		$31,824
16	DAMPER 40,000 CFM.	38,160	LBS	4,476	$68,020	$85,044		$163,064
		1	EA	96	$900	$1,824		$3,724
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,816	$230,805	$162,282	-	$393,087

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	SUBCONTRACT COSTS							
1	EXCAVATION FOR SLABS AND FOOTINGS	1,600	CYDS	171	-	-	$7,408	$7,408
2	STRUCTURE BUTLER BUILDING, 120 FT X 120 FT	1	EA	1,600	-	-	$432,000	$432,000
-	(30 FT EAVES, FULLY INSULATED, HVAC).	-	-	-	-	-	-	-
3	PARTITIONS-ADMINISTRATIVE & PERSONNEL AREA.	3,600	SFT	605	-	-	$82,800	$82,800
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,376	-	-	$522,208	$522,208
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	11,192	$230,805	$162,282	$522,208	$915,295

780

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FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 30%-3 A
CLIENT: US DOE
PROJECT TITLE: CEMENT STABILIZATION EQUIPMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	CEMENT STABILIZATION EQUIPMENT COSTS (CURRENT COST ESTIMATE)	15,543		$450,747	$585,971	$1,217,017	$2,253,700
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	15,543	18.00	$450,700	$586,000	$1,217,000	$2,253,700
SUPERVISION & SUPPRT LABOR	28.0%			$126,200			$126,200
SMALL TOOLS	$1.50					$23,300	$23,300
CONSUMABLES	$1.50					$23,300	$23,300
EQUIPMENT RENTAL	$3.00					$46,600	$46,600
TEMP. FACILITIES	4.0%			$6,300		$11,700	$18,000
TEMP. UTILITIES	1.0%			$1,600		$2,900	$4,[illegible]
JOB CLEAN-UP	6.0%			$9,500		$17,600	$27,[illegible]
SAFETY	7.0%			$11,000		$20,500	$31,500
HEALTH PHYSICS	20.0%	$605,300		$121,100			$121,100
CERCLA $1,500	PER PERSON	2,000				$11,700	$11,700
BOND	1.0%	$2,253,700				$22,500	$22,500
GEN CONTR MARKUP	5.0% LBR	5.0% MAT				$83,400	$83,400
OVERHEAD & PROFIT	9.0%	$2,792,900				$251,400	$251,400
EMISSION MODELING	0.50%	$2,253,700		$3,900		$7,300	$11,200
PSAR/FSAR(SAFE RPT)	0.50%	$2,253,700		$3,900		$7,300	$11,200
PAYRL BRD.&BENFT.	52.0%	$734,200		$381,800			$381,800
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,116,000		$1,746,500	$3,448,500
CONSTR. MGMT.	4.0%	$3,448,500					$137,900
SUB-TOTAL 3							$3,586,400
SOIL/WATER/AIR	1.0%	$2,253,700		$7,900		$14,600	$22,500
HOME OFFICE EXP.	1.0%	$3,586,400					$35,900
PROJ.MGMT.FERMCO	8.0%	$3,586,400					$286,900
ENGINEERING 20.0%	Title I	7.0%	Title II	10.0%	Title III	3.0%	$689,700
SUB-TOTAL 4	OFFICE COSTS						$4,621,400
SALES TAX	6.0%	$1,761,100					$105,700
SUB-TOTAL 5							$4,727,100
RISK BUDGET	11.0%						$520,000
SUB-TOTAL 6							$5,247,100
CONTINGENCY	20.0%						$1,049,400
TOTAL ESTIMATED INSTALLED COST							$6,296,500

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-1 B
CLIENT: US DOE
PROJECT TITLE: PNEUMATIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	10,700		$176,808		$680,350	$857,158
	CONCRETE	1,200		$22,000		$116,500	$138,500
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,510		$44,230		$1,432,960	$1,477,190
	MACHINERY AND EQUIPMENT	1,113		$22,200		$144,600	$166,800
	PIPING	737		$13,310		$50,820	$64,130
	ELECTRICAL	6,578		$118,900		$203,800	$322,700
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	2,079		$38,520		$43,890	$82,410
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	38,090	17.80	$678,148		$3,893,500	$4,571,608
SUPERVISION & SUPPRT LABOR	28.0%			$190,000			$190,000
SMALL TOOLS	$1.50					$57,100	$57,100
CONSUMABLES	$1.50					$57,100	$57,100
EQUIPMENT RENTAL	$3.00					$114,300	$114,300
TEMP. FACILITIES	4.0%			$9,500		$17,600	$27,100
TEMP. UTILITIES	1.0%			$2,400		$4,400	$6,800
JOB CLEAN-UP	6.0%			$14,200		$26,400	$40,600
SAFETY	7.0%			$16,600		$30,900	$47,500
HEALTH PHYSICS	20.0% $910,848			$182,200			$182,200
CERCLA	$1,500 PER PERSON 2,000					$28,600	$28,600
BOND	1.0% $4,571,608					$45,700	$45,700
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$228,600	$228,600
OVERHEAD & PROFIT	9.0% $5,597,208					$503,700	$503,700
EMISSION MODELING	0.50% $4,571,608			$8,000		$14,900	$22,900
PSAR/FSAR(SAFE RPT)	0.50% $4,571,608			$8,000		$14,900	$22,900
PAYRL BRD.&BENFT.	52.0% $1,109,048			$576,700			$576,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,685,700		$5,037,700	$6,723,400
CONSTR. MGMT.	4.0% $6,723,400						$268,900
SUB-TOTAL 3							$6,992,300
SOIL/WATER/AIR	1.0% $4,571,608			$16,000		$29,700	$45,700
HOME OFFICE EXP.	1.0% $6,992,300						$69,900
PROJ.MGMT.FERMCO	8.0% $6,992,300						$559,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%		Title III	3.0%		$1,344,700
SUB-TOTAL 4	OFFICE COSTS						$9,012,000
SALES TAX	6.0% $5,067,400						$304,000
SUB-TOTAL 5							$9,316,000
RISK BUDGET	11.0%						$1,024,800
SUB-TOTAL 6							$10,340,800
CONTINGENCY	20.0%						$2,068,200
TOTAL ESTIMATED INSTALLED COST							$12,409,000

FERNALD PROJECT - OU4

I. T.PROJECT NO.:409194

ALTERNATIVE # 3B.2 REMOVAL,STABILIZATION,AND OFF-SITE DISPOSAL AT FACILITY,WITHIN 300 MILES OF FEMP.(SILO # 3)
OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION.

FY 93-1 DOLLARS

06/10/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
1	WATER	974,484	GALS	-	$19,490	-	-	$19,490
2	BLAST FURNACE SLAG.	3,501,792	LBS	-	$52,527	-	-	$52,527
3	CEMENT	3,501,792	LBS	-	$115,559	-	-	$115,559
4	ELECTRICITY	3,858,593	KWHR	-	$176,376	-	-	$176,376
5	CRAFT LABOR.	105,882	HRS	105,882	-	$3,587,282	-	$3,587,282
6	SUPERVISION LABOR.	1,561	HRS	1,561	-	$104,712	-	$104,712
	SUBTOTAL OPERATION & MAINTENANCE COSTS.-CEMENT STABILIZATION OPTION	1	LS	107,443	$363,952	$3,691,994	-	$4,055,946

783

W-5039

ALTERNATIVE 4B

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 2
O&M DURING REMEDIATION (YRS): 2
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 4B: REMOVAL, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-24A	SITE PREPARATION	$579,500	$528,700	$1,108,200
–	WASTE PROCESSING	$183,100	$194,200	$377,300
3096-1B	PNEUMATIC REMOVAL/TRANSFER SYSTEM	$4,571,600	$4,744,400	$9,316,000
–	DISPOSAL VAULT	$937,100	$1,595,500	$2,532,600
–	PACKAGING (3,195 PKGS. @ $955/PKG.)	$843,500	$2,207,700	$3,051,200
TOTAL CAPITAL		$7,114,800	$9,270,500	$16,385,300
RISK BUDGET (11.0%)		$782,600	$1,019,800	$1,802,400
SUBTOTAL		$7,897,400	$10,290,300	$18,187,700
CONTINGENCY (20.0%)		$1,579,500	$2,058,100	$3,637,600
TOTAL ESTIMATED INSTALLED COST		$9,476,900	$12,348,400	$21,825,300
OPERATION AND MAINTENANCE (O&M) COSTS				
	DURING REMEDIATION			$1,094,000
	POST-REMEDIATION			$3,207,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$22,045,600

785

-5039

File: SUM4B.WK3

E-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-24.A
CLIENT: US DOE
PROJECT TITLE: SITE PREPARATION

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	SITE PREPARATION COSTS	2,566		$42,365		$151,539	$193,900
	ELECTRICAL COSTS	561		$9,262		$75,200	$84,500
	PIPING COSTS	650		$10,731		$5,475	$16,200
	SUBCONTRACTOR COSTS	2,777			$284,880		$284,900
SUB-TOTAL 1	DIRECT FIELD COSTS	6,554		$62,400	$284,900	$232,200	$579,500
SUPERVISION & SUPPRT LABOR	28.0%			$17,000			$17,000
SMALL TOOLS	$1.50					$9,800	$9,800
CONSUMABLES	$1.50					$9,800	$9,800
EQUIPMENT RENTAL	$3.00					$19,700	$19,700
TEMP. FACILITIES	4.0%			$900		$1,600	$2,500
TEMP. UTILITIES	1.0%			$200		$400	$60
JOB CLEAN-UP	6.0%			$1,300		$2,400	$3,700
SAFETY	7.0%			$1,500		$2,800	$4,300
HEALTH PHYSICS	20.0%	$83,300		$16,700			$16,700
CERCLA $1,500	PER PERSON	2,000				$4,900	$4,900
BOND	1.0%	$579,500				$5,800	$5,800
GEN CONTR MARKUP	5.0% LBR		5.0% MAT			$14,700	$14,700
OVERHEAD & PROFIT	9.0%	$689,000				$62,000	$62,000
EMISSION MODELING	0.50%	$579,500		$1,000		$1,900	$2,900
PSAR/FSAR(SAFE RPT)	0.50%	$579,500		$1,000		$1,900	$2,900
PAYRL BRD.&BENFT.	52.0%	$102,000		$53,000			$53,000
SUBTOTAL 2	INDIRECT CONSTRUCTION SUPPORT			$155,000		$369,900	$809,800
CONSTR. MGMT.	4.0%	$809,800					$32,400
SUB-TOTAL 3							$842,200
SOIL/WATER/AIR	1.0%	$579,500		$2,000		$3,800	$5,800
HOME OFFICE EXP.	1.0%	$842,200					$8,400
PROJ.MGMT.FERMCO	8.0%	$842,200					$67,400
ENGINEERING 20.0%	Title I 7.0%	Title II 10.0%		Title III 3.0%			$162,000
SUB-TOTAL 4	OFFICE COSTS						$1,085,800
SALES TAX	6.0%	$373,700					$22,400
SUB-TOTAL 5							$1,108,200
RISK BUDGET	11.0%						$121,900
SUB-TOTAL 6							$1,230,100
CONTINGENCY	20.0%						$246,000
TOTAL ESTIMATED INSTALLED COST							$1,476,100

EST.FILE #:3096-24A.

SITE PREPARATION.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: JOE PACELLI

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
-	SITE PREPARATION - CAPITAL COSTS							
1	OFFICE TRAILERS, 60 FT. DOUBLEWIDE FOR	-	-	-	-	-	-	-
2	PERSONNEL DECONAMINATION AND DRESS OUT AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
3	HEALTH PHYSICS PERSONNEL AND EQUIPMENT.	1	EA	64	$35,000	$1,057	-	$36,057
4	ADMINISTRATION PERSONNEL.	1	EA	64	$35,000	$1,057	-	$36,057
5	SECURITY LIGHTS, 200 WATTS, NEON VAPOR ON 30 FT. POLES.	20	EA	640	$25,840	$10,566	-	$36,406
6	POWER LINES FOR LIGHTS, 12 AWG	6,000	FT	1,734	$20,699	$28,628	-	$49,327
7	UTILITIES	-	-	-	-	-	-	-
-	ELECTRICAL:	-	-	-	-	-	-	-
8	TRANSFORMER, 34.4 KV-480 VAC, 3 PHASE., 4,000 KVA.	1	EA	125	$32,000	$2,064	-	$34,064
9	TRANSMISSION LINE, 34.4 KV, 7 POLES (67 AMPS) 4,000 KVA.	700	FT	210	$21,000	$3,467	-	$24,467
10	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,30 KVA DUTY.	1	EA	18	$1,020	$297	-	$1,317
11	TRANSMISSION LINE,480 VAC, 3 PHASE,5 POLES,(1,596 amps),1325 KVA.	500	FT	50	$10,000	$826	-	$10,826
12	TRANSFORMER,480 VAC 3 PHASE TO 240/120 VAC.1 PHASE,75 KVA DUTY.	2	EA	48	$3,680	$792	-	$4,472
13	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(96 amps),#2 WIRE, 80 KVA.	100	FT	20	$1,500	$330	-	$1,830
14	TRANSMISSION LINE,480 VAC, 3 PHASE,1POLE,(337 amps),2-500 MCM PER PHASE, 280 KVA.	300	FT	90	$6,000	$1,486	-	$7,486
-	WATER:	-	-	-	-	-	-	-
15	1-1/2" BURIED WATER PIPING CS.	320	FT	320	$1,600	$5,283	-	$6,883
16	2" BURIED WATER PIPING CS.	100	FT	250	$700	$4,128	-	$4,828
-	SEWER:	-	-	-	-	-	-	-
17	BURIED SEWER PIPE 4" CONCRETE.	300	FT	48	$885	$792	-	$1,677
-	COMPRESSED AIR:	-	-	-	-	-	-	-
18	AIR COMPRESSOR, 5 HP w/ 50 GALLON RECEIVER AND DRYER.	1	EA	32	$2,290	$528	-	$2,818
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	3,777	$232,214	$62,358	-	$294,572

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	CARRYFORWARD	1	LS	3,777	$232,214	$62,358	-	$294,572
	SUBCONTRACT COSTS							
1	CLEAR AND GRUB OU-4 REMEDIATION AREA.	340,000	SFT	368	INCL	-	$19,536	$19,536
2	FILL FOR REMEDIATION AREA.	15,000	CYD	1,170	-	-	$153,750	$153,750
3	CHAIN LINK FENCE,7 FT.BARBWIRE-TOPPED.	1,800	FT	162	-	-	$13,774	$13,774
4	GATES CHAIN LINK 7 FT X 15 FT.WIDE.	7	EA	168	-	-	$1,925	$1,925
5	EQUIPMENT STAGING AREA,6"CRUSHED STONE (1" MAX.)	30,000	SFT	150	-	-	$38,333	$38,333
6	ACCESS ROADS, 20 FT. WIDE, 6" CRUSHED STONE (1" MAX.)	1,500	FT	225	-	-	$27,000	$27,000
7	PREPARATION OF SURFACE FOR ACCESS ROADS.	1,500	FT	150	-	-	$16,500	$16,500
8	SEEDING, FERTILIZER & MULCHING	7,778	SYD	373	-	-	$13,456	$13,456
9	EXCAVATION & BACKFILL.	160	CYDS	11	-	$254	$606	$860
10								
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	2,777	-	254	284,880	$285,134
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	6,554	$232,214	$62,612	$284,880	$579,706

5039

E-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-1B
CLIENT: US DOE
PROJECT TITLE: PNEUMATIC REMOVAL / TRANSFER SYSTEM

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	EXCAVATION AND CIVIL	10,700		$176,808		$680,350	$857,158
	CONCRETE	1,200		$22,000		$116,500	$138,500
	STRUCTURAL STEEL	10,879		$204,450		$1,145,190	$1,349,640
	BUILDINGS	2,510		$44,230		$1,432,960	$1,477,190
	MACHINERY AND EQUIPMENT	1,113		$22,200		$144,600	$166,800
	PIPING	737		$13,310		$50,820	$64,130
	ELECTRICAL	6,578		$118,900		$203,800	$322,700
	INSTRUMENTS						
	PAINTING AND SCAFFOLD	2,294		$37,730		$75,350	$113,080
	INSULATION	2,079		$38,520		$43,890	$82,410
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	38,090	17.80	$678,148		$3,893,500	$4,571,608
SUPERVISION & SUPPRT LABOR	28.0%			$190,000			$190,000
SMALL TOOLS	$1.50					$57,100	$57,100
CONSUMABLES	$1.50					$57,100	$57,100
EQUIPMENT RENTAL	$3.00					$114,300	$114,300
TEMP. FACILITIES	4.0%			$9,500		$17,600	$27,100
TEMP. UTILITIES	1.0%			$2,400		$4,400	$6,80
JOB CLEAN-UP	6.0%			$14,200		$26,400	$40,600
SAFETY	7.0%			$16,600		$30,900	$47,500
HEALTH PHYSICS	20.0% $910,848			$182,200			$182,200
CERCLA $1,500	PER PERSON 2,000					$28,600	$28,600
BOND	1.0% $4,571,608					$45,700	$45,700
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$228,600	$228,600
OVERHEAD & PROFIT	9.0% $5,597,208					$503,700	$503,700
EMISSION MODELING	0.50% $4,571,608			$8,000		$14,900	$22,900
PSAR/FSAR(SAFE RPT)	0.50% $4,571,608			$8,000		$14,900	$22,900
PAYRL BRD.&BENFT.	52.0% $1,109,048			$576,700			$576,700
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$1,685,700		$5,037,700	$6,723,400
CONSTR. MGMT.	4.0% $6,723,400						$268,900
SUB-TOTAL 3							$6,992,300
SOIL/WATER/AIR	1.0% $4,571,608			$16,000		$29,700	$45,700
HOME OFFICE EXP.	1.0% $6,992,300						$69,900
PROJ.MGMT.FERMCO	8.0% $6,992,300						$559,400
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$1,344,700
SUB-TOTAL 4	OFFICE COSTS						$9,012,000
SALES TAX	6.0% $5,067,400						$304,000
SUB-TOTAL 5							$9,316,000
RISK BUDGET	11.0%						$1,024,800
SUB-TOTAL 6							$10,340,800
CONTINGENCY	20.0%						$2,068,200
TOTAL ESTIMATED INSTALLED COST							$12,409,000

ALTERNATIVE 1C

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 2
O&M DURING REMEDIATION (YRS): 0
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 1C: DEMOLITION, CONTAINMENT

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-16C	DEMOLITION AND CONTAINMENT	$7,351,100	$8,742,700	$16,093,800
-	PACKAGING (10,676 PKGS. @ $955/PKG.)	$2,818,500	$7,377,100	$10,195,600
	TOTAL CAPITAL	$10,169,600	$16,119,800	$26,289,400
	RISK BUDGET (11.0%)	$1,118,700	$1,773,200	$2,891,900
	SUBTOTAL	$11,288,300	$17,893,000	$29,181,300
	CONTINGENCY (20.0%)	$2,257,700	$3,578,600	$5,836,300
	TOTAL ESTIMATED INSTALLED COST	$13,546,000	$21,471,600	$35,017,600
OPERATION AND MAINTENANCE (O&M) COSTS				
	POST-REMEDIATION			$3,099,000
	TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)			$32,937,800

File: SUM1C.WK3

EST FILE #: 3096-16 C -5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

CLIENT: US DOE
PROJECT TITLE: ALTERNATIVE 1C-DEMOLITION, CONTAINMENT

DATE 24-Aug-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	DEMOLITION OF SILO COSTS	29,480		$520,028		$1,005,536	$1,525,600
	MACHINERY & EQUIPMENT	1,332		$23,497		$46,530	$70,000
	SUBCONTRACTOR COSTS	27,076			$4,537,881		$4,537,900
	D & D COSTS	33,000		$1,217,640			$1,217,640
SUB-TOTAL 1	DIRECT FIELD COSTS	90,888	AVG. 19.38	$1,761,200	$4,537,900	$1,052,100	$7,351,140
SUPERVISION & SUPPRT LABOR	28.0%			$493,000			$493,000
SMALL TOOLS	$1.50					$136,300	$136,300
CONSUMABLES	$1.50					$136,300	$136,300
EQUIPMENT RENTAL	$3.00					$272,700	$272,700
TEMP. FACILITIES	4.0%			$24,700		$45,800	$70,500
TEMP. UTILITIES	1.0%			$6,200		$11,400	$17,600
JOB CLEAN-UP	6.0%			$37,000		$68,700	$105,700
SAFETY	7.0%			$43,100		$80,100	$123,200
HEALTH PHYSICS	20.0%	$2,365,200		$473,000			$473,000
CERCLA	$1,500	PER PERSON	2,000			$68,200	$68,200
BOND	1.0%	$7,351,140				$73,500	$73,500
GEN CONTR MARKUP	5.0%	LBR	5.0% MAT			$140,700	$140,700
OVERHEAD & PROFIT	9.0%	$9,461,840				$851,600	$851,600
EMISSION MODELING	0.50%	$7,351,140		$12,900		$23,900	$36,800
PSAR/FSAR(SAFE RPT)	0.50%	$7,351,140		$12,900		$23,900	$36,800
PAYRL BRD.&BENFT.	52.0%	$2,864,000		$1,489,300			$1,489,300
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$4,353,300		$2,985,200	$11,876,300
CONSTR. MGMT.	4.0%	$11,876,300					$475,100
SUB-TOTAL 3							$12,351,400
SOIL/WATER/AIR	1.0%	$7,351,140		$25,700		$47,800	$73,500
HOME OFFICE EXP.	1.0%	$12,351,400					$123,500
PROJ.MGMT.FERMCO	8.0%	$12,351,400					$988,100
ENGINEERING	20.0%	Title I 7.0%	Title II 10.0%	Title III 3.0%			$2,375,300
SUB-TOTAL 4	OFFICE COSTS						$15,911,800
SALES TAX	6.0%	$3,033,000					$182,000
SUB-TOTAL 5							$16,093,800
RISK BUDGET	11.0%						$1,770,300
SUB-TOTAL 6							$17,864,100
CONTINGENCY	20.0%						$3,572,800
TOTAL ESTIMATED INSTALLED COST							$21,436,900

EST.FILE #:3097-16B.

ALTERNATIVE # 1C- DEMOLITION,CONTAINMENT.

FY 93-1 DOLLARS

08/24/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	DEMOLITION OF SILO:	-	-	-	-	-	-	-
		-	-	-	-	-	-	-
1	ROBOTIC SCARIFICATION ROBOT, w/ REMOTE CONTROL OPERATIONS.	1	EA	80	$300,000	$1,411	-	$301,411
2	LIGHTING FOR SILO INTERIOR	2	PLCS	64	$530	$1,129	-	$1,659
3	VIDEO EQUIPMENT FOR SILO INTERIOR.	1	EA	16	$1,200	$282	-	$1,482
4	3" STANDARD SLUDGE PUMPING SYSTEM,ELECTRIC DRIVE,& SHUTDOWN PKGS.	1	EA	60	$10,392	$1,058	-	$11,450
5	GLOVEBAGS FOR ROBOT ENTRY.	3	EA	12	$300	$212	-	$512
6	DIAMOND SAW w/ DIAMOND CHAIN, BOUGHT OUT.	6	EA	3,528	$46,020	$62,234	-	$108,254
7	PLASTIC, 10 MIL SHEETING TO CATCH DEBRIS.	2,000	SFT	-	$100	-	-	$100
8	CONCRETE SCABBLING MACHINES(INCL ONE OPERATOR)	3	EA	2,880	$346,500	$50,803	-	$397,303
9	STAGING AREA FOR FILLING AND LOADING BOXES,	2,500	SFT	80	$2,807	$1,411	-	$4,218
-	(REINFORCED CONCRETE PAD).	-	-	-	-	-	-	-
10	GROUT FOR DECANT TANK.	50	CYDS	20	$3,150	$353	-	$3,503
11	TENSION ARCH STRUCTUREw/ DOORWAY FOR EQUIPMENT PASSAGE	1	EA	640	$41,072	$11,290	-	$52,362
-	AND DOORWAY FOR PERSONNEL,FOR THREE MONTHS.(LEASED)	-	-	-	-	-	-	-
12	BORROW FILL FOR PADDY'S RUN(10 MILES ROUNDTRIP)(85% COMPACTION).	69,158	CYD	20,540	$235,829	$362,326	-	$598,155
13	FILTER FABRIC-OF COMPATIBLE MATERIAL	51,120	SFT	294	$2,556	$5,186	-	$7,742
14	SEED FERTILIZE & MULCH AROUND PADDY'S RUN	15,560	SYD	747	$2,334	$13,177	-	$15,511
15	RIPRAP (TWO LAYERS, STONE DIAMETER, 4")	1,262	CYD	326	$12,746	$5,751	-	$18,497
16	SCRAPE 6" DEPTH OF CONTAMINATED SURFACE SOIL.	3,787	CYDS	193	-	$3,405	-	$3,405
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	29,480	$1,005,536	$520,028	-	$1,525,564
	SUBCONTRACT COSTS							
1	MULTIMEDIA CAP.(PRORATED).	1	LS	-	-	-	$2,998,000	$2,998,000
2	MISCELANNEOUS SUBCONTRACT ITEMS.	1	LS	20,751	-	-	$1,136,896	$1,136,896
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	20,751	-	-	$4,134,896	$4,134,896
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	50,231	$1,005,536	$520,028	$4,134,896	$5,660,460

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ALTERNATIVE 2C

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 2
O&M DURING REMEDIATION (YRS): 0
POST-REMEDIATION O&M (YRS): 30

ALTERNATIVE 2C: DEMOLITION, REMOVAL, ON-PROPERTY DISPOSAL

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-17C	DEMOLITION & REMOVAL	$3,980,300	$5,977,100	$9,957,400
-	DISPOSAL VAULT	$6,410,200	$10,914,800	$17,325,000
TOTAL CAPITAL		$10,390,500	$16,891,900	$27,282,400
RISK BUDGET (11.0%)		$1,143,000	$1,858,100	$3,001,100
SUBTOTAL		$11,533,500	$18,750,000	$30,283,500
CONTINGENCY (20.0%)		$2,306,700	$3,750,000	$6,056,700
TOTAL ESTIMATED INSTALLED COST		$13,840,200	$22,500,000	$36,340,200
OPERATION AND MAINTENANCE (O&M) COSTS				
POST-REMEDIATION				$3,567,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)				$34,327,000

794

-5039

File: SUM2C.WK3

E-5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-17 C
CLIENT: US DOE
PROJECT TITLE: SUBUNIT C: DEMOLITION & REMOVAL

DATE 01-Sep-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	DEMOLITION OF SILO COSTS	8,245		$145,442		$807,093	$952,500
	MACHINERY & EQUIPMENT COSTS	1,332		$23,497		$46,530	$70,000
	SUBCONTRACTOR COSTS	28,589			$1,740,214		$1,740,200
	D & D COSTS	33,000		$1,217,640			$1,217,640
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	71,166	19.48	$1,386,600	$1,740,200	$853,600	$3,980,340
SUPERVISION & SUPPRT LABOR	28.0%			$388,000			$388,000
SMALL TOOLS	$1.50					$106,700	$106,700
CONSUMABLES	$1.50					$106,700	$106,700
EQUIPMENT RENTAL	$3.00					$213,500	$213,500
TEMP. FACILITIES	4.0%			$19,400		$36,100	$55,500
TEMP. UTILITIES	1.0%			$4,900		$9,000	$13,900
JOB CLEAN-UP	6.0%			$29,100		$54,100	$83,200
SAFETY	7.0%			$34,000		$63,100	$97,100
HEALTH PHYSICS	20.0% $1,862,000			$372,400			$372,400
CERCLA $1,500	PER PERSON 2,000					$53,400	$53,400
BOND	1.0% $3,980,340					$39,800	$39,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$112,000	$112,000
OVERHEAD & PROFIT	9.0% $5,622,540					$506,000	$506,000
EMISSION MODELING	0.50% $3,980,340			$7,000		$12,900	$19,900
PSAR/FSAR(SAFE RPT)	0.50% $3,980,340			$7,000		$12,900	$19,900
PAYRL BRD.&BENFT.	52.0% $2,248,400			$1,169,200			$1,169,200
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,417,600		$2,179,800	$7,337,500
CONSTR. MGMT.	4.0% $7,337,500						$293,500
SUB-TOTAL 3							$7,631,000
SOIL/WATER/AIR	1.0% $3,980,340			$13,900		$25,900	$39,800
HOME OFFICE EXP.	1.0% $7,631,000						$76,300
PROJ.MGMT.FERMCO	8.0% $7,631,000						$610,500
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$1,467,500
SUB-TOTAL 4	OFFICE COSTS						$9,825,100
SALES TAX	6.0% $2,205,700						$132,300
SUB-TOTAL 5							$9,957,400
RISK BUDGET	11.0%						$1,095,300
SUB-TOTAL 6							$11,052,700
CONTINGENCY	20.0%						$2,210,500
TOTAL ESTIMATED INSTALLED COST							$13,263,200

EST.FILE #:3096-17C.

DEMOLITION,REMOVAL,ON-PROPERTY DISPOSAL.

FY 93-1 DOLLARS

09/01/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	DEMOLITION OF SILO:	-	-	-	-	-	-	-
		-	-	-	-	-	-	-
1	ROBOTIC SCARIFICATION ROBOT, w/ REMOTE CONTROL OPERATIONS.	1	EA	80	$300,000	$1,411	-	$301,411
2	LIGHTING FOR SILO INTERIOR	2	PLCS	64	$530	$1,129	-	$1,659
3	VIDEO EQUIPMENT FOR SILO INTERIOR.	1	EA	16	$1,200	$282	-	$1,482
4	3" STANDARD SLUDGE PUMPING SYSTEM,ELECTRIC DRIVE,& SHUTDOWN PKGS.	1	EA	60	$10,392	$1,058	-	$11,450
5	GLOVEBAGS FOR ROBOT ENTRY.	3	EA	12	$300	$212	-	$512
6	DIAMOND SAW w/ DIAMOND CHAIN, BOUGHT OUT.	6	EA	3,528	$46,020	$62,234	-	$108,254
7	PLASTIC, 10 MIL SHEETING TO CATCH DEBRIS.	2,000	SFT	-	$100	-	-	$100
8	STAGING AREA FOR FILLING AND LOADING BOXES,	2,500	SFT	80	$2,807	$1,411	-	$4,218
9	(REINFORCED CONCRETE PAD).	-	-	-	-	-	-	-
10	CONCRETE SCABBLING MACHINES(INCL ONE OPERATOR)	3	EA	2,880	$346,500	$50,803	-	$397,303
11	TENSION ARCH STRUCTUREw/ DOORWAY FOR EQUIPMENT PASSAGE	1	EA	640	$41,072	$11,290	-	$52,362
-	AND DOORWAY FOR PERSONNEL,FOR THREE MONTHS.(LEASED).	-	-	-	-	-	-	-
12	BACKFILL OF THE EXCAVATED AREA.(MATERIAL ONLY-CLEAN SOIL).	14,727	CYDS	692	58,172	$12,207	-	$70,379
13	SCRAPE 6" DEPTH OF CONTAMINATED SURFACE SOIL.	3,787	CYDS	193	-	$3,405	-	$3,405
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,245	$807,093	$145,442	-	$952,535
	SUBCONTRACT COSTS							
1	MISCELLANEOUS SUBCONTRACT ITEMS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	30,509	$807,093	$145,442	$1,337,229	$2,289,764

ALTERNATIVE 3C.1

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 2
O&M DURING REMEDIATION (YRS): 0
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3C.1: SILO DEMOLITION, REMOVAL, OFF-SITE DISPOSAL AT NTS

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-17C	DEMOLITION & REMOVAL	$3,980,300	$5,977,100	$9,957,400
–	TRANSPORTATION	$11,000,200		$11,000,200
–	DISPOSAL	$11,229,000		$11,229,000
–	PACKAGING (26,215 PKGS. @ $955/PKG.)	$6,920,800	$18,114,600	$25,035,400
TOTAL CAPITAL		$33,130,300	$24,091,700	$57,222,000
RISK BUDGET (11.0%)		$3,644,300	$2,650,100	$6,294,400
SUBTOTAL		$36,774,600	$26,741,800	$63,516,400
CONTINGENCY (20.0%)		$7,354,900	$5,348,400	$12,703,300
TOTAL ESTIMATED INSTALLED COST		$44,129,500	$32,090,200	$76,219,700
TOTAL PRESENT WORTH COST (CAPITAL @ 7%)				$68,902,600

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File: SUM3C1.WK3

5039

EST FILE #: 3096-17C 5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

CLIENT: US DOE
PROJECT TITLE: SUBUNIT C: DEMOLITION & REMOVAL

DATE 01-Sep-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	DEMOLITION OF SILO COSTS	8,245		$145,442		$807,093	$952,500
	MACHINERY & EQUIPMENT COSTS	1,332		$23,497		$46,530	$70,000
	SUBCONTRACTOR COSTS	28,589			$1,740,214		$1,740,200
	D & D COSTS	33,000		$1,217,640			$1,217,640
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	71,166	19.48	$1,386,600	$1,740,200	$853,600	$3,980,340
SUPERVISION & SUPPRT LABOR	28.0%			$388,000			$388,000
SMALL TOOLS	$1.50					$106,700	$106,700
CONSUMABLES	$1.50					$106,700	$106,700
EQUIPMENT RENTAL	$3.00					$213,500	$213,500
TEMP. FACILITIES	4.0%			$19,400		$36,100	$55,500
TEMP. UTILITIES	1.0%			$4,900		$9,000	$13,900
JOB CLEAN-UP	6.0%			$29,100		$54,100	$83,200
SAFETY	7.0%			$34,000		$63,100	$97,100
HEALTH PHYSICS	20.0% $1,862,000			$372,400			$372,400
CERCLA $1,500	PER PERSON 2,000					$53,400	$53,400
BOND	1.0% $3,980,340					$39,800	$39,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$112,000	$112,000
OVERHEAD & PROFIT	9.0% $5,622,540					$506,000	$506,000
EMISSION MODELING	0.50% $3,980,340			$7,000		$12,900	$19,900
PSAR/FSAR(SAFE RPT)	0.50% $3,980,340			$7,000		$12,900	$19,900
PAYRL BRD.&BENFT.	52.0% $2,248,400			$1,169,200			$1,169,200
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,417,600		$2,179,800	$7,337,500
CONSTR. MGMT.	4.0% $7,337,500						$293,500
SUB-TOTAL 3							$7,631,000
SOIL/WATER/AIR	1.0% $3,980,340			$13,900		$25,900	$39,800
HOME OFFICE EXP.	1.0% $7,631,000						$76,300
PROJ.MGMT.FERMCO	8.0% $7,631,000						$610,500
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$1,467,500
SUB-TOTAL 4	OFFICE COSTS						$9,825,100
SALES TAX	6.0% $2,205,700						$132,300
SUB-TOTAL 5							$9,957,400
RISK BUDGET	11.0%						$1,095,300
SUB-TOTAL 6							$11,052,700
CONTINGENCY	20.0%						$2,210,500
TOTAL ESTIMATED INSTALLED COST							$13,263,200

EST.FILE #:3096-17C.

DEMOLITION,REMOVAL

FY 93-1 DOLLARS

09/01/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	DEMOLITION OF SILO:	-	-	-	-	-	-	-
		-	-	-	-	-	-	-
1	ROBOTIC SCARIFICATION ROBOT, w/ REMOTE CONTROL OPERATIONS.	1	EA	80	$300,000	$1,411	-	$301,411
2	LIGHTING FOR SILO INTERIOR	2	PLCS	64	$530	$1,129	-	$1,659
3	VIDEO EQUIPMENT FOR SILO INTERIOR.	1	EA	16	$1,200	$282	-	$1,482
4	3" STANDARD SLUDGE PUMPING SYSTEM,ELECTRIC DRIVE,& SHUTDOWN PKGS.	1	EA	60	$10,392	$1,058	-	$11,450
5	GLOVEBAGS FOR ROBOT ENTRY.	3	EA	12	$300	$212	-	$512
6	DIAMOND SAW w/ DIAMOND CHAIN, BOUGHT OUT.	6	EA	3,528	$46,020	$62,234	-	$108,254
7	PLASTIC, 10 MIL SHEETING TO CATCH DEBRIS.	2,000	SFT	-	$100	-	-	$100
8	STAGING AREA FOR FILLING AND LOADING BOXES,	2,500	SFT	80	$2,807	$1,411	-	$4,218
9	(REINFORCED CONCRETE PAD).	-	-	-	-	-	-	-
10	CONCRETE SCABBLING MACHINES(INCL ONE OPERATOR)	3	EA	2,880	$346,500	$50,803	-	$397,303
11	TENSION ARCH STRUCTUREw/ DOORWAY FOR EQUIPMENT PASSAGE	1	EA	640	$41,072	$11,290	-	$52,362
-	AND DOORWAY FOR PERSONNEL,FOR THREE MONTHS.(LEASED).	-	-	-	-	-	-	-
12	BACKFILL OF THE EXCAVATED AREA.(MATERIAL ONLY-CLEAN SOIL).	14,727	CYDS	692	58,172	$12,207	-	$70,379
13	SCRAPE 6" DEPTH OF CONTAMINATED SURFACE SOIL.	3,787	CYDS	193	-	$3,405	-	$3,405
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,245	$807,093	$145,442	-	$952,535
	SUBCONTRACT COSTS							
1	MISCELLANEOUS SUBCONTRACT ITEMS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	30,509	$807,093	$145,442	$1,337,229	$2,289,764

ALTERNATIVE 3C.2

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 2
O&M DURING REMEDIATION (YRS): 0
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3C.2: SILO DEMOLITION, REMOVAL, OFF-SITE DISPOSAL AT PERMITTED COMMERCIAL DISPOSAL FACILITY

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-17C	DEMOLITION & REMOVAL	$3,980,300	$5,977,100	$9,957,400
–	TRANSPORTATION	$8,039,200		$8,039,200
–	DISPOSAL	$18,527,900		$18,527,900
TOTAL CAPITAL		$30,547,400	$5,977,100	$36,524,500
RISK BUDGET (11.0%)		$3,360,200	$657,500	$4,017,700
SUBTOTAL		$33,907,600	$6,634,600	$40,542,200
CONTINGENCY (20.0%)		$6,781,500	$1,326,900	$8,108,400
TOTAL ESTIMATED INSTALLED COST		$40,689,100	$7,961,500	$48,650,600
TOTAL PRESENT WORTH COST (CAPITAL @ 7%)				$43,980,100

File: SUM3C2.WK3

EST FILE #: 3096-17 C[redacted]-5039
CLIENT: US DOE
PROJECT TITLE: SUBUNIT C: DEMOLITION & REMOVAL

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

DATE 01-Sep-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	DEMOLITION OF SILO COSTS	8,245		$145,442		$807,093	$952,50[illegible]
	MACHINERY & EQUIPMENT COSTS	1,332		$23,497		$46,530	$70,000
	SUBCONTRACTOR COSTS	28,589			$1,740,214		$1,740,200
	D & D COSTS	33,000		$1,217,640			$1,217,640
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	71,166	19.48	$1,386,600	$1,740,200	$853,600	$3,980,340
SUPERVISION & SUPPRT LABOR	28.0%			$388,000			$388,000
SMALL TOOLS	$1.50					$106,700	$106,700
CONSUMABLES	$1.50					$106,700	$106,700
EQUIPMENT RENTAL	$3.00					$213,500	$213,500
TEMP. FACILITIES	4.0%			$19,400		$36,100	$55,500
TEMP. UTILITIES	1.0%			$4,900		$9,000	$13,900
JOB CLEAN-UP	6.0%			$29,100		$54,100	$83,200
SAFETY	7.0%			$34,000		$63,100	$97,100
HEALTH PHYSICS	20.0% $1,862,000			$372,400			$372,40[illegible]
CERCLA $1,500	PER PERSON 2,000					$53,400	$53,400
BOND	1.0% $3,980,340					$39,800	$39,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$112,000	$112,000
OVERHEAD & PROFIT	9.0% $5,622,540					$506,000	$506,000
EMISSION MODELING	0.50% $3,980,340			$7,000		$12,900	$19,900
PSAR/FSAR(SAFE RPT)	0.50% $3,980,340			$7,000		$12,900	$19,900
PAYRL BRD.&BENFT.	52.0% $2,248,400			$1,169,200			$1,169,200
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,417,600		$2,179,800	$7,337,500
CONSTR. MGMT.	4.0% $7,337,500						$293,500
SUB-TOTAL 3							$7,631,000
SOIL/WATER/AIR	1.0% $3,980,340			$13,900		$25,900	$39,800
HOME OFFICE EXP.	1.0% $7,631,000						$76,300
PROJ.MGMT.FERMCO	8.0% $7,631,000						$610,500
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$1,467,500
SUB-TOTAL 4	OFFICE COSTS						$9,825,100
SALES TAX	6.0% $2,205,700						$132,300
SUB-TOTAL 5							$9,957,400
RISK BUDGET	11.0%						$1,095,300
SUB-TOTAL 6							$11,052,700
CONTINGENCY	20.0%						$2,210,500
TOTAL ESTIMATED INSTALLED COST							$13,263,200

EST.FILE #:3096-17C.

DEMOLITION,REMOVAL

FY 93-1 DOLLARS

09/01/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	DEMOLITION OF SILO:	-	-	-	-	-	-	-
		-	-	-	-	-	-	-
1	ROBOTIC SCARIFICATION ROBOT, w/ REMOTE CONTROL OPERATIONS.	1	EA	80	$300,000	$1,411	-	$301,411
2	LIGHTING FOR SILO INTERIOR	2	PLCS	64	$530	$1,129	-	$1,659
3	VIDEO EQUIPMENT FOR SILO INTERIOR.	1	EA	16	$1,200	$282	-	$1,482
4	3" STANDARD SLUDGE PUMPING SYSTEM,ELECTRIC DRIVE,& SHUTDOWN PKGS.	1	EA	60	$10,392	$1,058	-	$11,450
5	GLOVEBAGS FOR ROBOT ENTRY.	3	EA	12	$300	$212	-	$512
6	DIAMOND SAW w/ DIAMOND CHAIN, BOUGHT OUT.	6	EA	3,528	$46,020	$62,234	-	$108,254
7	PLASTIC, 10 MIL SHEETING TO CATCH DEBRIS.	2,000	SFT	-	$100	-	-	$100
8	STAGING AREA FOR FILLING AND LOADING BOXES,	2,500	SFT	80	$2,807	$1,411	-	$4,218
9	(REINFORCED CONCRETE PAD).	-	-	-	-	-	-	-
10	CONCRETE SCABBLING MACHINES(INCL ONE OPERATOR)	3	EA	2,880	$346,500	$50,803	-	$397,303
11	TENSION ARCH STRUCTUREw/ DOORWAY FOR EQUIPMENT PASSAGE	1	EA	640	$41,072	$11,290	-	$52,362
-	AND DOORWAY FOR PERSONNEL,FOR THREE MONTHS.(LEASED).	-	-	-	-	-	-	-
12	BACKFILL OF THE EXCAVATED AREA.(MATERIAL ONLY-CLEAN SOIL).	14,727	CYDS	692	58,172	$12,207	-	$70,379
13	SCRAPE 6" DEPTH OF CONTAMINATED SURFACE SOIL.	3,787	CYDS	193	-	$3,405	-	$3,405
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,245	$807,093	$145,442	-	$952,535
	SUBCONTRACT COSTS							
1	MISCELLANEOUS SUBCONTRACT ITEMS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL DIRECT.FIELD COSTS.	1	LS	30,509	$807,093	$145,442	$1,337,229	$2,289,764

804

5038

ALTERNATIVE 3C.3

DATE: 03-Dec-93

ALTERNATIVE COST SUMMARY SHEET

FERMCO CRU 4
FERNALD
PROJECT: RI/FS

CONSTRUCTION (YRS): 2
O&M DURING REMEDIATION (YRS): 0
POST-REMEDIATION O&M (YRS): 0

ALTERNATIVE 3C.3: SILO DEMOLITION, REMOVAL, OFF-SITE DISPOSAL AT FACILITY 300 MILES FROM FEMP

ESTIMATE COMPONENT	DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS				
3096-17C	DEMOLITION & REMOVAL	$3,980,300	$5,977,100	$9,957,400
–	TRANSPORTATION	$1,068,600		$1,068,600
–	DISPOSAL	$6,410,200	$10,914,800	$17,325,000
TOTAL CAPITAL		$11,459,100	$16,891,900	$28,351,000
RISK BUDGET (11.0%)		$1,260,500	$1,858,100	$3,118,600
SUBTOTAL		$12,719,600	$18,750,000	$31,469,600
CONTINGENCY (20.0%)		$2,543,900	$3,750,000	$6,293,900
TOTAL ESTIMATED INSTALLED COST		$15,263,500	$22,500,000	$37,763,500
TOTAL PRESENT WORTH COST (CAPITAL @ 7%)				$34,138,200

File: SUM3C3.WK3

5039

FERMCO
ESTIMATING SERVICES
SUMMARY SHEET

EST FILE #: 3096-1[illegible]C
CLIENT: US DO[illegible]
PROJECT TITLE: SUBUNIT C: DEMOLITION & REMOVAL

DATE 01-Sep-93
ESTIMATOR COSSMAN / WALTERS
LOCATION FERNALD

5039

CODE	ITEM DESCRIPTION	M/H	RATE	LABOR $	S/C $	MAT'L $	TOTAL $
	DEMOLITION OF SILO COSTS	8,245		$145,442		$807,093	$952,500
	MACHINERY & EQUIPMENT COSTS	1,332		$23,497		$46,530	$70,000
	SUBCONTRACTOR COSTS	28,589			$1,740,214		$1,740,200
	D & D COSTS	33,000		$1,217,640			$1,217,640
			AVG.				
SUB-TOTAL 1	DIRECT FIELD COSTS	71,166	19.48	$1,386,600	$1,740,200	$853,600	$3,980,340
SUPERVISION & SUPPRT LABOR	28.0%			$388,000			$388,000
SMALL TOOLS	$1.50					$106,700	$106,700
CONSUMABLES	$1.50					$106,700	$106,700
EQUIPMENT RENTAL	$3.00					$213,500	$213,500
TEMP. FACILITIES	4.0%			$19,400		$36,100	$55,500
TEMP. UTILITIES	1.0%			$4,900		$9,000	$13,900
JOB CLEAN-UP	6.0%			$29,100		$54,100	$83,200
SAFETY	7.0%			$34,000		$63,100	$97,100
HEALTH PHYSICS	20.0% $1,862,000			$372,400			$372,400
CERCLA $1,500	PER PERSON 2,000					$53,400	$53,400
BOND	1.0% $3,980,340					$39,800	$39,800
GEN CONTR MARKUP	5.0% LBR 5.0% MAT					$112,000	$112,000
OVERHEAD & PROFIT	9.0% $5,622,540					$506,000	$506,000
EMISSION MODELING	0.50% $3,980,340			$7,000		$12,900	$19,900
PSAR/FSAR(SAFE RPT)	0.50% $3,980,340			$7,000		$12,900	$19,900
PAYRL BRD.&BENFT.	52.0% $2,248,400			$1,169,200			$1,169,200
SUBTOTAL 2	DIRECT AND INDIRECT FIELD COSTS			$3,417,600		$2,179,800	$7,337,500
CONSTR. MGMT.	4.0% $7,337,500						$293,500
SUB-TOTAL 3							$7,631,000
SOIL/WATER/AIR	1.0% $3,980,340			$13,900		$25,900	$39,800
HOME OFFICE EXP.	1.0% $7,631,000						$76,300
PROJ.MGMT.FERMCO	8.0% $7,631,000						$610,500
ENGINEERING	20.0% Title I 7.0% Title II	10.0%	Title III		3.0%		$1,467,500
SUB-TOTAL 4	OFFICE COSTS						$9,825,100
SALES TAX	6.0% $2,205,700						$132,300
SUB-TOTAL 5							$9,957,400
RISK BUDGET	11.0%						$1,095,300
SUB-TOTAL 6							$11,052,700
CONTINGENCY	20.0%						$2,210,500
TOTAL ESTIMATED INSTALLED COST							$13,263,200

EST.FILE #:3096-17C.

DEMOLITION,REMOVAL

FY 93-1 DOLLARS

09/01/93

ESTIMATOR: F.H.GASLIGHTWALA

PROJ.ENGR: KEN STIER.

PROJ. MGR: SUSAN RHYNE.

ITEM NO	DESCRIPTION	Qty.	Unit	TOTAL MAN-HRS	$ MATERIAL	$ LABOR	SUBCONTRACTOR COSTS	TOTAL COST
	DEMOLITION OF SILO:	-	-	-	-	-	-	-
		-	-	-	-	-	-	-
1	ROBOTIC SCARIFICATION ROBOT, w/ REMOTE CONTROL OPERATIONS.	1	EA	80	$300,000	$1,411	-	$301,411
2	LIGHTING FOR SILO INTERIOR	2	PLCS	64	$530	$1,129	-	$1,659
3	VIDEO EQUIPMENT FOR SILO INTERIOR.	1	EA	16	$1,200	$282	-	$1,482
4	3" STANDARD SLUDGE PUMPING SYSTEM,ELECTRIC DRIVE,& SHUTDOWN PKGS.	1	EA	60	$10,392	$1,058	-	$11,450
5	GLOVEBAGS FOR ROBOT ENTRY.	3	EA	12	$300	$212	-	$512
6	DIAMOND SAW w/ DIAMOND CHAIN, BOUGHT OUT.	6	EA	3,528	$46,020	$62,234	-	$108,254
7	PLASTIC, 10 MIL SHEETING TO CATCH DEBRIS.	2,000	SFT	-	$100	-	-	$100
8	STAGING AREA FOR FILLING AND LOADING BOXES,	2,500	SFT	80	$2,807	$1,411	-	$4,218
9	(REINFORCED CONCRETE PAD).	-	-	-	-	-	-	-
10	CONCRETE SCABBLING MACHINES(INCL ONE OPERATOR)	3	EA	2,880	$346,500	$50,803	-	$397,303
11	TENSION ARCH STRUCTUREw/ DOORWAY FOR EQUIPMENT PASSAGE	1	EA	640	$41,072	$11,290	-	$52,362
-	AND DOORWAY FOR PERSONNEL,FOR THREE MONTHS.(LEASED).	-	-	-	-	-	-	-
12	BACKFILL OF THE EXCAVATED AREA.(MATERIAL ONLY-CLEAN SOIL).	14,727	CYDS	692	58,172	$12,207	-	$70,379
13	SCRAPE 6" DEPTH OF CONTAMINATED SURFACE SOIL.	3,787	CYDS	193	-	$3,405	-	$3,405
	SUBTOTAL CONTRACTOR DIRECT FIELD COSTS.	1	LS	8,245	$807,093	$145,442	-	$952,535
	SUBCONTRACT COSTS							
1	MISCELLANEOUS SUBCONTRACT ITEMS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL SUBCONTRACT COSTS.	1	LS	22,264	-	-	$1,337,229	$1,337,229
	SUBTOTAL DIRECT FIELD COSTS.	1	LS	30,509	$807,093	$145,442	$1,337,229	$2,289,764

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