FEMP-OU4-ESD-0 DRAFT FINAL
November 6, 1997

DRAFT FINAL

EXPLANATION OF SIGNIFICANT DIFFERENCES for OPERABLE UNIT 4 SILO 3 REMEDIAL ACTION at the FERNALD ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

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1. INTRODUCTION

1.1 Background

The Fernald Environmental Management Project (FEMP) is a former uranium processing facility located northwest of Cincinnati, Ohio and owned by the United States Department of Energy (DOE). In November 1989, the FEMP site (referred to at that time as the Feed Materials Production Center) was included on the National Priorities List (NPL) of the U.S. Environmental Protection Agency (U. S. EPA). DOE is the lead agency for remediation of the FEMP pursuant to the 'Consent Agreement as Amended Under CERCLA Sections 120 and 106(a)' (ACA), which was signed by DOE and U. S. EPA in September 1991 (Reference 1).

Operable Unit (OU) 4 is one of five operable units identified in the ACA and consists primarily of four concrete storage silos, three of which contain wastes placed there primarily in the 1950s. A Record of Decision (ROD) for OU4 was signed on December 7, 1994 (Reference 2), identifying on-site vitrification and off-site disposal at the DOE Nevada Test Site (NTS) as the selected remedy for remediation of the silo wastes.

1.2 Circumstances Giving Rise to Preparation of an Explanation of Significant Differences (ESD) for Remediation of Silo 3 Waste

As part of the OU4 remedial design process, a Vitrification Pilot Plant (VITPP) treatability study program was initiated to collect quantitative performance data to support full-scale application of the vitrification technology to the silo wastes. The high sulfate content of the surrogate Silo 3 waste resulted in significant technical and operational difficulties during Phase I operation of the VITPP (Reference 3). Through vitrification of surrogate materials simulating Silo 1, 2, and 3 wastes, it was observed that, although blending surrogate Silo 3 waste with surrogate Silo 1 and 2 waste did reduce the overall sulfate concentration of the feedstream, high melter operating temperatures (>1,150°C) and the use of reductants were still necessary to attempt control of sulfate layering and foaming events within the melt pool. The high operating temperatures resulted in accelerated component wear and, coupled with the addition of reductants, created a melt pool

environment conducive to the formation of molten lead. Thus, although addition of reductants did help to control sulfate foaming, their use exacerbated operational problems associated with the high lead content of the surrogate Silo 1 and 2 waste. The relatively high and varying lead content in the Silos 1 and 2 waste, without proper controls, could precipitate in the melter and compromise the integrity of the melter's materials of construction. The competing glass chemistry, specifically high lead content of Silos 1 and 2 waste and high sulfate concentration in Silo 3 waste, creates a high degree of uncertainty in the ability to reliably produce a vitrified waste on a full-scale continuous basis. These difficulties culminated on December 26, 1996 with failure of melter hardware caused by incompatible materials of construction and glass composition, in combination with high operating temperatures. Phase I operations were suspended following this incident.

Attempts to resolve technical and operational issues during Phase I operation resulted in documented schedule and cost increases. During early stages of Phase I operation, the DOE identified the need to reassess the technical path forward for remediation of OU4 in order to identify opportunities to address the technical and operational issues experienced with vitrification. In November 1996, the DOE convened the Silos Project Independent Review Team (IRT) as a technical resource to assist the DOE in reevaluating the path forward for remediation of the silo waste. The IRT was comprised of technical representatives from throughout the DOE complex and private industry with expertise in various aspects of waste treatment, vitrification, and other treatment technologies. The recommendations of the IRT (Reference 4), the evaluation of the December 26, 1996 melter hardware failure (Reference 5), and other evaluations on the part of the DOE and FEMP stakeholders (see Section 7), supported a decision that although a vitrification process could potentially be developed to effectively vitrify Silo 3 waste, the cost and the significant extension in cleanup time would not be practical. In addition, the evaluations concluded that separating the wastes would significantly reduce the technical uncertainties and programmatic risks of developing an effective treatment process for Silos 1 and 2 waste. The DOE made the decision that treatment of Silo 3 waste should be implemented separately from treatment of the Silo 1 and 2 waste, and further that an alternate remedy

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should be considered for treatment and disposal of Silo 3 waste. Consistent with the July 22, 1997 dispute settlement discussed in Section 2.3, this ESD has been prepared to document the change in remedy for treatment and disposal of Silo 3 waste.

1.3 Regulatory Basis

Pursuant to Section 117 of the Comprehensive Environmental Response, Compensation, and Liability Act as amended (CERCLA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) at Title 40 Code of Federal Regulations (CFR) §300.435(c)(2)(i), an ESD document should be published when "differences in the remedial or enforcement action, settlement, or consent decree significantly change but do not fundamentally alter the remedy selected in the ROD with respect to scope, performance, or cost." The U.S. EPA's position (Reference 8) is that implementation of an alternate remedy for treatment and disposal of Silo 3 waste is not a fundamental change as long as the alternate treatment process is a stabilization/solidification process that continues to meet all remedial objectives and performance standards of the approved OU4 ROD (see Section 2.2) for a cost roughly equivalent to the original remedy, and the remedy includes disposal at a protective, appropriately permitted offsite disposal facility. As long as the alternate remedy for treatment of Silo 3 waste satisfies these conditions, an ESD is a sufficient means of documenting the change.

1.4 Public Availability of ESD

This ESD will become part of the Administrative Record pursuant to 40 CFR §300.825(a)(2) and will be available at the Public Environmental Information Center (PEIC), 10995 Hamilton-Cleves Highway, Harrison, Ohio, phone (513) 648-7480. A draft ESD was submitted to Ohio EPA and U.S. EPA for review (Reference 21) and was approved by both agencies after incorporation of their comments (References 23 through 25). All comments received during public review of this draft Final ESD will be formally addressed in a responsiveness summary which will be incorporated into the Final ESD. A list of the documents which form the basis for this ESD is provided in Section 7. These documents are available at the PEIC.

2. SUMMARY OF SITE HISTORY, CONTAMINATION, AND SELECTED REMEDY

2.1 Site History

The FEMP site is a 425 hectare (1,050 acre) facility north of Fernald, Ohio, a small farming community 18 miles northwest of Cincinnati, Ohio, that lies on the boundary between Hamilton and Butler Counties. Between 1951 and 1989, the primary mission of the FEMP was to process uranium ore concentrates and residues into metallic uranium materials for use at other DOE facilities in the nation's defense program. Production operations at the facility were limited to a fenced 55 hectare (136 acre) tract of land, now known as the former Production Area, located near the center of the site.

OU4 is situated in the southwestern portion of the Waste Storage Area, west of the former Production Area, and consists of two earthen-bermed, concrete silos containing K-65 wastes (described below), a decant sump tank, one silo containing Silo 3 waste, one unused silo, and various quantities of contaminated soils, perched water, and debris.

The OU4 silos were constructed in the early 1950's for storage of waste materials. The wastes in Silos 1, 2, and 3 are classified as byproduct materials, as defined in Section 11(e)(2) of the Atomic Energy Act (AEA) of 1954. Silos 1 and 2 contain residues, known as K-65 waste, which were generated from the processing of high-grade uranium ores. K-65 waste is a silty, clay-like material containing significant activity concentrations of radionuclides including Radium-226, Thorium-230, Lead-210, and Polonium-210. The waste also contains levels of lead above the RCRA TCLP limits. Due to the radium content of the K-65 waste, Silos 1 and 2 represent a significant source of Radon-222 emanations. As required by the 1991 Federal Facility Agreement for Control and Abatement of Radon-222 Emissions, and the Amended Consent Agreement, a Removal Action was implemented to place a bentonite clay layer over the wastes inside Silos 1 and 2 to reduce chronic radon emanation from both silos.

Silo 3 contains waste, known as cold metal oxides, that was generated at the FEMP site during uranium extraction operations in the 1950s. These oxides were formed by calcining

residues from the solvent extraction process used to extract uranium from ore concentrates and residues. The waste in Silo 3 is substantially different from that in Silos 1 and 2. The K-65 waste is silty and clay-like, whereas Silo 3 waste is dry and powdery. Second, while the radiological constituents in Silo 3 waste are similar to those found in the Silo 1 and 2 waste, certain radionuclides, such as radium, are present in much lower concentrations in the Silo 3 waste. On an activity basis, the predominant radiological constituent of the Silo 3 waste is Thorium-230. Due to the lower radium content, Silo 3 exhibits a much lower direct radiation field and has substantially lower Radon-222 emanations than Silos 1 and 2. Therefore, where the original remedy identifies radon attenuation and destruction of organics as factors in selecting vitrification, those are factors almost exclusively associated with the Silos 1 and 2 waste and not with the Silo 3 waste. Data from the OU4 Remedial Investigation (RI) report indicates that Silo 3 waste contains the metals arsenic, cadmium, chromium, and selenium at levels above RCRA TCLP limits.

2.2 Description of Current Selected Remedy

In accordance with the ACA, the DOE performed a Remedial Investigation/Feasibility Study (RI/FS) for OU4 which was approved by the U.S. EPA in August 1994. The OU4 FS (Reference 9) evaluated a number of alternatives for stabilization/solidification of the K-65 and Silo 3 waste. The initial phase of this evaluation involved the development of Remedial Action Objectives (RAOs) for each portion of the remedial action. The RAOs identified in the FS for the Silo 3 waste are:

- Prevent direct contact with or ingestion of waste material;
- Prevent release or migration of waste materials to soil, groundwater, surface water or sediment; and
- Prevent exposures to waste material that may cause an individual to exceed applicable dose limits.

In addition, the OU4 ROD specifies that the Silo 1, 2, and 3 wastes will be treated to "significantly reduce the leachability of metal contaminants of concern to levels that are below RCRA regulatory thresholds."

The initial evaluation of potential alternatives for stabilization/solidification of Silo 3 waste

considered several stabilization/solidification-type technologies including vitrification, chemical treatment, and also removal and disposal with no additional treatment. Two treatment options, vitrification and cement stabilization, each with either on-site or off-site disposal, were carried forward along with removal and onsite disposal with no further treatment for detailed analysis. The evaluation summarized in the ROD indicated that vitrification provided greater radon attenuation than cement stabilization. The primary factors influencing the selection of vitrification over cement stabilization for treatment of Silo 3 waste were its anticipated reduction in waste volume and resulting lower estimated implementation cost.

The draft Final ROD for Remedial Actions at OU4 was submitted to the U.S. EPA in November 1994. The U.S. EPA approved and signed the ROD for Remedial Actions at OU4 on December 7, 1994. The selected remedy consisted of the following components:

- Removal of contents from the Silos 1, 2, and 3 structures, on-site vitrification of the silo wastes, and transportation and disposal at the DOE's Nevada Test Site (NTS);
- Decontamination and demolition of all silo structures and the vitrification facility in accordance with the approved OU3 ROD;
- Excavation and treatment of contaminated soils, and treatment of perched water encountered during remedial action, in accordance with the approved OU5 ROD.

This ESD addresses only a change in the treatment portion of the selected remedy for Silo 3 waste. No change to any other portion of the selected remedy for OU4 is addressed in this document.

2.3 Current Status

Consistent with the strategy outlined in the OU4 Remedial Design Work Plan approved by the U. S. EPA on June 15, 1995 (Reference 10), the DOE initiated several advanced pilot-scale treatability studies both on-site and in partnership with the academic community.

The VITPP Phases I and II Treatability Study Programs were integrated directly into the OU4 Remedial Design/Remedial Action (RD/RA) program in order to collect quantitative performance data to support application of the vitrification technology to remediation of the silo wastes. Phase I VITPP testing activities began June 19, 1996 with initiation of the first of four campaigns. On December 26, 1996, VITPP operations were suspended during the final campaign of Phase I due to failure of melter hardware.

In response to the previously discussed schedule delays and need to reassess the technical path forward for remediation of OU4, the DOE requested an extension of certain RD/RA milestones (Reference 11). The U.S. EPA denied the request for extension and agreed to a period of informal dispute resolution to allow the DOE, in consultation with the U. S. EPA, OEPA, and stakeholders, to reassess the path forward (Reference 12). During this period of informal dispute resolution, the DOE, with input from the IRT, U. S. EPA Ohio EPA, and the public, evaluated the results of the VITPP program, the results of the melter incident, and the technical and schedule impacts of alternatives for OU4 remediation.

These evaluations culminated in a decision not to restart the VITPP for additional Phase I or Phase II testing. These same evaluations supported DOEs decision, originally proposed in August 1996, to recommend that remediation of Silo 3 waste be implemented separately from Silo 1 and 2 waste and that an alternate remedy should be considered for treatment and disposal of Silo 3 waste.

The July 22, 1997 "Agreement Resolving Dispute Concerning Denial of Request for Extension of Time for Certain Operable Unit 4 Milestones," (Reference13) specified that the change in remedy for Silo 3 waste should be documented in an ESD, and further that the Feasibility Study, Proposed Plan, and ROD for Silos 1 and 2 Remedial Action should be revised and resubmitted.

As discussed in Section 6, a significant level of public involvement was maintained throughout reevaluation of the OU4 path forward, meetings of the Silos Project IRT, and the dispute resolution process.

3. DESCRIPTION OF THE SIGNIFICANT DIFFERENCES AND THE BASIS FOR THOSE DIFFERENCES

3.1 Separation of Silo 3 Waste Treatment From Treatment of Silo 1 and 2 Waste

Phase I operation of the Vitrification Pilot Plant evaluated the vitrification technology by testing a variety of silo surrogate waste stream formulations. Silo 3 waste contains relatively high concentrations of sulfates (approximately 15 wt%). It was observed that although a "blend" of the Silo 1, 2, and 3 surrogate waste streams reduced the overall sulfate concentrations of the feedstream, higher melter operating temperatures (>1,150°C) and the use of reductants were still necessary to control sulfate layering and foaming events within the melt pool. Although addition of reductants did help to control sulfate foaming, their use exacerbated operational problems associated with the high lead content of the surrogate Silo 1 and 2 waste. As was discussed in Section 1.2, the competing glass chemistry creates a high degree of uncertainty in the ability to reliably produce a vitrified waste from Silo 3 waste on a full-scale continuous basis. These phenomena were documented as significant causal factors in the February 1997 "Vitrification Pilot Plant Melter Incident Final Report." Tests conducted on a "Silo 3 only" surrogate waste stream at the Catholic University of America - Vitreous State Laboratory (VSL), in support of the VITPP program, observed the same inherent difficulties associated with vitrification of a waste, such as Silo 3 waste, with a high sulfate content.

It is theoretically possible that process flow sheets and melter designs could be developed to successfully vitrify Silo 3 waste alone or in combination with Silo 1 and 2 waste. However, as demonstrated during the VITPP program, materials containing high sulfate concentrations are extremely difficult to control during vitrification. Vitrification of these materials can result in foaming events which cause potentially serious safety and operational concerns. In addition, use of reductants to control foaming can reduce waste loading in the glass matrix to an undesirable level.

Although a vitrification process could potentially be developed to accommodate these conditions in order to effectively vitrify Silo 3 waste, the cost and the significant extension in cleanup time required to develop two independent melter designs would not be practical. Separating the wastes, however, will significantly reduce the technical uncertainties and programmatic risks of developing an effective treatment process for Silos 1 and 2 waste. For example, vitrification of Silo 1 and 2 waste separate from Silo 3 waste could be accomplished using a lower-temperature, commercially-available melter design, thus reducing the uncertainties associated with melt pool chemistry, melter life, and materials of construction. Therefore, DOE recommends that treatment of Silo 3 waste be evaluated and implemented separately from treatment of Silos 1 and 2 waste.

3.2 Decision to Identify an Alternative to Vitrification for Stabilization/Solidification of Silo 3 Waste

Based upon the results of the VITPP program, reductants alone would not be an effective means of managing the high sulfate levels present in Silo 3 waste. The use of reductants reduces waste loadings and increases the cost of treating the waste, and, even if reductants were to be used, foaming could still occur due to irregularities in the sulfate concentrations of the Silo 3 waste stream. The most certain means of managing the sulfate levels in the Silo 3 waste, in order to successfully vitrify the material, would be to dilute the Silo 3 waste to reduce the sulfate levels from the 15 to 17 weight-percent levels present in Silo 3 waste to as low as 1.5 weight-percent prior to vitrification. Dilution of the Silo 3 waste to reduce the sulfate content to these levels would result in a large increase in the volume of waste requiring vitrification and a resultant increase in treated waste volume. Associated with this increase in treated waste volume would be an increase in operation and maintenance costs, packaging, transportation, and disposal costs, and transportation risk. Thus, dilution of the Silo 3 waste effectively eliminates the advantages that resulted in the original selection of vitrification. Evaluations indicate that the cost to vitrify Silo 3 waste could be as much as several times higher than the cost to treat the waste using an alternate process.

The FEMP has demonstrated through several successful mixed waste stabilization projects that stabilization/solidification technologies other than vitrification can be effectively implemented for treatment of waste materials, such as thorium-bearing waste, that are relatively similar to the Silo 3 waste. Chemical stabilization technologies have been implemented successfully at the FEMP for treatment of waste streams including:

- Thorium Nitrate
- Grit Blast Residues
- Solidified Furnace Salts
- Sump Cakes
- Construction Rubble
- Miscellaneous Trash

A total of more than 850 yd^3 of waste has been successfully treated at the FEMP through these projects.

In addition to waste stabilized at the FEMP, chemical stabilization processes have been implemented at numerous projects of varying scales throughout the United States. A search of professional journals, electronic databases, and other sources revealed a substantial number of commercial and Superfund remediation projects that have utilized chemical stabilization processes to treat hazardous and mixed waste. A partial list of the journals that were consulted include the *Journal of Hazardous Materials Remediation, Environmental Protection,* and the *Journal of Environmental Science and Health.* The electronic databases that were accessed include the Superfund Innovative Technology Evaluation (SITE) Program, the Alternative Treatment Technology Information Center (ATTIC) and both the U.S. EPA and Ohio EPA Internet Home Pages. Information was also obtained from a variety of published literature, and Internet Home Pages for specific Agencies, Universities and Corporations.

This search revealed several successful chemical stabilization processes within the DOE, Superfund, and commercial sectors. Successful chemical stabilization processes within the DOE complex have stabilized/solidified over 70,000 yd^3 of liquids, sludges, and soils containing radioactive and mixed waste characteristics. The projects included the

Savannah River Site, M-Area, where 63,000 yd^3 of soil were stabilized in the 1988 - 1989 period. The Savannah River Saltstone Facility has also stabilized approximately 2,000 yd^3 of sodium nitrate mixed waste. The West Valley Facility stabilized approximately 5,100 yd^3 of sodium nitrate solution. Smaller scale projects have been completed on the Oak Ridge Melton Valley Storage Tanks, and at FERMI Laboratory, the Portsmouth Gaseous Diffusion Plant, and the Pantex Plant.

Of the information that could be quantified, this search revealed that over 1,000,000 yd^3 of soils, sludges, residues, and liquids have been successfully treated using cement (chemical) stabilization processes at Superfund sites and commercial facilities. Examples of these stabilization projects are listed below:

- Carolina Stadium Site, Charlotte NC - 19,000 yd^3 of soil contaminated with lead, PCBs, and semi-volatiles;
- Sacramento Army Depot - 40,000 yd^3 of contaminated soil burn pits and oxidation lagoons;
- Pennington Army Co. - 50,000 yd^3 of hazardous sludge stabilized in situ;
- Eglin Air Force Base - 900 yd^3 of contaminated sand;
- Vickery Surface Impoundment - 400,000 yd^3 of hazardous waste sludge also containing PCBs and dioxins;
- American Airlines, Oklahoma - 1,100 yd^3 of hazardous spent blast media;
- Pioneer Sand Site (Superfund) - 6,000 yd^3 of hazardous waste sludge containing metals and organics;
- Davie Landfill (Superfund) - 82,000 yd^3 of sludge containing cyanide, lead;
- Sapp Battery and Salvage (Superfund) - 200,000 yd^3 of soils containing lead and mercury; and
- Peppers Steel and Alloy (Superfund) - 89,000 yd^3 of soil containing lead, arsenic, and PCBs.

Treatability studies conducted on Silo 3 waste during the OU4 FS found alternatives such as cement (chemical) stabilization to be viable remediation alternatives. The characteristics of the Silo 3 wastes, and the level of commercial development of stabilization/solidification technologies, indicate that an alternative to vitrification will provide greater certainty of producing a treated Silo 3 waste form which satisfies all DOE and environmental regulations and requirements for disposal, in a timely and cost effective manner. Thus, the DOE recommends that the Silo 3 wastes not be vitrified either individually or in combination with the Silo 1 and 2 waste.

The DOE recommends that the method for achieving the objectives of the OU4 ROD for Silo 3 waste be changed from vitrification followed by disposal at the NTS to a revised alternative consisting of:

- Treatment at the FEMP or an appropriately-permitted offsite facility, using a process other than vitrification, to stabilize characteristic metals to levels below RCRA TCLP limits and disposal facility Waste Acceptance Criteria (WAC); and
- Offsite disposal at either the NTS or an appropriately-permitted Commercial Disposal Facility (PCDF) that complies with the CERCLA 'offsite rule' (40 CFR 300.440).

The remainder of this section will describe the process used to identify the acceptable stabilization/solidification technology, or technologies, to be used to implement the revised alternative described above for treatment and disposal of Silo 3 waste.

3.3 Screening of Potential Stabilization/Solidification Alternatives

As discussed in Section 1.3, in order to be acceptable for implementation through an ESD, the revised alternative must meet the RAOs and performance standards of the approved OU4 ROD for a cost roughly equivalent to that of the original selected remedy. Any treatment alternative not meeting these criteria would have to be evaluated through a ROD amendment. In Section 3.4, the stabilization alternatives selected for detailed evaluation will be compared against vitrification relative to the Silo 3 RAOs to demonstrate their acceptability for implementation through an ESD.

The first step in identifying the acceptable stabilization/solidification technology, or technologies, to be used to implement the revised alternative was to research literature and other information sources to identify potentially applicable technologies (References 14 through 19).

Several categories of potential treatment technologies were judged not applicable to

treatment of the Silo 3 waste and were eliminated from the screening process. Silo 3 waste is the result of oxidation of the residue from a solvent extraction process by calcination. Subjecting the material to further oxidation or solvent extraction would provide no further reduction in mobility of toxic constituents, and would fail to accomplish the remedial action objectives identified in Section 2.2. Solvent extraction and thermal desorption technologies were judged not to warrant further evaluation.

Retrieval and off-site disposal without treatment was also eliminated from the screening process. The requirements of RCRA, which are identified as Applicable or Relevant and Appropriate Requirements (ARARs) in the approved OU4 ROD, require that the waste be treated to remove the toxicity characteristic before being disposed. These regulations also preclude blending as a substitute for treatment. The option of retrieval and off-site disposal with no further treatment, therefore, fails to comply with all ARARs and does not warrant further evaluation.

The following alternatives were identified for consideration in the screening process:

- Asphalt (Bitumen) Stabilization
- Chemical Stabilization/Solidification
- Polymer (Micro) Encapsulation
- Ceramics
- Ceramic Silicon Foam
- Macro Encapsulation
- Metal Matrix (Ceramet)
- Molten Metal Technology
- Thermal Setting (Epoxy) Resins
- Sulfur/Polymer Encapsulation
- Phoenix Ash Stabilization

Information regarding the potential technologies was drawn from the previously identified research sources as well as from input of technical experts in waste treatment. The eleven alternatives were then evaluated, with participation of the public, against the 3 criteria specified in U.S. EPA regulations for the RI/FS Preliminary Screening of Alternatives process (40 CFR 300.430(e)(7)). Public involvement in the screening and detailed

evaluation of stabilization/solidification alternatives is discussed in greater detail in Section 6. As illustrated below, more detailed sub-criteria were developed within each of the three National Contingency Plan (NCP) screening criteria to provide a more detailed screening.

The following screening criteria were used to screen the alternatives and identify those to be carried forward for detailed evaluation:

Effectiveness

- Reduction in Mobility of Constituents of Concern (COCs)
- Volume Increase/Decrease
- Attainment of WAC for Characteristic Metals, based upon WAC at NTS and a representative PCDF
- Long-term Effectiveness/Permanence
- Attainment of ARARs and To Be Considered (TBC) requirements

Implementability

- Commercial Availability
- Generation of Secondary Waste Streams
- Pretreatment Requirements
- Processing Throughput
- System Reliability/Maintainability

Cost

- Overall Cost
- Capital or Operation, Maintenance, and Disposal Cost- Intensive

The comparison of potential stabilization/solidification alternatives against the screening criteria is summarized in Tables 1 through 3.

As a result of the screening process, it was determined that eight of the alternatives did not warrant further consideration in the detailed analysis of alternatives. These eight alternatives, and the basis for their exclusion, are identified in Table 4.

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TABLE 1
SCREENING OF POTENTIAL STABILIZATION/SOLIDIFICATION ALTERNATIVES - EFFECTIVENESS

STABILIZATION ALTERNATIVE	MOBILITY OF CONSTITUENTS OF CONCERN	VOLUME INCREASE / DECREASE	WAC[1] FOR CHARACTERISTIC METALS [1] Based upon evaluation of WAC from NTS and a representative PCDF	LONG-TERM EFFECTIVENESS / PERMANENCE
Asphalt (Bitumen) Stabilization	Mobility reduced through physical binding	Volume increase	May not meet WAC for characteristic metals	Acceptable long-term effectiveness
Chemical Stabilization/Solidification	Demonstrated ability to reduce mobility of Silo 3 COCs	20% volume increase shown in Silo 3 treatability tests	Demonstrated ability to attain WAC with same metals present in Silo 3 waste	Acceptable long-term effectiveness
Polymer (Micro) Encapsulation	Mobility reduced through physical binding	Volume increase should be similar to cement stabilization/solidification	Pilot-scale testing on similar waste shows ability to immobilize metals	Acceptable long-term effectiveness
Ceramics	Mobility reduced through physical binding	Volume increase / decrease unknown	Requires development work to confirm ability to meet WAC for characteristic metals	Acceptable long-term effectiveness
Ceramic Silicon Foam	Mobility reduced through physical binding	Volume increase less than that from cementation	Likely would not meet WAC for characteristic metals	Acceptable long-term effectiveness
Macro Encapsulation	Mobility reduced through physical binding	Volume increase	Would not meet WAC for characteristic metals	Would fail to produce acceptable waste form for long-term disposal from Silo 3 waste

TABLE 1

SCREENING OF POTENTIAL STABILIZATION/SOLIDIFICATION ALTERNATIVES - EFFECTIVENESS

STABILIZATION ALTERNATIVE	MOBILITY OF CONSTITUENTS OF CONCERN	VOLUME INCREASE / DECREASE	WAC[1] FOR CHARACTERISTIC METALS [1] Based upon evaluation of WAC from NTS and a representative PCDF	LONG-TERM EFFECTIVENESS / PERMANENCE
Metal Matrix (Ceramet)	Mobility reduced through physical binding	Volume increase / decrease unknown	Requires development work to confirm ability to meet WAC for characteristic metals	Acceptable long-term effectiveness
Molten Metal Technology	Reduces mobility of constituents of concern	Volume increase	Requires development work to confirm ability to meet WAC for characteristic metals	Acceptable long-term effectiveness
Thermal Setting (Epoxy) Resins	Reduces mobility of constituents of concern through physical binding	Volume increase or decrease unknown	Requires development work to confirm ability to meet WAC for characteristic metals	Acceptable long-term effectiveness
Sulfur/Polymer Encapsulation	Reduces mobility of constituents of concern through physical binding	Volume increase	May require additives to chemically bind characteristic metals	Acceptable long-term effectiveness
Phoenix Ash Stabilization	Reduces mobility of constituents of concern	Potential volume decrease	Requires development work to confirm ability to meet WAC for characteristic metals	Acceptable long-term effectiveness

TABLE 2

SCREENING OF POTENTIAL STABILIZATION/SOLIDIFICATION ALTERNATIVES - IMPLEMENTABILITY

STABILIZATION ALTERNATIVE	COMMERCIAL AVAILABILITY	SECONDARY WASTE	PRETREATMENT REQUIREMENTS	PROCESSING THROUGHPUT	RELIABILITY / MAINTAINABILITY
Asphalt (Bitumen) Stabilization	Mature technology; not widely used	Volatiles in offgas require treatment;	None required	Large processing throughput achievable	Flammability issue; complex facility and equipment requirements; operator-friendly and easily maintained
Chemical Stabilization/Solidification	Mature technology; used on a commercial scale by numerous vendors	Secondary waste is limited to HEPA filters	None required	Large processing throughput achievable	Facility and equipment requirements are not complex; ambient temperature operation; easily maintained
Polymer (Micro) Encapsulation	Commercially available	Volatiles in offgas may require offgas treatment	May require drying prior to encapsulation	Large processing throughput achievable	Facility and equipment requirements are not complex
Ceramics	Not commercially available	Volatiles in offgas may require offgas treatment	Pretreatment may be required; mechanical compression or drying	Processing throughput unknown	Complex facility and equipment requirements; Unknown reliability / maintainability

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TABLE 2

SCREENING OF POTENTIAL STABILIZATION/SOLIDIFICATION ALTERNATIVES - IMPLEMENTABILITY

STABILIZATION ALTERNATIVE	COMMERCIAL AVAILABILITY	SECONDARY WASTE	PRETREATMENT REQUIREMENTS	PROCESSING THROUGHPUT	RELIABILITY / MAINTAINABILITY
Ceramic Silicon Foam	Not commercially available	Volatiles in offgas may require offgas treatment	Pretreatment required: may require drying	Processing throughput unknown	Complex facility and equipment requirements; reliability and maintainability similar to polymer encapsulation
Macro Encapsulation	Mature technology for large discrete objects (equipment, debris, etc), but not applicable to Silo 3 waste	No secondary waste	No pretreatment required	Large processing throughput achievable	Facility and equipment requirements are not complex; operator-friendly and easily maintained
Metal Matrix (Ceramet)	Developmental technology; commercial availability unknown	Produces volatile gases	Pretreatment required; proprietary process	Processing throughput limited	Complex facility and equipment requirements; high temperature operation(above metal melting point); system reliability and maintainability unknown

TABLE 2

SCREENING OF POTENTIAL STABILIZATION/SOLIDIFICATION ALTERNATIVES - IMPLEMENTABILITY

STABILIZATION ALTERNATIVE	COMMERCIAL AVAILABILITY	SECONDARY WASTE	PRETREATMENT REQUIREMENTS	PROCESSING THROUGHPUT	RELIABILITY / MAINTAINABILITY
Molten Metal Technology	Has been used for volume reduction of nuclear reactor spent resins; not commercially available	Produces SO_2, CO_x, PO_x in offgas; also produces slag waste	Pretreatment required; waste sizing requirement	Processing throughput limited	Facility and equipment requirements, and system reliability / maintainability similar to vitrification
Thermal Setting (Epoxy) Resins	Not commercially available	Volatiles in offgas may require offgas treatment	Pretreatment (drying) may be required	Processing throughput unknown	Complex facility and equipment requirements; Higher-than-ambient operating temperatures. Reliability / maintainability similar to polymer encapsulation
Sulfur/Polymer Encapsulation	Commercially available	SO_2 and H_2S in offgas may require treatment	Pretreatment required; moisture sensitive	Large processing throughput possible	Thermal process; involves handling of molten sulfur; computerized process control required; flammability issues (flash point 177°C). More complex and difficult to maintain than cement stabilization

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TABLE 2

SCREENING OF POTENTIAL STABILIZATION/SOLIDIFICATION ALTERNATIVES - IMPLEMENTABILITY

STABILIZATION ALTERNATIVE	COMMERCIAL AVAILABILITY	SECONDARY WASTE	PRETREATMENT REQUIREMENTS	PROCESSING THROUGHPUT	RELIABILITY / MAINTAINABILITY
Phoenix Ash Stabilization	Developmental technology; commercially available; one equipment vendor	Secondary waste limited to HEPA filters	Pretreatment required - mechanical compression; particle size-reduction and pretreatment for chromium and cadmium	Limited processing throughput	Facility and equipment requirements and reliability similar to cement stabilization. High pressure operation results in higher maintenance requirements

TABLE 3

SCREENING OF POTENTIAL STABILIZATION/SOLIDIFICATION ALTERNATIVES - COST

STABILIZATION ALTERNATIVE	OVERALL COST	CAPITAL OR OPERATION AND MAINTENANCE (O&M) COST INTENSIVE
Asphalt (Bitumen) Stabilization	Medium	Majority of cost associated with processing, packaging, shipping, and disposal
Chemical Stabilization/Solidification	Medium	Majority of cost associated with processing, packaging, shipping, and disposal
Polymer (Micro) Encapsulation	Medium	Majority of cost associated with processing, packaging, shipping, and disposal
Ceramics	Medium	Capital cost is predominant factor
Ceramic Silicon Foam	Medium	Majority of cost associated with processing, packaging, shipping, and disposal
Macro Encapsulation	Medium	Majority of cost associated with processing, packaging, shipping, and disposal
Metal Matrix (Ceramet)	Medium	Capital cost is predominant factor
Molten Metal Technology	High	Capital cost is predominant factor
Thermal Setting (Epoxy) Resins	Medium	Majority of cost associated with processing, packaging, shipping, and disposal
Sulfur/Polymer Encapsulation	Medium	Majority of cost associated with processing, packaging, shipping, and disposal
Phoenix Ash Stabilization	Medium	Similar to cement stabilization

TABLE 4

STABILIZATION/SOLIDIFICATION ALTERNATIVES NOT CARRIED FORWARD FOR DETAILED EVALUATION

STABILIZATION ALTERNATIVE	BASIS FOR EXCLUSION FROM DETAILED EVALUATION
Asphalt (Bitumen) Stabilization	May not meet WAC for characteristic metals; complex facility and equipment requirements; safety (flammability) concerns
Ceramics	Not commercially available; complex facility and equipment requirements
Ceramic Silicon Foam	Not commercially available; may not meet WAC for characteristic metals
Macro Encapsulation	Would fail to meet WAC for characteristic metals; would fail to produce an acceptable waste form for long-term disposal from Silo 3 waste
Metal Matrix (Ceramet)	Commercial availability unknown; complex facility and equipment requirements
Molten Metal Technology	Not commercially available; complex facility and equipment requirements (analogous to vitrification); high cost
Thermal Setting (Epoxy) Resins	Not commercially available; complex facility and equipment requirements
Phoenix Ash Stabilization	Limited commercial availability; falls within Chemical Stabilization/Solidification alternative

The following three alternatives were identified for detailed evaluation:

Chemical Stabilization/Solidification

This type of stabilization process is the most widely commercially-used method for stabilization of low-level and mixed waste. The process involves mixing the waste with a variety of inorganic chemical additive formulations such as cement, lime, pozzolans, gypsum, or silicates, to accomplish chemical and physical binding of the constituents of concern. These processes provide reduction in contaminant mobility by chemically stabilizing contaminants into a non-leachable form, as well as physically binding the chemically stabilized contaminants in a solid matrix. It is a non-thermal process with relatively simple facility and equipment requirements. Cement stabilization/solidification was evaluated in detail in the original OU4 Feasibility Study.

Polymer (micro) Encapsulation

Polymer (micro) encapsulation is a thermal process which physically binds the COCs in a thermoplastic polymer. Polyethylene is melted and mixed with the dry waste using a typical commercial extruder. The molten mixture is poured into the disposal container where solidification occurs as the mixture cools.

Sulfur/Polymer Encapsulation

Similar to polymer (micro) encapsulation, sulfur/polymer encapsulation (SPC) is a thermal process that produces a solid waste form that physically binds the COCs. SPC encapsulates the COCs in a cement, sulfur, and polymer matrix. The sulfur provides a highly corrosion-resistant cement, while the polymer ensures proper curing to prevent crystallization of the sulfur.

3.4 Detailed Evaluation of Silo 3 Stabilization/Solidification Alternatives

The OU4 FS evaluated several alternatives for stabilization/solidification of Silo 3 waste, including vitrification, and cement stabilization, which is representative of a wide range of

chemical stabilization/solidification-type technologies. The FS found that both vitrification and cement stabilization successfully met all RAOs and treatment objectives for Silo 3 waste. Table 5 provides a comparison of Chemical Stabilization/Solidification, Polymer-based Encapsulation (which includes both Sulfur/Polymer encapsulation and Polymer (micro) Encapsulation), and vitrification, relative to the RAOs and treatment objectives for Silo 3 waste.

As illustrated in Table 5, the three alternatives carried forward from the initial screening are successful in attaining the RAOs and treatment objectives specified for vitrification of Silo 3 waste. The primary basis for selecting vitrification in the OU4 ROD was lower estimated implementation cost and lower treated waste volume. The superior radon attenuation provided by vitrification was also a factor influencing selection of vitrification for treatment of Silo 1 and 2 waste. Due to the significantly lower radium content of Silo 3 waste, radon attenuation was not a predominant factor in selecting the treatment remedy for Silo 3 waste; all three alternatives can provide adequate radon attenuation. As discussed in Section 3.2, measures to control the sulfate levels present in Silo 3 waste would likely minimize the advantage in treated waste volume offered by vitrification. The rough-order of-magnitude costs estimated for the three stabilization alternatives are roughly equivalent to the cost originally estimated for vitrification. Based upon the comparison summarized in Table 5, all three alternatives carried forward from the initial screening are judged acceptable for detailed evaluation through an ESD.

TABLE 5
ATTAINMENT OF SILO 3 REMEDIAL ACTION OBJECTIVES

REMEDIAL ACTION OBJECTIVE	VITRIFICATION	CHEMICAL STABILIZATION/SOLIDIFICATION	POLYMER-BASED ENCAPSULATION
Prevent Direct Contact with / Ingestion of Waste Material	Radiological and toxic constituents are solidified in a solid matrix. The disposal configuration will be permitted, designed and located to prevent contact with the treated waste by members of the public or inadvertent intruders.	Radiological and toxic constituents are solidified in a solid matrix. The disposal configuration will be permitted, designed and located to prevent contact with the treated waste by members of the public or inadvertent intruders.	Radiological and toxic constituents are physically bound in a polymer matrix. The disposal configuration will be permitted, designed and located to prevent contact with the treated waste by members of the public or inadvertent intruders.

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TABLE 5
ATTAINMENT OF SILO 3 REMEDIAL ACTION OBJECTIVES

REMEDIAL ACTION OBJECTIVE	VITRIFICATION	CHEMICAL STABILIZATION/SOLIDIFICATION	POLYMER-BASED ENCAPSULATION
Prevent Release or Migration of Waste Material to Soil, Groundwater, or Surface Water	COCs are chemically bound in a glass matrix.	COCs are chemically stabilized into a non-leachable form.	Migration of COCs is prevented through physical binding in a polymer matrix.
	Demonstrated ability to immobilize contaminants present in Silo 3 waste through OU4 FS and subsequent testing.	Demonstrated ability to immobilize contaminants present in Silo 3 waste through OU4 FS and subsequent testing, and both FEMP and commercial treatment of mixed wastes.	Pilot-scale testing on mixed wastes similar to Silo 3 waste shows ability to successfully immobilize hazardous constituents.
	Met TCLP limits for all hazardous constituents in OU4 FS and VITPP testing.	Met TCLP limits for all hazardous constituents in OU4 FS testing.	
	Met NESHAP Subpart Q radon flux limit in OU4 FS testing.	Met NESHAP Subpart Q radon flux limit in OU4 FS testing.	
	Disposal facility design and location minimizes exposure of treated waste to potential degradation mechanisms	Disposal facility design and location minimizes exposure of treated waste to potential degradation mechanisms	Disposal facility design and location minimizes exposure of treated waste to potential degradation mechanisms

TABLE 5
ATTAINMENT OF SILO 3 REMEDIAL ACTION OBJECTIVES

REMEDIAL ACTION OBJECTIVE	VITRIFICATION	CHEMICAL STABILIZATION/SOLIDIFICATION	POLYMER-BASED ENCAPSULATION
Prevent Exposures to Waste Material Causing an Individual to Exceed Annual Dose Limits of: 25mrem/year whole body 75 mrem/year to the thyroid 25 mrem/year to any other organ 100 mrem/year effective dose equivalent above background, from all exposure routes	-The disposal configuration will be permitted, designed and located to prevent contact with the treated waste by members of the public or inadvertent intruders. Cumulative dose equivalent to transportation worker during transportation of vitrified Silo 3 waste - 0.86 mrem Dose equivalent to maximally exposed member of the public during routine transportation of all shipments of vitrified Silo 3 waste - 0.002 mrem.	The disposal configuration will be permitted, designed and located to prevent contact with the treated waste by members of the public or inadvertent intruders. Cumulative dose equivalent to transportation worker during transportation of chemically stabilized Silo 3 waste - 0.95 mrem Dose equivalent to maximally exposed member of the public during routine transportation of all shipments of chemically stabilized Silo 3 waste - 0.006 mrem.	The disposal configuration will be permitted, designed and located to prevent contact with the treated waste by members of the public or inadvertent intruders. Dose to worker and member of the public during transportation of encapsulated Silo 3 waste can be assumed roughly equivalent to that from chemically-stabilized waste.

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TABLE 5
ATTAINMENT OF SILO 3 REMEDIAL ACTION OBJECTIVES

REMEDIAL ACTION OBJECTIVE	VITRIFICATION	CHEMICAL STABILIZATION/SOLIDIFICATION	POLYMER-BASED ENCAPSULATION
Achieve Residual Risk < $1x10^{-6}$			
Transportation	Estimated Lifetime Cancer Risk (LCR) of $3x10^{-10}$ to maximally exposed member of the public during routine transport from all shipments (assuming onsite treatment)	Estimated Lifetime Cancer Risk (LCR) of $8x10^{-10}$ to maximally exposed member of the public during routine transport from all shipments (assuming onsite treatment) Transportation risk for offsite treatment will be maintained less than $1x10^{-6}$ through onsite pretreatment of Silo 3 waste and packaging in accordance with DOT regulations	Estimated Lifetime Cancer Risk (LCR) to maximally exposed member of the public during routine transport from all shipments of $8x10^{-10}$ (assuming onsite treatment) Transportation risk for offsite treatment will be maintained less than$1x10^{-6}$ through onsite pretreatment of Silo 3 waste and packaging in accordance with DOT regulations
Onsite (FEMP)	Residual risk less than $1x10^{-6}$ will be attained through removal of the source term	Residual risk less than $1x10^{-6}$ will be attained through removal of the source term	Residual risk less than $1x10^{-6}$ will be attained through removal of the source term
Offsite (Disposal Facility)	Residual risk less than $1x10^{-6}$ will be attained through design and location of the disposal facility to minimize the potential for human or ecological receptors	Residual risk less than $1x10^{-6}$ will be attained through design and location of the disposal facility to minimize the potential for human or ecological receptors	Residual risk less than $1x10^{-6}$ will be attained through design and location of the disposal facility to minimize the potential for human or ecological receptors

TABLE 5
ATTAINMENT OF SILO 3 REMEDIAL ACTION OBJECTIVES

REMEDIAL ACTION OBJECTIVE	VITRIFICATION	CHEMICAL STABILIZATION/SOLIDIFICATION	POLYMER-BASED ENCAPSULATION
Cost	$28 million - 1994 dollars (ROM cost from OU4 FS, alternative 3B/1/Vit)	Rough-order-of-magnitude cost estimate - $25 million	Assumed roughly equivalent to cement stabilization due to expected similar waste volume and capital costs (based upon U.S. EPA literature review)

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The three technologies were then evaluated using the criteria defined by CERCLA for the RI/FS Detailed Analysis of Alternatives process [40 CFR 300.430(e)(9)]. These criteria are:

Threshold Criteria

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Balancing Criteria

- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-term Effectiveness
- Implementability
- Cost

As was the practice with the original OU4 FS, formal consideration of the modifying criteria of State and Community Acceptance will take place during review of the draft ESD by the state and the public and will be formally documented in the responsiveness summary included as part of the final ESD.

A comparison of the three stabilization/solidification alternatives against the criteria is summarized in Tables 6 through 11. As illustrated by Table 6, all three alternatives successfully meet the two threshold criteria. Although the evaluation identified potential advantages offered by each of the three alternatives in individual balancing criteria, none of the advantages were judged sufficient to preclude further consideration of all three alternatives.

3.5 Description of Alternate Remedy for Silo 3 Waste

Based upon the detailed evaluation against the criteria prescribed by the NCP, both Chemical Stabilization / Solidification, and Polymer-based Encapsulation processes (such as Polymer (micro) Encapsulation and Sulfur/Polymer Encapsulation) were judged acceptable, and demonstrated to meet RAOs and treatment objectives for stabilization/solidification of

TABLE 6
COMPARATIVE EVALUATION OF SILO 3 STABILIZATION/SOLIDIFICATION ALTERNATIVES

THRESHOLD CRITERIA

EVALUATION CRITERION	CHEMICAL STABILIZATION	POLYMER (micro) ENCAPSULATION	SULFUR/POLYMER ENCAPSULATION
PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	<= = = = = = = = = = = = = = = = = =	All alternatives are very protective: Effectively immobilizes all hazardous and radiological constituents to meet disposal facility WAC Potential disposal facilities will be permitted, designed, and located to minimize the potential for human or ecological exposure Engineered disposal design minimizes potential for access by inadvertent intruders Short-term (transportation) risks to the public are maintained well within CERCLA criteria (see short-term effectiveness evaluation)	= = = = = = = = = = = = = = = = =

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TABLE 7
COMPARATIVE EVALUATION OF SILO 3 STABILIZATION/SOLIDIFICATION ALTERNATIVES

BALANCING CRITERIA

LONG-TERM EFFECTIVENESS AND PERMANENCE

CHEMICAL STABILIZATION	POLYMER (micro) ENCAPSULATION	SULFUR/POLYMER ENCAPSULATION
<= = = =

TABLE 8
COMPARATIVE EVALUATION OF SILO 3 STABILIZATION/SOLIDIFICATION ALTERNATIVES

BALANCING CRITERIA

REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

	CHEMICAL STABILIZATION	POLYMER (micro) ENCAPSULATION	SULFUR/POLYMER ENCAPSULATION
TOXICITY	<= = = = = = = = = = = = = = = = = = = =	None of the three alternatives provide destruction of toxic constituents (no significant reduction of toxicity is accomplished). All three alternatives provide effectiveness by immobilizing toxic constituents	= >
MOBILITY	Demonstrated ability to immobilize contaminants present in Silo 3 waste through OU4 FS and subsequent testing, and both FEMP and commercial treatment of similar wastes. Reduces mobility through chemical stabilization of COCs, as well as physical binding.	Pilot-scale testing on wastes similar to Silo 3 waste shows ability to successfully immobilize hazardous constituents. Reduces mobility by physically encapsulating COCs; no chemical stabilization	Pilot-scale testing on wastes similar to Silo 3 waste shows ability to successfully immobilize hazardous constituents. Reduces mobility by physically encapsulating COCs; no chemical stabilization
VOLUME	Estimated 20% volume increase, based upon treatability tests with Silo 3 waste Minimal secondary waste	Assumed equivalent to Cement Stabilization, based upon U.S. EPA literature review. Could potentially provide lower treated waste volume than cement stabilization	Assumed equivalent to Cement Stabilization, based upon U.S. EPA literature review. Could potentially provide lower treated waste volume than cement stabilization

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TABLE 9

COMPARATIVE EVALUATION OF SILO 3 STABILIZATION/SOLIDIFICATION ALTERNATIVES

BALANCING CRITERIA

IMPLEMENTABILITY

	CHEMICAL STABILIZATION	POLYMER (micro) ENCAPSULATION	SULFUR/POLYMER ENCAPSULATION
ADMINISTRATIVE IMPLEMENTABILITY	<= = = = = = = = = = = = = = = =	NTS provides preliminary confirmation of acceptability of treated waste under existing PA	= = = = = = = = = = = = = = = = = = = >
TECHNICAL IMPLEMENTABILITY	More widely implemented on a commercial scale for mixed waste treatment than other two alternatives Has been successfully implemented on a commercial scale to treat mixed waste at numerous DOE and non-DOE superfund sites Has been successful at FEMP on other mixed wastes, including thorium waste	Limited commercial implementation Successful on a bench scale with mixed waste and on a pilot-scale with surrogate Development required to confirm treated waste volume and achievable throughput	More uncertain than Cement(chemical) Stabilization due to limited commercial implementation More complex facility and equipment requirements than cement(chemical) stabilization or polymer (micro) encapsulation Successful on a pilot scale; small-scale commercial facility exists Development required to confirm treated waste volume and achievable throughput

TABLE 10
COMPARATIVE EVALUATION OF SILO 3 STABILIZATION/SOLIDIFICATION ALTERNATIVES

BALANCING CRITERIA

SHORT-TERM EFFECTIVENESS

	CHEMICAL STABILIZATION	POLYMER (MICRO) ENCAPSULATION	SULFUR / POLYMER ENCAPSULATION
Worker Risks	Lower than other three alternatives due to lower operating temperature and shorter period of operation	Operating temperatures, and therefore worker risk, are slightly higher than Cement Stabilization, but lower than Sulfur/Polymer Encapsulation.	Higher than Cement Stabilization or Polymer Encapsulation due to higher operating temperatures and handling of molten sulfur
Transportation Risk	Occupational, public, and accident-scenario (including accident with fire) transportation risks are well within CERCLA guidelines	Equivalent to Cement Stabilization, assuming equal treated waste volume; lower treated waste volume would result in risk lower than that for cement stabilization	Equivalent to Cement Stabilization, assuming equal treated waste volume; lower treated waste volume would result in risk lower than that for cement stabilization
Offgas Issues	Minimal; process maintains moisture in untreated waste, resulting in minimal particulate emissions	Minimal; process requires very low moisture content in feed stream, resulting in waste particulate generation during material handling	Greater than cement stabilization or Polymer (micro) encapsulation. Process requires very low moisture content in feed stream , resulting in waste particulate generation during material handling. Potential generation of SO_2 and H_2S during process upsets can be treated through typical offgas controls
Clean-up Time	Clean-up time is most certain of the three alternatives based upon OU4 treatability testing and commercial experience with similar wastes. Potential clean-up time of less than 9 months - actual cleanup time will be determined by selected subcontractor	Achievable throughput and resulting clean-up time must be determined through development work. U.S. EPA literature indicates clean-up time should be roughly similar to that achievable by chemical stabilization	Achievable throughput and resulting clean-up time must be determined through development work. U.S. EPA literature indicates clean-up time should be roughly similar to that achievable by chemical stabilization

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TABLE 11
COMPARATIVE EVALUATION OF SILO 3 STABILIZATION/SOLIDIFICATION ALTERNATIVES
BALANCING CRITERIA

COST

CHEMICAL STABILIZATION	POLYMER (micro) ENCAPSULATION	SULFUR/POLYMER ENCAPSULATION
Due to wide-spread commercial implementation and more certain implementability, cost is most certain of the three alternatives	Assumed roughly equivalent to cement stabilization due to expected similar waste volume and capital costs (based upon U.S. EPA literature review)	Assumed roughly equivalent to cement stabilization due to expected similar waste volume and capital costs (based upon U.S. EPA literature review)
Rough- order-of-magnitude cost estimate: $25 million	Cost is more uncertain than that for cement stabilization due to limited commercial-scale basis for estimate	Cost is more uncertain than that for cement stabilization due to limited commercial-scale basis for estimate

the Silo 3 waste. Therefore, the alternate remedy for remediation of Silo 3 waste will be defined as:

- Treatment, using either Chemical Stabilization/Solidification or a Polymer-Based Encapsulation process, to stabilize characteristic metals to meet RCRA TCLP limits and attain disposal facility Waste Acceptance Criteria (WAC); and
- Offsite disposal at either the NTS or an appropriately-permitted Commercial Disposal Facility (PCDF).

The treatment portion of the alternate remedy may be accomplished through either onsite treatment at the FEMP to meet disposal facility WAC, or pretreatment onsite as required to reduce dispersability of thorium-bearing particulates and render the waste acceptable for transportation, followed by transportation to an appropriately permitted offsite facility for treatment using Chemical Stabilization/Solidification or a polymer-based encapsulation process to meet disposal facility WAC. For offsite treatment to attain the Silo 3 RAOs, onsite pretreatment, in combination with packaging in accordance with Department of Transportation (DOT) regulations, must reduce the dispersability of thorium-bearing particulates and result in transportation risk less than 1×10^{-6}. The specific process to be used will be selected through evaluation of proposals submitted by potential subcontractors. A request for proposal (RFP) will be issued requesting potential contractors to submit proposals for implementation of the alternate remedy described above. The specific process to accomplish the treatment and disposal of Silo 3 waste will then be designed, tested, and implemented by the selected contractor.

4. SUPPORT AGENCY AND PUBLIC COMMENTS AND RESPONSIVENESS SUMMARY

To be developed after review of draft Final ESD.

5. AFFIRMATION OF STATUTORY DETERMINATION

Changing the stabilization/solidification process for Silo 3 wastes from vitrification to Chemical Stabilization/Solidification, or a Polymer-based Encapsulation process, followed by off-site disposal, does not fundamentally alter the remedy selected in the approved OU4 ROD. The alternate remedy will effectively immobilize the heavy metals present in the waste to reduce the leachability and associated toxicity of the material and in order to meet RCRA TCLP limits and disposal facility WAC. In addition, the alternative provides for disposal of treated waste at a protective off-site disposal facility after stabilization/ solidification. As discussed in Section 3.4, either type of treatment process can attain the Remedial Action Objectives specified by the OU4 FS and ROD for Silo 3 waste. Treatment, using either of the identified treatment technologies, at an offsite location can also attain all of the Silo 3 RAOs, provided that the risk during transportation to the treatment facility is maintained less than 1×10^{-6} through onsite pretreatment to reduce dispersability and packaging in accordance with Department of Transportation (DOT) regulations.

The NTS and representative PCDFs are located in remote, arid regions of the western United States so that human health and environmental impacts are similar for both facilities. Changing the selected remedy for Silo 3 wastes from vitrification to either of the potential alternatives will not result in any changes to the ARARs which are identified in the approved OU4 ROD. Treatment of Silo 3 wastes using either Chemical Stabilization/Solidification or a Polymer-based Encapsulation process will comply with all ARARs identified in the approved OU4 ROD. Offsite treatment of Silo 3 waste, using either type of technology, can also attain all ARARs, provided that transportation risk is minimized as discussed above.

In order to meet the substantive and procedural requirements of the DOE's National Environmental Policy Act (NEPA) Implementing Regulations (10 CFR 1021), the OU4 FS and Proposed Plan (PP) were prepared as an integrated NEPA Environmental Impact Statement (EIS). The DOE's NEPA regulations mandate that proposed changes to a federal

action which has been the subject of an EIS evaluation, must be evaluated in a Supplemental Analysis to determine if formal revision to the original EIS is required through issuance of a Supplemental EIS. A Supplemental Analysis (Reference 20) was prepared to evaluate the NEPA impacts of the proposed changes in the Silo 3 stabilization technology and potential changes in the final disposal location. The Supplemental Analysis concluded the proposed change in treatment technology and the potential change in the disposal location were sufficiently evaluated in the original OU4 FS/PP-EIS and did not require the preparation of a Supplemental EIS. The Silo 3 Supplemental Analysis was made available for stakeholder review and approved by the DOE-Ohio Field Office NEPA Compliance Officer and placed in the Public Environmental Information Center in December of 1996 pursuant to the requirements of the DOE's NEPA Regulations regarding public availability.

6. PUBLIC PARTICIPATION

Public participation has played an integral role in reevaluating the remedy for remediation of Silo 3 waste. Formal public involvement opportunities during identification of the alternate remedy for Silo 3 waste and development of this draft Final ESD are summarized in Table 12.

A draft ESD was reviewed and approved by both U.S. EPA and Ohio EPA (References 21-25). This draft Final ESD is being made available for public review from November 17, 1997 through December 16, 1997. Formal public hearings will be held during the review period to receive stakeholder comments and concerns. A responsiveness summary document, which formally addresses stakeholder comments received on the draft Final ESD, will accompany the Final ESD submitted for U.S. EPA approval.

After approval of the Final ESD, public participation will continue to be an integral part of implementing stabilization/solidification of Silo 3 waste. The DOE will keep stakeholders, both locally and at potential disposal locations, involved throughout implementation of Silo 3 waste stabilization/solidification through periodic written and verbal updates. The Administrative Record, which provides greater detail on the decision-making process for

TABLE 12

FORMAL PUBLIC INVOLVEMENT OPPORTUNITIES
DEVELOPMENT OF ALTERNATE REMEDY FOR SILO 3 WASTE

DATE	PARTICIPANTS	TOPIC
August 20, 1996	DOE, FDF, U. S. EPA, Ohio EPA, local stakeholders	OU4 path forward; Evaluation of Silo 3 Alternatives
September 4, 1996	DOE, FDF, Nevada Test Site Citizens Advisory Board, NTS Stakeholders	OU4 path forward; Evaluation of Silo 3 Alternatives
September 11, 1996	DOE, FDF, Fernald Citizens Advisory Board (FCAB), Waste Management Subcommittee	Reevaluation of OU4 path forward
November 6, 1996	DOE, FDF, Nevada Test Site Citizens Advisory Board, NTS Stakeholders	Resolution of NTS stakeholder comments on Silo 3 Alternatives Evaluation
November 9, 1996	DOE, FDF, FCAB	VITPP status; Silo 3 path forward
November 14-15, 1996	DOE, FDF, IRT, U.S. EPA, Ohio EPA, local stakeholders	OU4 Path forward, IRT kickoff
December 12-13, 1996	DOE, FDF, IRT, U.S. EPA, Ohio EPA, local stakeholders	IRT meeting
January 21-23, 1997	DOE, FDF, IRT, U.S. EPA, Ohio EPA, local stakeholders	IRT meeting
February 11-13. 1997	DOE, FDF, IRT, U.S. EPA, Ohio EPA, local stakeholders	IRT meeting; included a public availability session concerning the IRT on February 12, 1997

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TABLE 12

FORMAL PUBLIC INVOLVEMENT OPPORTUNITIES
DEVELOPMENT OF ALTERNATE REMEDY FOR SILO 3 WASTE

DATE	PARTICIPANTS	TOPIC
February 25-28, 1997	DOE, FDF, IRT, U. S. EPA, Ohio EPA, local stakeholders	IRT meeting; included a public briefing on draft recommendations of the IRT on February 26, 1997
May 14, 1997	DOE, FDF, U. S. EPA, Ohio EPA, local stakeholders	Screening of potential stabilization/solidification alternatives
June 3, 1997	DOE, FDF, Nevada Test Site Citizens Advisory Board, NTS Stakeholders	Presentation of May 14, 1997 public workshop to NTS stakeholders
June 16, 1997	DOE, FDF, U.S. EPA, Ohio EPA, local stakeholders	Review of screening of potential stabilization / solidification alternatives; technical briefing on stabilization, solidification and encapsulation technologies; initial detailed evaluation of alternatives
July 1, 1997	DOE, FDF, Nevada Test Site Citizens Advisory Board, NTS Stakeholders	Presentation of June 16, 1997 public workshop to NTS stakeholders
July 16, 1997	DOE, FDF, Fernald Citizens Advisory Board(FCAB)	Technical briefing and tour at Brookhaven National Laboratory concerning polymer-based encapsulation technologies
July 29, 1997	DOE, FDF, U.S. EPA, Ohio EPA, local stakeholders	Detailed evaluation of stabilization/solidification alternatives

changing the selected treatment technology for Silo 3 wastes is available at the Public Environmental Information Center, 10995 Hamilton-Cleves Highway, Harrison, Ohio. The Public Environmental Information Center may also be contacted by calling (513) 648-7480 or (513) 648-7481.

7. REFERENCES

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