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Conceptual Thermal Treatment Technologies Feasibility Study

by

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WSRC-TR-95-0206

**CONCEPTUAL THERMAL TREATMENT TECHNOLOGIES
FEASIBILITY STUDY (U)**

May 15, 1995

**Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808**

SIGNATURE PAGE

Conceptual Thermal Treatment Technologies Feasibility Study

This document was prepared for the United States Department of Energy under the direction of Ahmet Suer of the Westinghouse Savannah River Company Environmental Restoration Department. We have reviewed the document, and to the best of our knowledge, it is true, accurate, and correct.

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CONTENTS

1.0	EXECUTIVE SUMMARY	1-1
2.0	INTRODUCTION	2-1
2.1	Purpose and Organization of Report	2-1
2.2	SRS Background	2-1
3.0	THERMAL TREATMENT TECHNOLOGIES OVERVIEW	3-1
3.1	Introduction	3-1
3.2	Ex-Situ Thermal Treatment Technologies	3-2
3.2.1	<i>Low Temperature Thermal Desorption</i>	3-2
3.2.1.1	<u>Description</u>	3-2
3.2.1.2	<u>Mobility/Toxicity/Volume</u>	3-3
3.2.1.3	<u>Long/Short Term Effectiveness</u>	3-3
3.2.1.4	<u>Regulatory/Permitting Issues</u>	3-3
3.2.1.5	<u>Secondary Waste and Treatment</u>	3-3
3.2.1.6	<u>Reliability</u>	3-3
3.2.1.7	<u>Availability</u>	3-3
3.2.1.8	<u>Cost</u>	3-4
3.2.1.9	<u>Public Acceptance</u>	3-4
3.2.1.10	<u>Contaminant Applicability</u>	3-4
3.2.1.11	<u>Contaminant Concentration Achievable</u>	3-4
3.2.1.12	<u>Mobilization/Demobilization</u>	3-4
3.2.1.13	<u>References</u>	3-4
3.2.2	<i>High Temperature Thermal Desorption</i>	3-5
3.2.2.1	<u>Description</u>	3-5
3.2.2.2	<u>Mobility/Toxicity/Volume</u>	3-6
3.2.2.3	<u>Long/Short Term Effectiveness</u>	3-6
3.2.2.4	<u>Regulatory/Permitting Issues</u>	3-6
3.2.2.5	<u>Secondary Waste and Treatment</u>	3-6
3.2.2.6	<u>Reliability</u>	3-6
3.2.2.7	<u>Availability</u>	3-6
3.2.2.8	<u>Cost</u>	3-6
3.2.2.9	<u>Public Acceptance</u>	3-7
3.2.2.10	<u>Contaminant Applicability</u>	3-7
3.2.2.11	<u>Contaminant Concentration Achievable</u>	3-7
3.2.2.12	<u>Mobilization/Demobilization</u>	3-7
3.2.2.13	<u>References</u>	3-7

CONTENTS (Cont'd)

3.2.3 Incineration	3-7
3.2.3.1 <u>Description</u>	3-7
3.2.3.2 <u>Mobility/Toxicity/Volume</u>	3-9
3.2.3.3 <u>Long/Short Term Effectiveness</u>	3-9
3.2.3.4 <u>Regulatory/Permitting Issues</u>	3-9
3.2.3.5 <u>Secondary Waste and Treatment</u>	3-10
3.2.3.6 <u>Reliability</u>	3-10
3.2.3.7 <u>Availability</u>	3-10
3.2.3.8 <u>Cost</u>	3-10
3.2.3.9 <u>Public Acceptance</u>	3-10
3.2.3.10 <u>Contaminant Applicability</u>	3-10
3.2.3.11 <u>Contaminant Concentration Achievable</u>	3-10
3.2.3.12 <u>Mobilization/Demobilization</u>	3-11
3.2.3.13 <u>References</u>	3-11
3.2.4 Pyrolysis	3-11
3.2.4.1 <u>Description</u>	3-11
3.2.4.2 <u>Mobility/Toxicity/Volume</u>	3-12
3.2.4.3 <u>Long/Short Term Effectiveness</u>	3-12
3.2.4.4 <u>Regulatory/Permitting Issues</u>	3-12
3.2.4.5 <u>Secondary Waste and Treatment</u>	3-12
3.2.4.6 <u>Reliability</u>	3-12
3.2.4.7 <u>Availability</u>	3-13
3.2.4.8 <u>Cost</u>	3-13
3.2.4.9 <u>Public Acceptance</u>	3-13
3.2.4.10 <u>Contaminant Applicability</u>	3-13
3.2.4.11 <u>Contaminant Concentration Achievable</u>	3-13
3.2.4.12 <u>Mobilization/Demobilization</u>	3-13
3.2.4.13 <u>References</u>	3-13
3.2.5 Vitrification	3-14
3.2.5.1 <u>Description</u>	3-14
3.2.5.2 <u>Mobility/Toxicity/Volume</u>	3-15
3.2.5.3 <u>Long/Short Term Effectiveness</u>	3-15
3.2.5.4 <u>Regulatory/Permitting Issues</u>	3-15
3.2.5.5 <u>Secondary Waste and Treatment</u>	3-16
3.2.5.6 <u>Reliability</u>	3-16
3.2.5.7 <u>Availability</u>	3-16
3.2.5.8 <u>Cost</u>	3-16
3.2.5.9 <u>Public Acceptance</u>	3-16

CONTENTS (Cont'd)

	3.2.5.10	<u>Contaminant Applicability</u>	3-16
	3.2.5.11	<u>Contaminant Concentration Achievable</u>	3-16
	3.2.5.12	<u>Mobilization/Demobilization</u>	3-17
	3.2.5.13	<u>References</u>	3-17
3.3		In-Situ Thermal Treatment Technologies	3-17
	3.3.1	<i>Thermally Enhanced Soil Vapor Extraction</i>	3-17
	3.3.1.1	<u>Description</u>	3-17
	3.3.1.2	<u>Mobility/Toxicity/Volume</u>	3-18
	3.3.1.3	<u>Long/Short Term Effectiveness</u>	3-18
	3.3.1.4	<u>Regulatory/Permitting Issues</u>	3-18
	3.3.1.5	<u>Secondary Waste and Treatment</u>	3-18
	3.3.1.6	<u>Reliability</u>	3-18
	3.3.1.7	<u>Availability</u>	3-18
	3.3.1.8	<u>Cost</u>	3-19
	3.3.1.9	<u>Public Acceptance</u>	3-19
	3.3.1.10	<u>Contaminant Applicability</u>	3-19
	3.3.1.11	<u>Contaminant Concentration Achievable</u>	3-19
	3.3.1.12	<u>Mobilization/Demobilization</u>	3-19
	3.3.1.13	<u>References</u>	3-19
	3.3.2	<i>In-Situ Vitrification</i>	3-19
	3.3.2.1	<u>Description</u>	3-19
	3.3.2.2	<u>Mobility/Toxicity/Volume</u>	3-20
	3.3.2.3	<u>Long/Short Term Effectiveness</u>	3-20
	3.3.2.4	<u>Regulatory/Permitting Issues</u>	3-21
	3.3.2.5	<u>Secondary Waste and Treatment</u>	3-21
	3.3.2.6	<u>Reliability</u>	3-21
	3.3.2.7	<u>Availability</u>	3-21
	3.3.2.8	<u>Cost</u>	3-21
	3.3.2.9	<u>Public Acceptance</u>	3-21
	3.3.2.10	<u>Contaminant Applicability</u>	3-21
	3.3.2.11	<u>Contaminant Concentration Achievable</u>	3-22
	3.3.2.12	<u>Mobilization/Demobilization</u>	3-22
	3.3.2.13	<u>References</u>	3-22
3.4		Offgas Treatment Technologies	3-22
	3.4.1	<i>Adsorption (Offgas Treatment)</i>	3-22
	3.4.1.1	<u>Description</u>	3-22
	3.4.1.2	<u>Mobility/Toxicity/Volume</u>	3-23
	3.4.1.3	<u>Long/Short Term Effectiveness</u>	3-23

CONTENTS (Cont'd)

3.4.1.4	<u>Regulatory/Permitting Issues</u>	3-23
3.4.1.5	<u>Secondary Waste and Treatment</u>	3-23
3.4.1.6	<u>Reliability</u>	3-23
3.4.1.7	<u>Availability</u>	3-23
3.4.1.8	<u>Cost</u>	3-24
3.4.1.9	<u>Public Acceptance</u>	3-24
3.4.1.10	<u>Contaminant Applicability</u>	3-24
3.4.1.11	<u>Contaminant Concentration Achievable</u>	3-24
3.4.1.12	<u>Mobilization/Demobilization</u>	3-24
3.4.1.13	<u>References</u>	3-24
3.4.2	<i>Thermal Oxidation (Offgas Treatment)</i>	3-24
3.4.2.1	<u>Description</u>	3-24
3.4.2.2	<u>Mobility/Toxicity/Volume</u>	3-25
3.4.2.3	<u>Long/Short Term Effectiveness</u>	3-25
3.4.2.4	<u>Regulatory/Permitting Issues</u>	3-25
3.4.2.5	<u>Secondary Waste and Treatment</u>	3-25
3.4.2.6	<u>Reliability</u>	3-25
3.4.2.7	<u>Availability</u>	3-25
3.4.2.8	<u>Cost</u>	3-25
3.4.2.9	<u>Public Acceptance</u>	3-25
3.4.2.10	<u>Contaminant Applicability</u>	3-26
3.4.2.11	<u>Contaminant Concentration Achievable</u>	3-26
3.4.2.12	<u>Mobilization/Demobilization</u>	3-26
3.4.2.13	<u>References</u>	3-26
3.4.3	<i>Catalytic Oxidation (Offgas Treatment)</i>	3-26
3.4.3.1	<u>Description</u>	3-26
3.4.3.2	<u>Mobility/Toxicity/Volume</u>	3-27
3.4.3.3	<u>Long/Short Term Effectiveness</u>	3-27
3.4.3.4	<u>Regulatory/Permitting Issues</u>	3-27
3.4.3.5	<u>Secondary Waste and Treatment</u>	3-27
3.4.3.6	<u>Reliability</u>	3-27
3.4.3.7	<u>Availability</u>	3-27
3.4.3.8	<u>Cost</u>	3-27
3.4.3.9	<u>Public Acceptance</u>	3-27
3.4.3.10	<u>Contaminant Applicability</u>	3-28
3.4.3.11	<u>Contaminant Concentration Achievable</u>	3-28
3.4.3.12	<u>Mobilization/Demobilization</u>	3-28
3.4.3.13	<u>References</u>	3-28

CONTENTS (Cont'd)

3.4.4	<i>Biofiltration (Offgas Treatment)</i>	3-28
3.4.4.1	<u>Description</u>	3-28
3.4.4.2	<u>Mobility/Toxicity/Volume</u>	3-28
3.4.4.3	<u>Long/Short Term Effectiveness</u>	3-29
3.4.4.4	<u>Regulatory/Permitting Issues</u>	3-29
3.4.4.5	<u>Secondary Waste and Treatment</u>	3-29
3.4.4.6	<u>Reliability</u>	3-29
3.4.4.7	<u>Availability</u>	3-29
3.4.4.8	<u>Cost</u>	3-29
3.4.4.9	<u>Public Acceptance</u>	3-29
3.4.4.10	<u>Contaminant Applicability</u>	3-29
3.4.4.11	<u>Contaminant Concentration Achievable</u>	3-30
3.4.4.12	<u>Mobilization/Demobilization</u>	3-30
3.4.4.13	<u>References</u>	3-30
4.0	ASCAD OVERVIEW	4-1
4.1	Background	4-1
4.2	ASCAD Approach	4-1
4.3	ASCAD Waste Unit Groups	4-2
5.0	APPLICABILITY OF THERMAL TREATMENT TECHNOLOGIES TO ASCAD GROUPS	5-1
5.1	Performance Evaluation	5-1
5.2	Cost Evaluation	5-5
5.3	Implementability Evaluation	5-8
5.4	Overall Evaluation	5-9
6.0	CONCLUSIONS AND RECOMMENDATIONS	6-1
6.1	Preliminary Thermal Treatment Technology Alternatives	6-1
6.1.1	<i>Alternatives for ASCAD Groups 1, 2, 3 and 5</i>	6-1
6.1.2	<i>Alternatives for ASCAD Groups 4 and 9</i>	6-7
6.1.3	<i>Alternatives for ASCAD Groups 6, 7 and 8</i>	6-8
6.2	Recommendations for Additional Study	6-10
7.0	REFERENCES	7-1

LIST OF TABLES

1-1	Preliminary SRS Soil Thermal Treatment Technology Alternatives	1-3
4-1	Summary of ASCAD Groups and Representative Waste Units	4-4
4-2	ASCAD Waste Unit Groups, Waste Units, And Contaminants	4-8
5-1	Thermal Process Performance Assessment	5-2
5-2	Technology Applicability by Contaminant Group	5-4
5-3	Summary Evaluation of Thermal Treatment Technologies	5-7
5-4	Potentially Applicable Thermal Treatment Technologies for Each ASCAD Group	5-10
6-1	Preliminary SRS Soil Thermal Treatment Technology Alternatives	6-2

LIST OF FIGURES

5-1	Range of Operating Temperatures for Thermal Treatment Technologies	.. 5-3
5-2	Range in Costs for Thermal Treatment Technologies 5-6

LIST OF ACRONYMS

ASCAD	Approved Standardized Corrective Action Design
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
Btu	British thermal unit
C	Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
DRE	Destruction and Removal Efficiency
DWPF	Defense Waste Processing Facility
EPA	U.S. Environmental Protection Agency
F	Fahrenheit
FS	Feasibility Study
ft	feet
ft³	cubic feet
HCl	Hydrochloric Acid
HEPA	High Efficiency Particulate Air
HTTD	High Temperature Thermal Desorption
ISV	In-Situ Vitrification
kVA	kilo-volt-amp
lbs	pounds
LTTD	Low Temperature Thermal Desorption
M&O	Management and Operating
OTD	Office of Technology Development
P,P-DDT	1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane
PAH	Polyaromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethylene
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RF	Radio Frequency
RI	Remedial Investigation
RTF	Replacement Tritium Facility
S/S	Solidification/Stabilization
SAFER	Streamlined Approach for Environmental Restoration
SITE	Superfund Innovative Technology Evaluation
SREL	Savannah River Ecology Laboratory
SRS	Savannah River Site
SRTC	Savannah River Technology Center
SVE	Soil Vapor Extraction

LIST OF FIGURES

5-1	Range of Operating Temperatures for Thermal Treatment Technologies	.. 5-3
5-2	Range in Costs for Thermal Treatment Technologies 5-6

LIST OF ACRONYMS (Cont'd)

SVOC	Semi-Volatile Organic Compound
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TOX	Total Organic Halides
TSCA	Toxic Substance Control Act
UV	Ultraviolet
VISITT	Vendors Information Service for Innovative Treatment Technologies
VOC	Volatile Organic Compound
WSRC	Westinghouse Savannah River Company
yd³	cubic yards

1.0 EXECUTIVE SUMMARY

Thermal treatment technologies are of interest to the Environmental Restoration Department at Westinghouse Savannah River Company (WSRC) for two reasons: (1) the potential technical applicability of these technologies to treat contaminated Savannah River Site (SRS) soils and (2) the availability and potential applicability to SRS of a thermal treatment unit currently located at the U.S. Department of Energy (DOE) Fernald facility. This report presents a conceptual Thermal Treatment Technologies Feasibility Study (FS) for the Savannah River Site (SRS) focusing exclusively on thermal treatment technologies for contaminated soil remediation projects. These projects may become part of the WSRC Approved Standardized Corrective Action Design (ASCAD) program. This conceptual FS also presents information on selected vapor phase offgas treatment technologies.

The conceptual FS presented in this report is based on preliminary information regarding contaminants present at SRS waste units and estimated contaminated soil volumes. While conceptual treatment approaches have been discussed based on this limited information, additional data are required to make final technology selections.

A three-part process was implemented during the development of this conceptual FS resulting in preliminary alternatives for thermal technology selection for the SRS waste units. The process involved:

- Thermal technology overview
- ASCAD overview
- Determination of applicability of thermal technologies to ASCAD groups.

Thermal Technology Overview

Five ex-situ and two in-situ thermal treatment technologies were evaluated in depth to address factors including but not limited to the operating principles of the technology, availability, costs, public acceptance, and mobilization/demobilization. Overviews were prepared for the seven thermal treatment technologies and four additional offgas treatment technologies. These overviews are presented in Section 3.0.

ASCAD Overview

A WSRC environmental restoration streamlining initiative known as the ASCAD approach was reviewed. This initiative involves assigning an ASCAD group designation to each waste unit based on similar contaminant characteristics. WSRC has developed nine draft ASCAD groups and has assigned SRS waste units to these groups. Implementation of this approach is expected to streamline technology selection, design, and construction based on the identification of pre-approved cleanup strategies for each ASCAD group. The ASCAD concept is presented in Section 4.0.

Determination of Applicability of Thermal Technologies to ASCAD Groups

The conceptual FS presents an evaluation of applicability of the seven in-situ and ex-situ thermal treatment technologies to the SRS waste units characterized in the nine ASCAD waste unit groups. The evaluation of applicability is based on three general parameters: performance, cost, and implementability. An overall evaluation of applicability is also presented.

Section 5.0 presents this applicability analysis, with Table 5-4 summarizing applicable technologies for each ASCAD group. All technologies that are expected to have effective performance are retained as potentially applicable regardless of cost or implementability factors.

Conclusions

In the absence of additional data, only preliminary technology alternatives for thermal treatment are presented in this report. The preliminary thermal technology alternatives, both in-situ and ex-situ, for each ASCAD group and supporting rationale are presented in detail in Section 6.1. The alternative treatment approaches are also summarized in Table 1-1.

The ASCAD approach is a promising framework for streamlining the remediation process from data collection through technology selection, decision making, and ultimately site cleanup. Because the available data on remediation quantities, contaminants, and physical state of the waste units are limited at this time, final technology recommendations are not appropriate. Specific recommendations for additional studies to support the final technology selection process are presented in Section 6.2.

Table 1-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 1 - Burial Ground Complex	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 2 - Old Solvent Storage Tanks	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 3 - Radioactive/Mixed Waste Seepage Basins and Pits	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

Table 1-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives (Cont'd)

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 4 - Coal Pile Run-off Basins	Metals	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies (e.g., in-situ solidification/stabilization) may be more appropriate and should be evaluated.	Ex-situ vitrification with offgas treatment may be appropriate. Other non-thermal treatment technologies (e.g., ex-situ solidification/stabilization or potential extraction with soil washing) may be more appropriate and should be evaluated.
Group 5 - Process Sewer Lines	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 6 - Pits/Piles	Organics, Pesticides, and Metals	An in-situ thermal treatment approach is not recommended due to the high volume of soils. Other non-thermal treatment technologies may be appropriate and should be evaluated.	If proven effective for pesticides, high temperature thermal desorption may be appropriate followed by solidification/ stabilization and required offgas and effluent treatment. Other thermal treatment (pyrolysis or incineration) may also be appropriate, followed by offgas, effluent, and residual treatment. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

Table 1-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives (Cont'd)

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 7 - Non-Radioactive Basins	Organics, Pesticides, and Metals	An in-situ thermal treatment approach is not recommended due to the high volume of soils. Other non-thermal treatment technologies may be appropriate and should be evaluated.	If proven effective for pesticides, high temperature thermal desorption may be appropriate followed by solidification/ stabilization and required offgas and effluent treatment. Other thermal treatment (pyrolysis or incineration) may also be appropriate, followed by offgas, effluent, and residual treatment. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 8 - Sludge Application Units	Organics, Pesticides, and Metals	An in-situ thermal treatment approach is not recommended due to the high volume of soils. Other non-thermal treatment technologies may be appropriate and should be evaluated.	If proven effective for pesticides, high temperature thermal desorption may be appropriate followed by solidification/ stabilization and required offgas and effluent treatment. Other thermal treatment (pyrolysis or incineration) may also be appropriate, followed by offgas, effluent, and residual treatment. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

Table 1-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives (Cont'd)

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 9 - Acid/Caustic Basins	Metals	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies (e.g., in-situ solidification/stabilization) may be more appropriate and should be evaluated.	Ex-situ vitrification with offgas treatment may be appropriate. Other non-thermal treatment technologies (e.g., ex-situ solidification/stabilization or potential extraction with soil washing) may be more appropriate and should be evaluated.

* These alternatives are preliminary in nature, based upon a conceptual Feasibility Study that considered only thermal treatment technologies. Site characterization, treatability testing, and economic analyses are required prior to the development of final technology selections.

2.0 INTRODUCTION

2.1 Purpose and Organization of Report

This report presents a conceptual Thermal Treatment Technologies FS for the SRS focusing exclusively on ex-situ and in-situ thermal treatment technologies for contaminated soil, sediment, or sludge remediation projects. This conceptual FS also presents information on selected vapor phase offgas treatment technologies. Thermal treatment technologies are of interest to the Environmental Restoration Department of WSRC for two reasons: (1) the potential technical applicability of these technologies to treat contaminated SRS soils and (2) the availability and potential applicability to SRS of a thermal treatment unit currently located at the DOE Fernald facility.

The conceptual FS presented in this report is based on preliminary information regarding contaminants present at waste units and potential contaminated soil volumes. While conceptual treatment approaches have been discussed based on this limited information, additional data are required to make final technology selections.

This conceptual FS is summarized in the Executive Summary and introduced in Section 2.0 of this report. Section 3.0 presents an overview of five ex-situ and two in-situ thermal treatment technologies as well as four offgas treatment technologies. Section 4.0 discusses the types of contaminated soils present at SRS, summarized using the nine draft ASCAD groups. Section 5.0 presents the applicability of the thermal treatment technologies to the draft ASCAD groups considering performance, cost, and implementability. Section 6.0 presents alternatives and conclusions regarding thermal treatment technology applicability to contaminated soils at the SRS.

2.2 SRS Background

The SRS is a key DOE nuclear installation. Owned by DOE and operated under contract by WSRC, the complex covers some 198,344 acres, or 310 square miles. The site encompasses parts of Aiken, Barnwell, and Allendale counties in western South Carolina, bordering the Savannah River.

The SRS was constructed during the early 1950s to produce the basic materials used in the fabrication of nuclear weapons, primarily tritium and plutonium-239. The site originally consisted of five reactors to produce nuclear materials by irradiating target materials with neutrons. Support facilities included two chemical separations plants, a heavy water extraction plant, a nuclear fuel and target fabrication facility and waste management facilities.

SRS has adjusted through the years to meet changing site priorities and rising and falling defense requirements. Of the five original SRS production reactors, four are permanently shut down. The fifth reactor, K Reactor, is in "cold standby".

In the past, irradiated materials were moved from the reactors to the chemical separations facilities, the next step in the production process. In these facilities, known as "canyons", the irradiated fuel and target assemblies were chemically processed to separate useful products from waste. After refinement, some nuclear materials were shipped to other DOE sites for final use.

Today, these separations facilities are processing existing inventories of materials for a variety of purposes, including supplying plutonium-238 for deep space probes; and processing inventoried liquid radioactive materials into solid form for storage and testing. This activity is expected to continue for several years.

Another historic mission of the SRS was the production of tritium. While the production of new tritium will not be necessary for many years, recycling and reloading of tritium to keep the nation's supply of nuclear weapons ready is a continuing site mission. Tritium, with a half-life of 12.5 years, must be continually replenished, and SRS is the nation's only source for recycling tritium from nuclear weapons reservoirs returned from service.

All tritium unloading, mixing and loading will be performed in the new Replacement Tritium Facility (RTF). The RTF will replace a majority of SRS facilities that have processed the nation's tritium for the past 35 years.

Waste management operations and environmental monitoring at the SRS employ the latest technology to ensure the safety of employees and the public. The Defense Waste Processing Facility (DWPF), with a state-of-the-art process for changing liquid high-level radioactive waste into durable glass, is currently undergoing final tests before it begins production (WSRC 1993b).

3.0 THERMAL TREATMENT TECHNOLOGIES OVERVIEW

3.1 Introduction

This section of the conceptual FS presents an overview of key thermal treatment technologies organized in three main categories:

- Ex-Situ Thermal Treatment Technologies (Section 3.2)
- In-Situ Thermal Treatment Technologies (Section 3.3)
- Offgas Treatment Technologies (Section 3.4).

The thermal treatment technology overviews are based exclusively on secondary source materials, with references cited throughout the overviews as appropriate and listed in Section 7.0. Each individual thermal technology overview for ex-situ and in-situ thermal processes is presented in a common format addressing the following elements:

- Description
- Mobility/Toxicity/Volume
- Long/Short Term Effectiveness
- Regulatory/Permitting Issues
- Secondary Waste and Treatment
- Reliability
- Availability
- Cost
- Public Acceptance
- Contaminant Applicability
- Contaminant Concentration Achievable
- Mobilization/Demobilization
- References

The offgas technology overviews are limited to technologies targeted to control organics. A variety of other systems will be required to control acid gases and particulates; however, these technologies are not addressed in this document.

Discussions of treatment technologies for solid and liquid residuals from thermal treatment technologies are not presented in this conceptual FS; however, they may be required to complement thermal waste treatment prior to disposal of the residues.

3.2 Ex-Situ Thermal Treatment Technologies

Technology overviews are presented for five ex-situ thermal treatment technologies in this section of the conceptual FS. They include the following:

- Low Temperature Thermal Desorption (Section 3.2.1)
- High Temperature Thermal Desorption (Section 3.2.2)
- Incineration (Section 3.2.3)
- Pyrolysis (Section 3.2.4)
- Vitrification (Section 3.2.5)

3.2.1 *Low Temperature Thermal Desorption*

3.2.1.1 Description

Low temperature thermal desorption (LTTD) is a technology that volatilizes organic contaminants and water by heating the contaminated soil to temperatures ranging from 200° to 600° Fahrenheit (F) [93° to 316° Celsius (C)]. The technology operates by physically transferring the contaminants from the soil matrix to the vapor phase. Oxidation is prevented by either operating the unit under a vacuum or supplying an inert carrier gas such as nitrogen. The gas containing the contaminants is collected and sent to the offgas treatment system. Water is normally added to the treated soil for dust control. Non-volatile inorganic contaminants including most metals and radionuclides remain in the soil and do not inhibit the treatment process.

The thermal desorption unit consists of a rotary dryer or a screw type conveyer that transports the waste through the unit. The rotary dryer unit mechanically conveys and tumbles the soil to expose fresh surface area in order to enhance volatilization of contaminants. The screw conveyer system conveys the soil by the action of the screws. Heat to the rotary dryer unit is supplied by natural gas or oil firing. The screw conveyor system supplies heat through contact with steam or circulating oil in heated screws. Additional heat may also be provided by exposure to hot carrier gas.

The offgas treatment system in LTTD systems normally consists of a baghouse collector or cyclone separator to remove particulates; an acid gas scrubber; and either a condensing unit to concentrate the organic contaminants into a liquid waste stream, a carbon adsorption unit, a thermal oxidizer, or a catalytic oxidizer. Particulates may be returned to the unit for additional processing and condenser water may be treated by a prefilter and carbon filters and reused in the system for soil re-hydration. Also, the carrier gas may be recycled from the offgas handling system.

Site specific factors that affect the treatment effectiveness include the type of soil and the soil moisture content. High soil moisture content greatly increases the heat input and fuel

requirements and reduces the process throughput. Multiple passes through the system may also be necessary to achieve the desired removal efficiency for difficult-to-treat organic contaminants.

3.2.1.2 Mobility/Toxicity/Volume

This technology reduces the mass of waste by transferring the organic contaminants from the soil into a vapor stream that is subsequently treated to either destroy or concentrate the contaminants. However, the soil volumes may remain relatively constant if the organic content and percent moisture of the untreated soil are low.

3.2.1.3 Long/Short Term Effectiveness

This technology permanently removes the contaminants from the soil, and thereby protects human health and the environment from potential future exposure. There is the potential for exposure of site workers during implementation of this technology, which can be controlled with onsite engineering controls.

3.2.1.4 Regulatory/Permitting Issues

Air permits may be required for discharge of treated offgases.

3.2.1.5 Secondary Waste and Treatment

The LTTD technology produces offgases that contain particulates and organic contaminants. Secondary wastes that may be generated by the offgas treatment system include captured particulates, spent carbon, a concentrated organic liquid waste stream, and wastewater. The particulates may be returned to the treatment unit or disposed of offsite, while the spent carbon and concentrated organic liquid waste may be treated or disposed offsite. Any waste generated may be treated onsite and reused or shipped offsite for treatment and disposal.

3.2.1.6 Reliability

This technology has had demonstrated reliability at the full scale and has been successfully implemented at numerous contaminated sites.

3.2.1.7 Availability

There are a number of vendors that offer this technology at the full scale as well as for bench and pilot scale testing.

3.2.1.8 Cost

This technology is expected to cost from \$50 to \$275 per ton, depending on factors such as contaminant type, target contaminant concentration, and moisture content. The lower cost range is for treating contaminants that are readily volatilized such as benzene, toluene, ethylbenzene and xylene (BTEX) compounds, while the higher costs are associated with harder to treat compounds, such as semi-volatile organic compounds (SVOCs).

3.2.1.9 Public Acceptance

It is anticipated that this technology would be acceptable to the public due to past acceptance at other contaminated sites.

3.2.1.10 Contaminant Applicability

LTTD is applicable to halogenated and non-halogenated volatile organic compounds (VOCs) and BTEX compounds. It is also potentially applicable to SVOCs, pesticides, polychlorinated biphenyls (PCBs), and dioxins/furans, but may be less effective for these compounds. This technology is not applicable to metals or radionuclides.

3.2.1.11 Contaminant Concentration Achievable

Achievable concentrations were frequently reported as below detection limits for VOCs.

3.2.1.12 Mobilization/Demobilization

The LTTD unit is mounted on semi-trailers and transported to the site. Depending on the size of the unit, costs are expected to range from \$10,000 to \$100,000.

3.2.1.13 References

EPA, 1992a
EPA, 1993a
EPA, 1993b
EPA, 1994
VISITT, 1994
WRS, 1993

3.2.2 *High Temperature Thermal Desorption*

3.2.2.1 Description

During high temperature thermal desorption (HTTD), contaminated soil is heated to temperatures ranging from 600° to 1,000° F (315° to 538° C), thereby volatilizing the organic contaminants and water. The technology operates by physically transferring the contaminants from the soil matrix to the vapor phase. Oxidation is prevented by either operating the unit under a vacuum or supplying an inert carrier gas such as nitrogen. The gas containing the contaminants is collected and sent to the offgas treatment system. Higher temperatures are necessary for removing less volatile organic compounds. Water is normally added to the treated soil for dust control. Non-volatile inorganic contaminants including most metals and radionuclides remain in the soil and do not inhibit the treatment process.

The thermal desorption unit consists of a rotary dryer or a screw type conveyor that transports the waste through the unit. The rotary dryer unit mechanically conveys and tumbles the soil to expose fresh surface area in order to enhance volatilization of contaminants. The screw conveyor system conveys the soil by the action of the screws. Heat to the rotary dryer unit is supplied by natural gas or oil firing. The screw conveyor system supplies heat through contact with steam or circulating oil in heated screws. Additional heat may also be provided by exposure to hot carrier gas.

Westinghouse Remediation Services developed a thermal desorption unit that operates by applying infrared heat to the soil as it is transferred through the unit on a conveyor. The organic contaminants are volatilized and sent to the offgas treatment system. This process has the ability to achieve a wide range of operating temperatures (300° to 1,500° F) due to the infrared heating process, and is particularly applicable to high boiling point organic contaminants. Also, the process minimizes fines carryover due to minimal solids agitation and gas flow.

The offgas treatment system in HTTD systems normally consists of a baghouse collector or cyclone separator to remove particulates; an acid gas scrubber; and either a condensing unit to concentrate the organic contaminants into a liquid waste stream, a carbon adsorption unit, a thermal oxidizer, or a catalytic oxidizer. Particulates may be returned to the unit for additional processing and condenser water may be treated by a prefilter and carbon filters and reused in the system for soil re-hydration. Also, the carrier gas may be recycled from the offgas handling system.

Site specific factors that affect the treatment effectiveness include the type of soil and the soil moisture content. High soil moisture content greatly increases the heat input and fuel requirements and reduces the process throughput. Multiple passes through the system may also be necessary to achieve the desired removal efficiency for difficult-to-treat organic contaminants.

3.2.2.2 Mobility/Toxicity/Volume

This technology reduces the mass of waste by transferring the organic contaminants from the soil into a vapor stream that is subsequently treated to either destroy or concentrate the contaminants. However, the soil volume may remain relatively constant if the organic content and percent moisture of the untreated soil are low.

3.2.2.3 Long/Short Term Effectiveness

This technology permanently removes the contaminants from the soil, and thereby protects human health and the environment from potential future exposure. There is the potential for exposure of site workers during implementation of this technology, which can be controlled with onsite engineering controls.

3.2.2.4 Regulatory/Permitting Issues

Air permits will likely be required for discharge of treated offgases.

3.2.2.5 Secondary Waste and Treatment

The HTTD technology produces offgases that contain particulates and organic contaminants. Secondary wastes that may be generated by the offgas treatment system include captured particulates, spent carbon, a concentrated organic liquid waste stream, and wastewater. The particulates may be returned to the treatment unit or disposed of offsite, while the spent carbon and concentrated organic liquid waste may be treated or disposed offsite. Any waste generated may be treated onsite and reused or shipped offsite for treatment and disposal.

3.2.2.6 Reliability

This technology has had demonstrated reliability at the full scale and has been successfully implemented at numerous contaminated sites.

3.2.2.7 Availability

There are a number of vendors that offer this technology at the full scale as well as for bench and pilot scale testing.

3.2.2.8 Cost

This technology is expected to cost from \$200 to \$450 per ton, depending on factors such as contaminant type, target contaminant concentration, and moisture content.

3.2.2.9 Public Acceptance

It is anticipated that this technology would be acceptable to the public due to past acceptance at other contaminated sites.

3.2.2.10 Contaminant Applicability

The HTTD technology is targeted for halogenated and non-halogenated SVOCs and pesticides. It is also effective on VOCs, however, LTDD would be more appropriate for these compounds. This technology is not applicable to metals or radionuclides.

3.2.2.11 Contaminant Concentration Achievable

Achievable concentrations were frequently reported as below detection limits for VOCs.

3.2.2.12 Mobilization/Demobilization

The HTTD unit is mounted on semi-trailers and transported to the site. Costs for mobilization/demobilization are expected to be in the range of \$100,000 to \$300,000.

3.2.2.13 References

DOE, 1994a
EPA, 1992a
EPA, 1993a
EPA, 1993b
EPA, 1994
VISITT, 1994

3.2.3 *Incineration*

3.2.3.1 Description

In the incineration technology the contaminated soil is heated to temperatures ranging from 1,600° to 2,200° F (871° to 1,204° C) in the presence of oxygen to volatilize and combust the organic contaminants. The offgas is sent to the offgas treatment system to remove particulates, organic compounds, and volatilized metals and radionuclides, and typically consists of a baghouse collector or cyclone separator, and a wet scrubber. Nonvolatile metals and radionuclides remain in the soil, while certain metals and radionuclides may be volatilized thereby requiring more sophisticated offgas treatment systems. Also, the metals in the soil may become less leachable after incineration. The effectiveness of the incinerator is measured as the destruction removal efficiency (DRE) and incinerators can achieve a DRE of 99.9999 percent (%) for most organic contaminants including PCBs and dioxins.

Common incineration process configurations include rotary kiln, multiple hearth, circulating fluidized bed, and infrared systems.

- Rotary Kiln Incinerators

The rotary kiln incinerator design is the primary transportable incinerator design due to its proven record over the past several years on soils and sludges. This technology consists of a slightly inclined refractory-lined cylindrical unit that rotates on its axis. The waste is fed into the elevated end and is transported through the combustion chamber via gravity. The unit is heated by combusting fuel within the kiln in the presence of oxygen. Gases from the rotary kiln are sent to the secondary combustion chamber for further destruction of organic contaminants.

- Multiple Hearth Incinerators

The multiple hearth incinerator consists of a series of circular hearths that are supported by the interior walls of the furnace. Wastes are fed into the top of the unit and are transported through each of the hearths where organic contaminants are combusted with oxygen. They are primarily used for treating wet sludges and slurries, and were originally developed for incinerating wastewater treatment sludges.

- Circulating Fluidized Bed Incinerators

For the circulating fluidized bed incinerator, air is passed through the unit at high velocity to entrain the circulating wastes, which enhances mixing and heat transfer in the combustion chamber. The particulates are separated from the gases in a solids separator cyclone and recirculated through the unit. Organic contaminants are destroyed in the combustion chamber. This technology is applicable to soils and sludges. Limestone may be added to the feed to control the generation of acid gases.

- Infrared Incinerators

Infrared incinerators operate by exposing the waste to infrared radiant heat to generate the elevated temperatures at which combustion can occur. Any organic contaminants remaining in the gas stream are oxidized in the secondary combustion chamber. The use of electrically-powered silicon carbide rods is one technique for heating the soil to combustion temperatures.

Several modifications to enhance the performance of conventional incineration systems have been developed. The use of pure oxygen rather than air has been included in recent incineration designs to increase the throughput of waste. A system has been developed that generates large-amplitude acoustical pulsations inside the incinerator, which is reported to increase mixing rates and mass transfer. Other innovations include the addition of fluxing agents to the soil to create

nodules of ash that encapsulate metals in the waste residue and produce a residue with low leachability properties.

Limitations to this technology include wastes with water content greater than 50%. Offgas treatment systems must be properly designed to remove hydrogen chloride, sulfur oxides, and other acid gases, nitrogen oxides, carbon monoxide, and volatile metals and radionuclides. Also, alkali metals such as sodium and potassium can form a sticky particulate that can cause fouling.

Incineration units are either transported to the site for onsite use or are fixed units located offsite. Incineration systems that are transportable include rotary kiln, circulating fluidized bed, and infrared incinerators. Non-transportable or offsite incinerators are found in these same process configurations and are also designed as multiple hearth processes.

Offsite incinerators are available that accept hazardous waste, but may not be permitted to accept radioactive or mixed waste. Offsite cement kilns are also available that burn hazardous waste as fuel during the production of cement, but are more applicable to liquid wastes with high British thermal unit (Btu) values rather than contaminated soils and sludges. There are 18 commercial hazardous waste incinerators that accept hazardous waste in the United States, two of which are located in South Carolina. These incinerators are the Laidlaw incinerator located in Roebuck, South Carolina and the ThermalKEM incinerator located in Rock Hill, South Carolina.

3.2.3.2 Mobility/Toxicity/Volume

This technology reduces the toxicity of the organic contaminants by the destruction of these contaminants in the primary and/or secondary combustion chambers.

3.2.3.3 Long/Short Term Effectiveness

This technology provides long term effectiveness by permanently removing the organic contaminants from the soil, and thereby protects human health and the environment from potential future exposure. There is the potential for exposure of site workers during implementation of this technology, which can be controlled with onsite engineering controls.

3.2.3.4 Regulatory/Permitting Issues

An onsite incinerator would be a treatment, storage, or disposal facility and would be required to meet the substantive requirements of a variety of federal regulations, including meeting performance-based criteria and the successful completion of a trial burn. Air permits may also be required for discharge of treated offgases.

3.2.3.5 Secondary Waste and Treatment

The offgas will require treatment to remove particulates, acid gases, and any volatilized metals and radionuclides. Secondary wastes from the offgas treatment system include particles trapped on the air filters and wastewater from the scrubbers. The wastewater may be treated onsite and used to hydrate the treated soil or shipped offsite for treatment and disposal.

3.2.3.6 Reliability

Incineration is a well established technology that has been demonstrated at the full scale on many hazardous waste remediation projects.

3.2.3.7 Availability

This technology is readily available from several remediation vendors.

3.2.3.8 Cost

This technology is estimated to cost from \$500 to \$1,000 per ton, depending on factors such as incinerator design, quantity of waste treated, water content of the waste, and types of contaminants.

3.2.3.9 Public Acceptance

Although incineration of hazardous wastes is sometimes met with resistance from local communities, it may be acceptable to the public at the SRS due to the large buffer zone that surrounds the plant. Proper design and operation of the offgas treatment system to prevent the release of noxious odors would be an important factor in minimizing public disapproval.

3.2.3.10 Contaminant Applicability

Incineration is applicable to halogenated and non-halogenated organic compounds. Certain metals and radionuclides are volatilized at the high operating temperatures, and are reported to be removed by the offgas treatment system. The leachability of metals in the treated soil may be reduced. This technology is not applicable to reactive or explosive materials.

3.2.3.11 Contaminant Concentration Achievable

Complete destruction of organic contaminants is typically achieved by incineration, yielding values of less than detection limits in the treated soil. DREs have been reported from 99.99% to 99.9999%.

3.2.3.12 Mobilization/Demobilization

Costs for mobilization/demobilization have been reported as high as \$3,000,000, requiring as many as 70 tractor trailer truck loads to transport the equipment to the site.

3.2.3.13 References

DOE, 1994d
EPA, 1990
EPA, 1993a
EPA, 1993b
Niessen, 1994
ReOpt, 1994
VISITT, 1994

3.2.4 *Pyrolysis*

3.2.4.1 Description

During pyrolysis, organic materials are broken down using heat in the presence either of limited oxygen (starved air incineration) or without oxygen altogether. Two emerging processes under this category have been identified. The first is flash pyrolysis offered by Product Control Ltd., and the second is electro pyrolysis offered by Bio-Electrics, Inc.

Electric pyrolysis, as currently being tested, is proposed for in-situ use. However, it is discussed in this section for brevity and clarity. Keeping the two emerging processes, ex-situ flash pyrolysis and in-situ electro pyrolysis, together allows for easier comparison. If the two processes become commercialized as proposed, one ex-situ and the other in-situ, it will be appropriate to discuss them separately.

- Flash Pyrolysis

Flash pyrolysis operates by exposing soil to temperatures of approximately 1,800° F (1,000° C). Organic components are vaporized, and are then exposed to a higher temperature chamber operating at 2,282° F (1,250° C) for a minimum of 2 seconds. In this secondary chamber the vapors are mixed with air or oxygen for combustion. The gas is cleaned in a high-capture gas scrubber prior to discharge. Scrubber process water is treated with a mechanical/chemical cleaning step with the soil being introduced into the pyrolysis process for treatment. The cleaned water is reused by the gas scrubber. Heavy metals that may be in the pretreated waste are concentrated in the solid end-product. Limitations of the process include treatment of liquids, treatment of solid material having more than 45% moisture, explosives (due to detonation during pyrolysis), and materials that cannot be decomposed by thermal treatment at 1,000° C.

- Electro Pyrolysis

Electro pyrolysis operates in a similar manner but it is designed for in-situ use. The contaminated area is prepared using hydrofracturing, gas fracturing, or horizontal drilling. A filling media, such as sand or a similar material, is injected into the fracture zone to fill and support the fracture openings. Two ground electrodes are introduced to the fracture zone and a 500 kiloVolt-Amp (kVA) generator is used to pass a current through the electrodes. The current heats the soil, and as the temperature of the soil increases, hydrocarbon contaminants are broken down by pyrolysis. Offgas is collected by extracting the vapor through the electrode wells. Offgas treatment is then performed.

3.2.4.2 Mobility/Toxicity/Volume

This technology acts to reduce the toxicity of the organic contaminants via permanent destruction. There is a reduction in volume associated with this technology that will be dependent on the amount of organic material present in the soil. Some sintering of metal ions may occur, potentially fixing a portion of the inorganic contaminants in the solid residue.

3.2.4.3 Long/Short Term Effectiveness

This technology has long-term effectiveness since it immediately destroys the organic contaminants in the soil. Some fixation of a portion of the inorganic ions (e.g., metals) may occur. There is the potential for exposure of site workers to the contaminants during the implementation of this technology, which can be controlled with onsite engineering controls.

3.2.4.4 Regulatory/Permitting Issues

Air permits may be required for discharge of treated offgases.

3.2.4.5 Secondary Waste and Treatment

The flash pyrolysis process has a well-integrated means of treating both solid and liquid residuals as well as offgas products. No information is available regarding secondary waste treatment for the electro pyrolysis process, which is under development.

3.2.4.6 Reliability

Flash pyrolysis has been operated at the pilot scale for over 2,000 hours with no record of breakdown. To date, there has been no pilot scale testing of the electro pyrolysis process, but it has been operated successfully at the bench scale level.

3.2.4.7 Availability

Flash pyrolysis has been used in pilot scale treatment processes. There is one full scale unit which is reportedly under design and a second unit that is under construction. The capacity of the units is planned to be two (2) tons of soil per hour. The electro pyrolysis system is available for pilot scale testing.

3.2.4.8 Cost

There are no reliable cost figures for flash pyrolysis at this time. However, it is estimated that cost would range from \$400 - \$600 per ton, depending on factors such as preprocessing requirements, site preparation, and soil moisture content. Costs for the electro pyrolysis process were not available.

3.2.4.9 Public Acceptance

Public acceptance is unknown because pyrolysis has not been implemented at the full scale level. However, it would likely be as acceptable as other transportable remediation processes.

3.2.4.10 Contaminant Applicability

Flash pyrolysis is applicable to VOCs, SVOCs, dioxins/furans, PCBs, polyaromatic hydrocarbons (PAHs), organic acids, and pesticides. Metals have been included in treatability tests with no adverse effects but no remediation with the exception of potential fixation of some metal ions. Electro pyrolysis is applicable to nonhalogenated VOCs and SVOCs, PAHs, and BTEX compounds.

3.2.4.11 Contaminant Concentration Achievable

Achievable concentrations for the flash pyrolysis process are reported at 0.5 mg/kg for phenols. No other values were included in the available information. No achievable concentrations were noted for the electro pyrolysis process.

3.2.4.12 Mobilization/Demobilization

The pyrolysis system is a transportable unit that may be brought to the site via tractor trailers. Mobilization/demobilization costs are not available at this stage of technology development.

3.2.4.13 References

EPA, 1993a
VISITT, 1994

3.2.5 *Vitrification*

3.2.5.1 Description

Vitrification is the process of heating the contaminated soil to temperatures of over 2,900° F (~1,600° C) which melts the soil and results in the pyrolysis or combustion of organic compounds. Glass forming additives may need to be blended with the soil depending on its composition. The molten glass slag is directed into a mold or drum for onsite or offsite disposal. The vitrified mass produced is chemically stable, resistant to weathering and leaching, and is predicted to be stable for thousands of years.

There are four advantages for vitrification over other treatment technologies, but vitrification also has two disadvantages. The primary advantage is immobilization of non-volatile wastes in a durable glass residue, which is resistant to leaching. The second advantage is the wide range of contaminants that can be incorporated in the waste glass without degrading its physical properties.

The third advantage is the ability of vitrification to handle organic, inorganic, and radionuclide contaminated wastes with a single technology. Inorganic compounds and radionuclides are immobilized in the glass and crystalline structure that forms from the molten slag. Organics are volatilized and destroyed by either pyrolysis or combustion. The fourth advantage of vitrification is the volume reduction of between 20% and 50% of the waste. The two disadvantages to vitrification are the costs involved due to the high energies required to heat the soil, and the potential for volatilization. Organics and some inorganics may volatilize and require offgas treatment. The offgas is sent to the offgas treatment system to remove particulates, organic compounds, and volatilized metals.

The energy for vitrification is derived from either of two sources: electric process heating and thermal process heating. Electric process heating includes three types: joule heating, plasma heating and microwave heating. Thermal process heating consists of one additional type: fossil fuel-fired heating.

- Electric Joule Heating

The electric joule heating vitrification process involves heating the contaminated soil by pressing an electric current through the soil to create a molten glass phase. Emissions of organics and metals are minimized by the presence of a relatively thick blanket of feed material above the molten glass.

- Plasma Arc Heating

The plasma arc vitrification process involves heating the soil with a plasma arc torch in a chamber that either rotates (centrifugal furnace) or remains stationary (fixed hearth). The plasma torch is produced by energizing air to its plasma state. Temperatures in excess of 9,000° F (~5,000° C) are generated in the arc, while ambient temperatures inside the unit are

approximately 2,900° F (~1,600° C). As the activated components of the plasma decay, their energy is transferred to the waste exposed to the plasma. The wastes are then broken into atoms, ionized, pyrolyzed, and finally destroyed as they interact with the decaying plasma species.

Westinghouse Electrical Corporation has developed a plasma arc cupola melting process that produces high temperatures using plasma arc technology. The waste is passed through the plasma arc where the organic contaminants are destroyed and the soils are melted to produce a vitrified mass that immobilizes metals and radionuclides.

- Microwave Heating

In microwave-heated vitrification the soil absorbs electromagnetic radiation to raise its temperature to the melting point. The soil, a dielectric or insulating material, becomes polarized by the electric field. When the electromagnetic radiation is alternated, the successive distortion of the material's molecules causes heating.

- Thermal Process (Fossil Fuel-Fired) Heating

The externally fired heating process uses fossil fuels to heat the vitrification unit to melt the soil and pyrolyze the organic contaminants. In this process, the contaminated soil is fed to a precombustor to preheat the soil, volatilize the water, and initiate oxidation of the contaminants. The soil is then fed to a heated cyclone melter to form a molten glass product.

3.2.5.2 Mobility/Toxicity/Volume

This technology reduces the mobility of the inorganic and radionuclide contaminants by binding them up within the vitrified mass, and reduces the toxicity of the organic contaminants via combustion.

3.2.5.3 Long/Short Term Effectiveness

This technology provides long term effectiveness by permanently immobilizing the inorganic and radionuclide contaminants, and removing and destroying the organic contaminants. There is the potential for exposure of site workers during implementation of this technology, which can be controlled with onsite engineering controls.

3.2.5.4 Regulatory/Permitting Issues

Air permits may be required for discharge of treated offgases.

3.2.5.5 Secondary Waste and Treatment

The offgases generated from this technology must be collected and treated prior to release to the environment. Secondary waste streams generated by the offgas treatment system include wastewater and solids trapped in the air filters.

3.2.5.6 Reliability

This technology is based on well established smelting/metallurgical methods and has been demonstrated at the pilot scale; however, full scale application is still in the development stage.

3.2.5.7 Availability

This technology is offered by a limited number of remediation vendors.

3.2.5.8 Cost

This technology is expected to cost from \$600 to \$1,000 per ton, depending on factors such as water content of waste and heating technique used to heat the vitrification unit.

3.2.5.9 Public Acceptance

This technology may be acceptable to the public but would depend on the types of wastes treated and the effectiveness of the offgas treatment system in minimizing the potential for exposure to air emissions.

3.2.5.10 Contaminant Applicability

Vitrification is applicable to metals, radionuclides, and halogenated and non-halogenated organic compounds. Some metals and radionuclides are volatilized at the high operating temperatures, and are reported to be removed by the offgas treatment system. This technology is particularly applicable to soils contaminated with organic and metal/radionuclide contamination since both general types of contaminants are treated by the system. This technology is not applicable to reactive or explosive materials.

3.2.5.11 Contaminant Concentration Achievable

This technology works by immobilizing contaminants in the vitrified mass rather than reducing contaminant concentration levels. Destruction of organic contaminants have been reported at less than 1 mg/kg in the treated soil.

3.2.5.12 Mobilization/Demobilization

The vitrification system is a transportable unit that may be brought to the site via tractor trailers. Mobilization/demobilization costs are not reported but are estimated to be less than \$300,000.

3.2.5.13 References

EPA, 1992b
EPA, 1993a
EPA, 1993b
DOE, 1994a
DOE, 1994b
DOE, 1994c
VISITT, 1994
WRS, 1993

3.3 **In-Situ Thermal Treatment Technologies**

Technology overviews are presented for two in-situ thermal treatment technologies in this section of the conceptual FS. They include Thermally Enhanced Soil Vapor Extraction (Section 3.3.1) and In-Situ Vitrification (Section 3.3.2).

3.3.1 *Thermally Enhanced Soil Vapor Extraction*

3.3.1.1 Description

In the thermally enhanced soil vapor extraction (SVE) technology, vadose zone soil heating, using electric joule or radio frequency (RF) techniques or injected steam or hot air, enhances volatilization and extraction of organic contaminants during SVE. A vapor barrier is typically installed on the ground surface to prevent short circuiting of the vapor extraction system. The organic vapors can be treated by various available techniques, such as carbon adsorption or thermal oxidation. The water vapor is condensed and treated before being discharged.

The steam or hot air enhanced extraction process accelerates contaminant removal rates by pumping steam or hot air through the soil using injection wells, and is useful in removing organic contaminants from the soil as well as the groundwater. For the electric joule and radio frequency heating techniques, a series of electrodes are placed into the vadose zone and electromagnetic energy heats the soil and enhances the removal of the contaminants. Soil can be heated to temperatures of 480° F (~250° C) and higher via the radio frequency method.

A field demonstration of in-situ RF heating was performed at the SRS as part of the DOE Office of Technology Development (OTD) Integrated Demonstration.

Limitations to this technology are tightly bound clayey soils where soil vapor extraction may be less effective. In these instances, the use of electric joule or RF heating is more effective in enhancing vapor recovery than the use of steam or hot air.

3.3.1.2 Mobility/Toxicity/Volume

This technology reduces the volume of waste by transferring the organic contaminants from the soil into a vapor stream that is subsequently treated to concentrate or destroy the contaminants.

3.3.1.3 Long/Short Term Effectiveness

This technology provides long term effectiveness by permanently removing the contaminants from the soil, and thereby protecting human health and the environment from potential future exposure. There is the potential for exposure of site workers during implementation of this technology, which can be controlled with onsite engineering controls.

3.3.1.4 Regulatory/Permitting Issues

Air permits may be required for discharge of treated offgases.

3.3.1.5 Secondary Waste and Treatment

The offgases collected by the soil vapor extraction system will contain organic contaminants that will require removal by the offgas treatment system. The contaminants may either be collected onto a carbon adsorption bed and subsequently destroyed by the carbon regeneration process, destroyed by an oxidation process, or condensed into a concentrated liquid and treated or disposed offsite. The condensed water generated may be treated onsite or shipped offsite for treatment or disposal.

3.3.1.6 Reliability

This technology has had demonstrated reliability on several full scale remediation projects. It has been shown to be effective in pilot scale demonstrations on several sites including the SRS, and has also been evaluated in the U.S. Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) program.

3.3.1.7 Availability

There are a number of vendors that offer this technology at the full scale as well as for bench and pilot scale testing.

3.3.1.8 Cost

This technology is estimated to cost from \$50 to \$175 per ton, depending on factors such as soil moisture content, soil characteristics, and target contaminant concentration.

3.3.1.9 Public Acceptance

It is anticipated that thermally enhanced SVE would be acceptable to the public due to past acceptance of SVE at other site remediation projects.

3.3.1.10 Contaminant Applicability

Thermally enhanced SVE is applicable to halogenated and non-halogenated VOCs and BTEX compounds. It is also potentially applicable to SVOCs and pesticides, but may be less effective. This technology is not applicable to metals or radionuclides.

3.3.1.11 Contaminant Concentration Achievable

Achievable concentrations were frequently reported as less than 1 part per million (ppm) for VOCs and less than 5 ppm for SVOCs.

3.3.1.12 Mobilization/Demobilization

The thermally enhanced SVE system is easily transported to the site via semi-trailers. Costs for mobilization/demobilization are not reported, but are expected to be less than \$100,000.

3.3.1.13 References

DOE, 1994b
DOE, 1994f
DOE, 1994g
EPA, 1993a
EPA, 1993b
VISITT, 1994
WRS, 1993

3.3.2 *In-Situ Vitrification*

3.3.2.1 Description

During in-situ vitrification (ISV), an electric current is applied to melt the contaminated soil in place, producing a glass and crystalline material similar to obsidian or basalt rock, which is

chemically stable and resistant to weathering and leaching. The vitrified mass is predicted to be stable for thousands of years. The inorganic contaminants and radionuclides are immobilized within the vitrified mass and the organic contaminants are destroyed by pyrolysis. The pyrolyzed byproducts migrate to the surface of the vitrified zone where they combust in the presence of oxygen. An advantage of this technology is that organics, metals and radionuclides can be treated in a single step.

ISV begins by placing four electrodes arranged in a square into the contaminated soil. To initiate the vitrification process, flaked graphite and glass frit are placed on the soil surface between the electrodes to provide a starter path for the electric current. As the melt continues downward and outward from the surface, the electrodes are lowered to the desired depth. The soil is heated to temperatures of 2,900° to 3,600° F (~1,600° to 2,000° C) in the process. The soil is melted at a rate of four (4) to six (6) tons per hour. Individual melts may be up to 1,000 tons with a width of 40 feet, and to a depth of 20 to 30 feet. Special settings to reach deep contamination are also available.

A large area of contaminated soil is treated by overlapping consecutive melts to form one continuous monolith. Since the vitrification process removes most of the void space in the soil, a volume reduction of 20% to 50% is achieved.

A stainless steel hood is placed over the processing area to collect offgases and a negative pressure is maintained in the hood to prevent gases from escaping. Gases are collected and sent to the offgas treatment system, typically consisting of a quencher, scrubber, demister, High Efficiency Particulate Air (HEPA) filter, and carbon adsorption unit before being released through a stack. A thermal oxidizer may also be used after the offgas treatment system as a polishing step.

The effectiveness of this technology is limited by large void volumes present in the soil, large amounts of rubble or debris, and high levels of combustible organics in the soil. Also, processing soil below the water table requires methods to prevent recharge into the area being treated. ISV has been demonstrated under EPA's SITE Program and full scale application has been completed at various sites.

3.3.2.2 Mobility/Toxicity/Volume

This technology reduces the mobility of inorganic and radionuclide contaminants by binding these contaminants within the vitrified mass, and reduces the toxicity of organic contaminants via pyrolysis.

3.3.2.3 Long/Short Term Effectiveness

This technology provides long term effectiveness by permanently immobilizing the inorganic and radionuclide contaminants, and removing and destroying the organic contaminants. There is the potential for exposure of site workers during implementation of this technology, which can be controlled with onsite engineering controls.

3.3.2.4 Regulatory/Permitting Issues

Air permits may be required for discharge of treated offgases.

3.3.2.5 Secondary Waste and Treatment

The offgases generated from vitrification must be collected and treated prior to release to the environment. Secondary waste streams generated by the offgas treatment system are the wet scrubber solution and solids trapped in the air filters.

3.3.2.6 Reliability

This technology has had demonstrated reliability in full scale demonstrations on at least ten sites including the DOE's Savannah River, Hanford, Oak Ridge, and Idaho National Engineering Laboratory sites, and has participated in the EPA SITE program. This technology has been selected for site remediation on a number of Superfund sites and has been initiated on at least five projects. However, at a recent large-scale test there was a sudden gas release which is a cause for some concern.

3.3.2.7 Availability

This technology is available for full scale operation and was originally developed by Batelle Pacific Northwest Laboratory for DOE in 1980. The patent is assigned to DOE, is licensed by Batelle, and is sublicensed to Geosafe Corporation.

3.3.2.8 Cost

This technology is estimated to cost from \$500 to \$800 per ton, depending on factors such as depth of contamination, amount of debris present, and whether the soil to be treated is within the saturated zone.

3.3.2.9 Public Acceptance

This technology may be acceptable to the public depending on the types of wastes treated and the effectiveness of the offgas treatment system in minimizing potential for exposure to air emissions.

3.3.2.10 Contaminant Applicability

The ISV technology is applicable to metals, radionuclides, and halogenated and non-halogenated organic compounds. Some metals and radionuclides are volatilized at the high operating temperatures. These compounds are reported to be removed by the wet scrubber and filtration step in the offgas treatment system. This technology is not applicable to reactive or explosive materials.

3.3.2.11 Contaminant Concentration Achievable

This process works by immobilizing contaminants in the vitrified mass rather than reducing contaminant concentration levels. Destruction of organic contaminants has been reported at less than 1 mg/kg in the treated soil.

3.3.2.12 Mobilization/Demobilization

The mobile ISV system is mounted on three semi-trailers, with mobilization/demobilization costs estimated at \$200,000 to \$300,000.

3.3.2.13 References

DOE, 1994b
DOE, 1994e
EPA, 1993a
EPA, 1993b
VISITT, 1994

3.4 Offgas Treatment Technologies

This section of the conceptual FS provides brief overviews of four categories of offgas treatment technologies. These technologies are targeted to primarily control organics in the thermal technology offgas. A variety of other air pollution control technologies will be required to control acid gases and particulates such as settling chambers, cyclones and inertial collectors, scrubbers, electrostatic precipitators, and fabric filters (baghouses). These technologies are not addressed in this document because they are more conventional and are widely available. This conceptual FS focuses on the following offgas treatment technologies which are primarily targeted to control organics:

- Adsorption (Section 3.4.1)
- Thermal Oxidation (Section 3.4.2)
- Catalytic Oxidation (Section 3.4.3)
- Biofiltration (Section 3.4.4)

3.4.1 *Adsorption (Offgas Treatment)*

3.4.1.1 Description

For the adsorption process, the offgas is passed through a packed bed of adsorption material where the organic contaminants adsorb to the surface of the bed material. Activated carbon is the

most common adsorption media, but resins have also been used effectively. Once the bed material becomes saturated with organic contaminants, it is replaced and either regenerated onsite, or regenerated or disposed of offsite.

The adsorption material may be regenerated by thermal techniques in which the organic contaminants are removed via combustion. Another regeneration technique is to pass an inert gas or steam through heated bed material to strip off the organic contaminants. The contaminants in the gas stream are then condensed and disposed of offsite. The use of an inert gas rather than steam in the regeneration process eliminates the creation of wastewater.

Conditions that may affect the performance of this technology include contaminant concentrations, moisture content, temperature, contact time, and flow rate. Also, adsorption capacity is normally reduced somewhat by the regeneration process.

3.4.1.2 Mobility/Toxicity/Volume

This technology acts to capture the organic contaminants from the offgas, and reduces the volume of waste by concentration onto the adsorption media.

3.4.1.3 Long/Short Term Effectiveness

This technology provides long-term effectiveness by permanently removing organic contaminants from the offgas. There are minimal short-term impacts due to this technology.

3.4.1.4 Regulatory/Permitting Issues

Air permits may be required for release of treated offgases.

3.4.1.5 Secondary Waste and Treatment

The spent adsorption material is a secondary waste that requires either onsite regeneration, or offsite regeneration or disposal.

3.4.1.6 Reliability

This technology has had widespread use for many years and has been proven highly reliable.

3.4.1.7 Availability

A number of vendors offer this technology at the full scale, and many provide regeneration services for spent adsorbent.

3.4.1.8 Cost

Cost estimates for offgas treatment vary widely depending on the underlying waste treatment technology, e.g., LTTD, HTTD, ISV, etc. The flow rate of the offgas, the contaminants and contaminants' concentrations, as well as the inlet temperature, all affect the cost of offgas treatment. Further analysis, which is beyond the scope of this report, can be found in the Air Pollution Engineering Manual (Buonicore and Davis 1992).

3.4.1.9 Public Acceptance

This technology is widely used and has been accepted by the public at other site remediation projects.

3.4.1.10 Contaminant Applicability

This process is applicable to halogenated and non-halogenated VOCs and SVOCs, and BTEX compounds.

3.4.1.11 Contaminant Concentration Achievable

Organic compounds are removed from the gas phase to over 99%.

3.4.1.12 Mobilization/Demobilization

The system is either skid- or trailer-mounted for easy transportation via tractor trailer.

3.4.1.13 References

EPA, 1993a
VISITT, 1994

3.4.2 *Thermal Oxidation (Offgas Treatment)*

3.4.2.1 Description

Thermal oxidation operates by exposing organic contaminants in the offgas to temperatures ranging from 1,830° to 2,550° F (1,000° to 1,400° C) where combustion occurs in the presence of oxygen. The offgases enter the combustion chamber and are mixed under turbulent flow conditions with combustion air and auxiliary fuel. Supplemental fossil fuels are needed when the heating value of the offgas is low. The organic contaminants are completely destroyed to carbon dioxide and water. Hydrochloric acid (HCl) is also produced when halogenated organic contaminants are combusted.

3.4.2.2 Mobility/Toxicity/Volume

This technology acts to destroy the organic contaminants from the offgas, thereby reducing the toxicity of the gas stream.

3.4.2.3 Long/Short Term Effectiveness

This technology provides long-term effectiveness by permanently removing and destroying organic contaminants from the offgas. There are minimal short-term impacts due to this technology.

3.4.2.4 Regulatory/Permitting Issues

Air permits may be required for release of treated offgases.

3.4.2.5 Secondary Waste and Treatment

No secondary wastes are generated. However, acid gas scrubbers may be necessary because HCl is produced by the combustion of halogenated organic contaminants, thereby generating wastewater that requires treatment or disposal.

3.4.2.6 Reliability

This technology has been operated successfully on many site remediation projects. The process requires frequent monitoring to maintain operating temperatures.

3.4.2.7 Availability

A number of vendors offer this technology for full scale operation.

3.4.2.8 Cost

Cost estimates for offgas treatment vary widely depending on the underlying waste treatment technology, e.g., LTTD, HTTD, ISV, etc. The flow rate of the offgas, the contaminants and contaminants' concentrations, as well as the inlet temperature, all affect the cost of offgas treatment. Further analysis, which is beyond the scope of this report, can be found in the Air Pollution Engineering Manual (Buonicore and Davis 1992).

3.4.2.9 Public Acceptance

This technology has been used on many site remediation projects where it has been acceptable to the public.

3.4.2.10 Contaminant Applicability

This technology is applicable to non-halogenated and halogenated organic compounds, and BTEX compounds.

3.4.2.11 Contaminant Concentration Achievable

Destruction of organic compounds has been demonstrated at over 99%.

3.4.2.12 Mobilization/Demobilization

The system is either skid- or trailer-mounted for easy transportation via tractor trailer.

3.4.2.13 References

DOE, 1994d
Freeman, 1989
Niessen, 1994
VISITT, 1994

3.4.3 *Catalytic Oxidation (Offgas Treatment)*

3.4.3.1 Description

Catalytic oxidation is a process that destroys organic contaminants in the offgas by passing the gas over a catalytic surface at elevated temperatures. The catalyst increases the oxidation rate of the organic contaminants thereby reducing the temperatures required for oxidation to less than 1,000° F (537° C), which is much lower than conventional thermal oxidation systems that typically operate at temperatures greater than 1,800° F (1,000° C). The catalyst may be affixed to ceramic or metal supports installed in the incinerator (fixed bed) or to small particles that are recirculated through the unit (fluidized bed). Platinum is often selected as the catalyst, however other materials are also effective including titanium, palladium, rhodium, iridium, and gold. One modification to the standard design is the application of ultraviolet (UV) light (photolysis), which allows for the unit to be operated at ambient temperatures. Offgases may require further treatment such as acid gas scrubbers to remove any HCl due to oxidation of chlorinated organic compounds.

Limitations of this technology are the potential for poisoning and masking of the catalytic surface by metals, halogens, and high molecular weight organic compounds. This may be overcome by periodic regeneration or replacement of the catalyst.

3.4.3.2 Mobility/Toxicity/Volume

This technology acts to remove and destroy the organic contaminants from the offgas, thereby reducing the toxicity of the gas stream.

3.4.3.3 Long/Short Term Effectiveness

This technology provides long-term effectiveness by permanently removing and destroying organic contaminants from the offgas. There are minimal short-term impacts due to this technology.

3.4.3.4 Regulatory/Permitting Issues

Air permits may be required for release of treated offgases.

3.4.3.5 Secondary Waste and Treatment

Spent catalyst is a secondary waste that will need to be regenerated or disposed of offsite. Also, acid gas scrubbers may be necessary if HCl is produced by the oxidation of halogenated organic contaminants, thereby generating wastewater that requires treatment or disposal.

3.4.3.6 Reliability

This process has had demonstrated reliability, but requires frequent monitoring to maintain operating temperatures.

3.4.3.7 Availability

A number of vendors offer this technology for full scale operation.

3.4.3.8 Cost

Cost estimates for offgas treatment vary widely depending on the underlying waste treatment technology, e.g., LTTD, HTTD, ISV, etc. The flow rate of the offgas, the contaminants and contaminants' concentrations, as well as the inlet temperature, all affect the cost of offgas treatment. Further analysis, which is beyond the scope of this report, can be found in the Air Pollution Engineering Manual (Buonicore and Davis 1992).

3.4.3.9 Public Acceptance

This technology has been demonstrated to be effective and is expected to be acceptable to the public.

3.4.3.10 Contaminant Applicability

This technology is applicable to non-halogenated and halogenated organic compounds, and BTEX compounds. The presence of halogenated organic compounds may require more frequent replacement of the catalyst due to poisoning or masking of the catalyst.

3.4.3.11 Contaminant Concentration Achievable

Destruction of organic compounds has been demonstrated at over 99%.

3.4.3.12 Mobilization/Demobilization

The system is either skid- or trailer-mounted for easy transportation via tractor trailer.

3.4.3.13 References

DOE, 1994d
Freeman, 1989
VISITT, 1994

3.4.4 *Biofiltration (Offgas Treatment)*

3.4.4.1 Description

Biofiltration utilizes the adsorptive properties of the soil, compost, or other organic bed media to remove organic contaminants from the offgas. As the gas is forced through the bed, the contaminants adsorb to the bed material where they are degraded by microorganisms. The adsorbed gases are continually biodegraded to carbon dioxide and water under aerobic conditions, and the degradation process continuously regenerates the bed's adsorption capacity. Oxygen, moisture, and nutrient conditions of the biofilters may require adjusting to optimize degradation rates. Treated gas can be directly released to the atmosphere or sent to a vapor phase carbon adsorption unit for polishing.

This technology may be limited by physical conditions that affect bacteria growth including extreme temperatures, extreme pH conditions, and bactericidal contaminants in high concentrations such as metals. Also, excessive buildup of biomass may cause plugging of the filtration bed, and may require periodic maintenance.

3.4.4.2 Mobility/Toxicity/Volume

This technology destroys the organic contaminants in the offgas, thereby reducing the toxicity of the gas stream.

3.4.4.3 Long/Short Term Effectiveness

This technology provides long-term effectiveness by permanently removing organic contaminants from the offgas. There are minimal short-term impacts due to this technology.

3.4.4.4 Regulatory/Permitting Issues

Air permits may be required for release of treated offgases.

3.4.4.5 Secondary Waste and Treatment

No secondary waste is generated by this process.

3.4.4.6 Reliability

Biofiltration has been proven to be effective for many years in the removal of odors from sewage, primarily in Europe and Japan.

3.4.4.7 Availability

This technology is readily available at the full scale.

3.4.4.8 Cost

Cost estimates for offgas treatment vary widely depending on the underlying waste treatment technology, e.g., LTLD, HTLD, ISV, etc. The flow rate of the offgas, the contaminants and contaminants' concentrations, as well as the inlet temperature, all affect the cost of offgas treatment. Further analysis, which is beyond the scope of this report, can be found in the Air Pollution Engineering Manual (Buonicore and Davis 1992).

3.4.4.9 Public Acceptance

This technology is expected to be readily acceptable to the public.

3.4.4.10 Contaminant Applicability

This process has been shown to be effective on nonhalogenated VOCs and SVOCs, BTEX, and PAHs.

3.4.4.11 Contaminant Concentration Achievable

The concentrations achievable are dependent on the biodegradability of the contaminants being treated. Non-halogenated organic compounds and BTEX compounds are completely biodegraded under proper operating conditions.

3.4.4.12 Mobilization/Demobilization

The biofilter and blower units are self-contained and are easily connected to the offgas treatment system. The filter units are approximately 25 x 10 x 15 feet high, and can be transported to the site via tractor trailers.

3.4.4.13 References

EPA, 1993a
VISITT, 1994

4.0 ASCAD OVERVIEW

4.1 Background

The WSRC has developed a streamlined approach to performing remedial action planning at SRS.

Three basic changes have necessitated modifications and streamlining in DOE's operations:

- An increased emphasis on cleanup
- A need for improvement in Management and Operating (M&O) contractor performance
- A national drive to reduce federal spending.

The ASCAD approach developed by WSRC offers standardized remediation designs for specified waste unit groups. The standardized remediation designs associated with the ASCAD concept will respond to these changing DOE initiatives regarding streamlining and developing new approaches to performing environmental remediation at the SRS.

The anticipated benefit from using this approach is a transition from characterization and selection of the appropriate ASCAD groupings directly to design and construction. The primary reduction in cost and schedule is expected to be related to reductions in investigations and feasibility studies and the associated risks of delays associated with each regulatory step.

4.2 ASCAD Approach

The ASCAD process components to be performed by WSRC include the following:

- Screen SRS waste units for similar contaminants and establish common waste unit groupings.
- Establish waste characterization standards for each waste unit grouping.
- Perform similar streamlined characterizations for each waste unit grouping.
- Develop/document the FS and Remedial Investigation (RI) for a grouping of waste units where possible.
- Establish a standard design basis for the corrective actions for each grouping of waste units using common technologies for common sites.

- Obtain regulator approval of the standard design basis as being the Proposed Plan/Record of Decision approved for application to any waste unit documented to meet the waste unit grouping characterization.
- Provide the regulators with verification during the process (WSRC, 1994a).

A number of benefits will potentially result from the implementation of the ASCAD concept at SRS. These potential benefits include but are not limited to the following:

- Overall characterization scope is streamlined by focusing on known contaminants of concern at each site within a waste unit grouping.
- One treatability study workplan is developed and one laboratory scale testing contract is awarded for a given waste unit grouping.
- One FS, one "standardized" Proposed Plan and one "standardized" Record of Decision are developed for each waste unit grouping.
- One SRS design review process is required for each waste unit grouping.
- One conceptual design package and one remedial design package are prepared for a given waste unit grouping.

4.3 ASCAD Waste Unit Groups

The SRS ASCAD waste unit groups are as follows:

- Group 1 Burial Ground Complex
- Group 2 Old Solvent Storage Tanks
- Group 3 Radioactive/Mixed Waste Seepage Basins and Pits
- Group 4 Coal Pile Run-off Basins
- Group 5 Process Sewer Lines
- Group 6 Pits/Piles
- Group 7 Non-Radioactive Basins
- Group 8 Sludge Application Units
- Group 9 Acid/Caustic Basins

The development of the ASCAD concept and the designation of waste units to ASCAD waste unit groups is under development. A preliminary summary of representative waste units organized by their ASCAD designation is presented in Table 4-1 (WSRC 1994b). For each waste unit listed, this summary presents the ASCAD group, estimated quantity of soil to be remediated,

and representative contaminants of concern. An additional ASCAD summary prepared in mid-1994 is also presented as Table 4-2 (WSRC 1994c). Due to the developmental status of this initiative, these lists are not complete at this time. The ASCAD group summaries that follow represent the full range of data presented in the two data sources.

Group 1 Burial Ground Complex

The Burial Ground Complex contains approximately 275,000 cubic feet (ft³) of contaminated soil located primarily in the top 30 feet of an approximate seven (7) acre area. The primary contaminants of concern include VOCs, SVOCs, metals (including mercury and lead), and radionuclides.

Group 2 Old Solvent Storage Tanks

There are 22 old solvent storage tanks which contain unknown quantities of residual materials requiring remediation. The volume of soil to be remediated is estimated to be in a range of 1,600 to 71,000 ft³. The primary contaminants of concern include organics, metals (including mercury and lead), and radionuclides. If Group 2 soils require remediation they are likely to be combined with Group 1 soils (WSRC 1994c).

Group 3 Radioactive/Mixed Waste Seepage Basins and Pits

Approximately 16 waste units have been designated in ASCAD Group 3 consisting of more than 2,300,000 ft³ of potentially contaminated soils. A wide variety of contaminants of concern are present including VOCs, SVOCs, metals including mercury and lead, and radionuclides.

Group 4 Coal Pile Run-off Basins

Eight sites have been designated in ASCAD Group 4 with over 3,000,000 ft³ of potentially contaminated soils. Coal piles on the SRS Site Evaluation List may be brought into this ASCAD group as well as lines to the basins and tanks (WSRC 1994c). Potential contaminants of concern include metals associated with coal. The soils are also very acidic.

Group 5 Process Sewer Lines

Three process sewer lines are included in this ASCAD group. Approximately 47,000 ft³ of potentially contaminated soil may require treatment. Contaminants of concern include VOCs, metals (including lead), and radionuclides.

Table 4-1. Summary of ASCAD Groups and Representative Waste Units

Waste Units	ASCAD Group	Quantity of Soil	Contaminants
Burial Ground Complex (S01-S22, 643-E, 643-7E)	1	~275,000 ft ³	tributylphosphate-kerosene; naphthalene; TCE; toluene; benzene; phenol; Pb; Cd; Hg
Tank 16 (241-H)	2	1,620 - 71,820 ft ³	Cs-137; Ag; Cr; Hg; Pb
Tank 37 CTS Line Leak (081-1H)	2	unknown (~500 lbs of high level waste)	Cs-137; Ag; Cr; Hg; Pb
Ford Building Waste Unit (643-11G)	3	~1,800 ft ³	unknown alpha; beta; and gamma emitters; PCE; trans-1,2-dichloroethylene
Old F-Area Seepage Basin	3	~1,188,000 ft ³	Cs-137; I-129; Pu-238; -239; Sr-90; Tritium; U-233; -234; -235; -238
F-Area Retention Basin (281-3F)	3	~300,000 ft ³	Cs-137; Pu-238; Sr-89; -90
H-Area Retention Basin (281-3H)	3	~400,000 ft ³	Ce-144; Cs-134; -137; Pu-238; Sr-90
R-Area Bingham Pump Outage Pits (643-8G, -9G, 10G)	3	unknown	Cs-137; Co-60; Ru-103; -106; Pm-147
R-Reactor Seepage Basins (904-57G, -58G, -59G, -60G, -103G, -104G) and 108-4R Overflow Basin (108-4R)	3	unknown	Cs-137; Co-60; Pu-239; Sr-90; tritium; Y-90
K-Area Reactor Seepage Basin (904-65G)	3	~139,200 ft ³	Cs-137; Co-60; Sr-90; tritium, PCE; TCE
K-Area Bingham Pump Outage Pits (643-1G)	3	unknown	Cs-137; Co-60; Ru-103; -106; Pm-147
Ford Building Seepage Basin (788-3A)	3	~1,800 ft ³	Cs-137; Co-60; Eu-155; Sr-90; Cd; Hg; Zn; bis (2-ethylhexyl) phthalate
TNX Burying Ground (643-5G), Old TNX Seepage Basin (904-076G)	3	unknown	U-235; -238; nitrate; nitrite
L-Area Oil and Chemical Basin	3	~51,000 ft ³	Am-241; Sb-125; Cd-109; Cs-137; Co-60; Eu-152; -154; -155; I-129; Pu-239; -240; U-235; tritium; TCE; PCE; Cd; Cr; Fe; Pb; Mn; Hg
L-Area Bingham Pump Outage Pits (643-2G, -3G)	3	unknown	Cs-137; Co-60; Ru-103; -106; Pm-147
P-Area Bingham Pump Outage Pit (643-4G)	3	unknown	Cs-137; Co-60; Ru-103; -106; Pm-147
K-Area Coal Pile Runoff Basin (189-K)	4	~366,000 ft ³	Al; As; Cd; Cr; Fe; Mn; sulfate; low pH soils
C-Area Coal Pile Runoff Basin (189-C)	4	~110,000 ft ³	Al; As; Cd; Cr; Fe; Mn; sulfate; low pH soils
P-Area Coal Pile Runoff Basin (189-P)	4	~345,000 ft ³	Al; As; Cd; Cr; Fe; Mn; sulfate; low pH soils
A-Area Coal Pile Runoff Basin (904-101G)	4	~190,000 ft ³	Al; As; Cd; Cr; Fe; Mn; sulfate; low pH soils
D-Area Ash Basin (488-D)	4	-----	-----
D-Area Coal Pile Runoff Basin (489-D)	4	~1,360,000 ft ³	Al; As; Cd; Cr; Fe; Mn; sulfate; low pH soils

Table 4-1 (Cont'd). Summary of ASCAD Groups and Representative Waste Units

Waste Units	ASCAD Group	Quantity of Soil	Contaminants
F-Area Coal Pile Runoff Basin (289-F)	4	~454,000 ft ³	Al; As; Cd; Cr; Fe; Mn; sulfate; low pH soils
H-Area Coal Pile Runoff Basin (289-H)	4	~240,000 ft ³	Al; As; Cd; Cr; Fe; Mn; sulfate; low pH soils
M-Area Settling Basin Inactive Process Sewers to Manhole 1 (081-M)	5	~13,500 ft ³	Pb; Ni; U; TCE; PCE; trichloroethane
F-Area Inactive Process Sewer Lines from Building to the Security Fence (081-1F)	5	20,250 ft ³	low-level radionuclides; metals; nitrates; low pH
H-Area Inactive Process Sewer Lines from Building to the Security Fence (081-H)	5	13,500 ft ³	low-level radionuclides; metals; nitrates; low pH
D-Area Burning/Rubble Pits (431-D, -1D)	6	~203,391 ft ³	As; Cu; Hg; Ba; Pb; Se; Cr; Ni; SVOC
F-Area Burning/Rubble Pits (231-F, -1F, -2F)	6	~54,000 ft ³	As; Cd; Cr; Pb; Hg; SVOC
Silverton Road Waste Unit	6	~210,000 ft ³	Pb; Mn; Zn; Ba; Cd; Fe; Cr; carbon tetrachloride; TCE; PCE
Burma Road Rubble Pit (231-4F)	6	unknown	Cl-C4 Hydrocarbons; BTEX; Selected Chlorinated Hydrocarbons; TOX; Tritium; Metals
Central Shops Burning/Rubble Pit (631-6G)	6	unknown	organic compounds; Hg; Cd; Cr
A-Area Rubble Pit (731-2A)	6	unknown	methane; ethane; propane; ethylene; propylene; pentane; octane; o-xylene
A-Area Burning/Rubble Pits (731-A, -1A)	6	~342,000 ft ³	2-methyl naphthalene; acetone; methylene chloride; dimethoate; di-n-butyl phthalate; carbon disulfide; toluene; xylene; As; Ba; Cd; Cr; Pb; Hg; Ni; Ag
CMP Pits(080-17G, -17.1G, -18G, -19G, -18.1G, -18.2G, -18.3G)	6	unknown	TCE; chloroform; methane; PCE
C-Area Burning/Rubble Pit (131-C)	6	~81,000 ft ³	Sb; Pb; Cd; Ni; Cu; As; Ba; Sn; V; Hg; Zn; Cr; Ag; VOC; SVOC; xylene; chlorinated solvents
Central Shops Burning/Rubble Pits (631-1G, -3G)	6	unknown	organic compounds; Hg; Cd; Cr
M-Area West (631-21G)	6	~10,000 ft ³	Pb; Sn; Zn; As; Cr; Cu; V; acetone; benzoic acid; silvex; p-dichlorobenzene; phenols; acetone; benzoic acid; dibutyl phthalate; methylene chloride; carbon disulfide; o-dichlorobenzene; octachlorodibenzo-p-dioxin
K-Area Rubble Pile (631-20G), K-Area Burning/Rubble Pit (131-K)	6	~118,800 ft ³	As; Cr; Pb; SVOC

Table 4-1 (Cont'd). Summary of ASCAD Groups and Representative Waste Units

Waste Units	ASCAD Group	Quantity of Soil	Contaminants
P-Area Burning/Rubble Pit (131-P)	6	~175,500 ft ³	Ag; Pb; Cr; methylene chloride; toluene; bis(2-ethylhexyl)phthalate; di-n-butyl phthalate; 1,1,1-trichloroethane
Central Shops Burning/Rubble Pit (631-5G)	6	unknown	organic compounds; Hg; Cd; Cr
L-Area Rubble Pit (131-3L), L-Area Burning/Rubble Pit (131-L)	6	~59,400 ft ³ to ~67,500 ft ³	Pb; As; Cr; Hg; Cd; Ba; Ag; bis(2-ethylhexyl)phthalate; methylene chloride; 2-methyl naphthalene; phenanthrene; ethyl benzene; fluoranthene; chlorinated solvents; pyrene; benzo (a) anthracene; chrysene; 1,1,1-trichloroethane; PCE; toluene; P,P-DDT
Road A Chemical Basin (904-111G)	6	~252,000 ft ³	methylene chloride; acetone; chlorobenzene; total radium
SRTC Oil Test Site (080-16G)	6	~121,500 ft ³	petroleum hydrocarbons; methane; ethylene; propylene
Hydrofluoric Acid Spill (631-4G)	6	unknown	Cd; Mn; Fe; lindane; total radium; hydrofluoric acid
R-Area Burning/Rubble Pits (131-R, -1R)	6	unknown	bis(2-ethylhexyl)phthalate; methylene chloride; ethyl benzene; trans-1,2-dichloroethane; PCE, n-nitrous diphenyl amine; acetone; toluene; TCE; 1,2-dichlorobenzene; diphenylamine; Ba; Pb; V, Cu; Cr; Zn
West of SREL "Georgia Fields" Site (631-19G)	6	unknown	chloroform; ethane; trans-1,2-dichloromethane; methane; propane; ethylene, propanol; o-xylene
L-Area Rubble Pit (131-1L)	6	unknown	volatile hydrocarbon compounds from methane to hexane
Gunsite 218 Rubble Pile (631-28G)	6	10,000 ft ³	As; Ba; Pb; Zn; Hg; Sn; V; Cr
Miscellaneous Chemical/Metal Burning Pits (731-4A, -5A)	7	~2,000 ft ³	Al; Li; Pb; chlorobenzene; chloroform; TCE; PCE
D-Area Oil Seepage Basin (631-G)	7	~202,500 ft ³ to 270,000 ft ³	Sb; As; Ba; Cd; Cr; Cu; Pb; Hg; Ni; Se; Ag; V; Zn; 2-ethylhexylphthalate; 4-methylphthalate; 4-methyl-2-pentanone; acetone, ethylbenzene; naphthalene; methylene chloride; n-nitrosodiphenylamine; phenanthrene; styrene, toluene
716-A Motor Shop Seepage Basin (904-101G)	7	~160,000 ft ³	Sb; As; Ba; Cd; Pb; Hg; Ni; Ti; V; Zn
G-Area Oil Seepage Basin (761-13G)	7	~162,000 ft ³ and ~2000 ft of pipeline	Ba; Cr; Pb; Ag; chlordane
Central Shops Sludge Lagoon (080-24G)	8	~51,300 ft ³	Ag; As; Pb; Ba; Ni; Cr; Se; Hg; Cd; chlorobenzene; 1,2-dichlorobenzene; chlordane
K-Area Sludge Land Application Site (761-4G)	8	~48.6 million ft ³	Ag; Pb; As; Se; Cr; Cd; Ni; Ba; Hg; chlordane

Table 4-1 (Cont'd). Summary of ASCAD Groups and Representative Waste Units

Waste Units	ASCAD Group	Quantity of Soil	Contaminants
Par Pond Sludge Land Application Site (761-5G)	8	78.3 million ft ³	Ag; Pb; As; Se; Cr; Cd; Ni; Ba; Hg; chlordane
L-Area Acid/Caustic Basin (904-83G, -77G)	9	~93,501 ft ³ and ~7500 ft ³ water	Sb; Cd; Cr; Fe; Pb; Mn; Hg
R-Area Acid/Caustic Basin (904-79G)	9	~463 yd ³ & ~7,500 ft ³ water	Sb; Cd; Cr; Fe; Pb; Mn; Hg

Acronyms & Abbreviations

ASCAD - Approved Standardized Corrective Action Design
ft - feet
ft³ - cubic feet
lbs - pounds
yd³ - cubic yards

SREL - Savannah River Ecological Laboratory
SRTC - Savannah River Technology Center

Compounds

BTEX - Benzene, Toluene, Ethylbenzene, and Xylene
PCE - Tetrachloroethylene
P,P-DDT - 1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane
SVOC - Semi-Volatile Organic Compound
TCE - Trichloroethylene
TOX - Total Organic Halides
VOC - Volatile Organic Compound

Elements

Ag - Silver	Ni - Nickel
Al - Aluminum	Pb - Lead
As - Arsenic	Pm - Promethium
Ba - Barium	Pu - Plutonium
Cd - Cadmium	Ru - Ruthenium
Co - Cobalt	Sb - Antimony
Cr - Chromium	Se - Selenium
Cs - Cesium	Sn - Tin
Cu - Copper	Sr - Strontium
Eu - Europium	Tl - Thallium
Fe - Iron	U - Uranium
Hg - Mercury	V - Vanadium
I - Iodine	Y - Yttrium
Li - Lithium	Zn - Zinc
Mn - Manganese	

Source: Savannah River Site Remedial Action Status Summary, dated December 2, 1994, Inter-office Memorandum from A. Suer to File.

TABLE 4-2. ASCAD Waste Unit Groups, Waste Units, And Contaminants

ASCAD Group	Waste Units	Contaminants
Group 1 - Burial Ground Complex	Burial Ground Complex	Metals, organics, radionuclides, inorganics and debris
Group 2 - Old Solvent Storage Tanks	RWBG 643-G Old Solvent Storage Tanks (S1-S22)	Organics, metals, inorganics, radionuclides
Group 3 - Radioactive/Mixed Waste Seepage Basins and Pits	Ford Bldg. SB, F-Area Retention B, H-Area Retention B, Old TNX SB, Old F-Area SB, L-Area Oil and Chem. B, R-Reactor SB, K-Area Reactor SB, TNX Burying Ground, Ford Bldg. Waste Unit, Bingham Pump Outage Pits	Metals, radionuclides, organics
Group 4 - Coal Pile Run-off Basins	Coal Pile Run-off Basins (A,C,D,F,H,K,P) and 488-D Ash Basin (Coal piles on Site Evaluation List may be brought into program. The lines to the basins and the tanks may also be included in the remediation.)	Metals and inorganics associated with coal
Group 5 - Process Sewer Lines	Process Sewer Lines	Metals, organics, radionuclides
Group 6 - Pits/Piles	SRTC Oil Test Site, Gunsite 218, R-Area BRP [131-IR, -R], A-Area BRP [731-1A, -A], A-Area RP [731-6A, -2A], CS BRPs [631-1G, -3G, -5G, -6G], Road A Chemical Basin, Burma Road RP, Georgia Fields, C-Area BRP [131-C], K-Area BRP [131-K], L-Reactor BRP [131-L, -1L, -3L], P-Reactor BRP [131-P], K-Area RP [631-20G], D-Area BRP [431-D, -1D], F-Area BRP [231-F, -1F, -2F], Silvertown Road, Metals/Burning Pit [731-4A], M-Area West, CMP Pits, Hydrofluoric Acid Spill	Organics, metals, inorganics, debris
Group 7 - Non-Radioactive Basins	108-4R Overflow, 716-A Motor Shop SB [904-101G], Miscellaneous Chemical Basin [731-5A], G-Area Oil Basin, D-Area Oil Seepage Basin	Organics, metals
Group 8 - Sludge Application Units	Par Pond Sludge Application Unit, K-Area Sludge Application Unit, Central Shops Sludge Lagoon	Chlordane, metals, organics
Group 9 - Acid/Caustic Basins	Acid/Caustic Basins (R, F, H, K, P, L)	Metals

ASCAD - Approved Standardized Corrective Action Design

Source: WSRC, 1994c. Waste Unit Groupings for Remediation, Summary Table. WSRC, May 26, 1994

Group 6 Pits/Piles

Approximately 20 sites have been designated in ASCAD Group 6 for an approximate volume of over 1,600,000 ft³ of potentially contaminated soils. Potential contaminants of concern include VOCs, SVOCs, pesticides and dioxins, and metals (including mercury and lead). While radionuclides are not considered to be contaminants of concern, their potential presence should be considered (WSRC 1994c).

Group 7 Non-Radioactive Basins

Four sites have been included in this ASCAD grouping. The volume of potentially contaminated soil exceeds 526,000 ft³. Potential contaminants of concern include VOCs, pesticides, and metals (including mercury and lead).

Group 8 Sludge Application Units

Three sites have been included in this ASCAD grouping with estimates of potentially contaminated soil exceeding 126,000,000 ft³ (WSRC 1994c and WSRC 1994b). Potential contaminants of concern primarily include pesticides (chlordan). Volatile organics and metals (including mercury and lead) may also be present.

Group 9 Acid/Caustic Basins

As many as six acid/caustic basins may be included in Group 9. Specific volume estimates are not available but the total volume is expected to exceed 93,000 ft³. Potential contaminants of concern are metals (including mercury and lead).

5.0 APPLICABILITY OF THERMAL TREATMENT TECHNOLOGIES TO ASCAD GROUPS

This section of the conceptual FS presents an evaluation of the applicability of the seven in-situ and ex-situ thermal treatment technologies to the SRS waste units characterized in the nine ASCAD waste unit groups. The evaluation of applicability is based on three general parameters: performance, cost, and implementability, which are discussed in Sections 5.1, 5.2, and 5.3, respectively. An overall evaluation of applicability is presented in Section 5.4.

5.1 Performance Evaluation

The focus of the performance evaluation includes an analysis of the operating temperature ranges of the various thermal treatment technologies with respect to the contaminants found in waste unit soils in the various ASCAD groups. Using the contaminants listed for each waste unit (Table 4-1) a summary was developed for each ASCAD group, defining the presence or absence of the following contaminant groups:

- VOCs
- SVOCs
- Pesticides/PCBs/Dioxins
- Metals
- Radionuclides.

Special challenges (e.g., mercury, cesium) are also noted. This contaminant summary by ASCAD group is depicted in the first two columns of Table 5-1.

Referring to the technology summaries presented in Section 3.0, a summary of the range of operating temperatures for each of the seven in-situ and ex-situ technologies was developed. This summary, which is presented in Figure 5-1, arrays the technologies in order of increasing operating temperature, from LTTD to ISV.

A framework that predicts technology applicability by contaminant group was then developed using the technology summaries, operating temperatures, and physical data regarding representative contaminants in each contaminant group. The framework, presented in Table 5-2, predicts treatment applicability for each technology and contaminant group combination.

The soils in each ASCAD group typically are contaminated with combinations of contaminants. This complexity was considered in assessing the performance of each technology on each ASCAD group. Table 5-1 presents the results of this assessment indicating with an "Applicable," or "Not Applicable," or "Potentially Applicable" the applicability of each technology to each ASCAD group from a technology effectiveness or performance perspective. Table 5-1 also discusses the rationale for each performance assessment.

Table 5-1. Thermal Process Performance Assessment

ASCAD GROUP	CONTAMINANTS					Estimated Soil Volume (ft ³)	EX-SITU PROCESSES					IN-SITU PROCESSES		RATIONALE FOR PERFORMANCE ASSESSMENT
	Volatile Organics	Semi-Volatile Organics	Pesticides/PCBs/Dioxins	Metals	Radionuclides		Special Challenges	Low Temperature Thermal Desorption (LTTD)	High Temperature Thermal Desorption (HTTD)	Incineration	Pyrolysis	Vitricification	Thermally Enhanced Soil Vapor Extraction (SVE)	
Group 1 Burial Ground Complex	✓	✓	-	✓	✓	Mercury	NA	A	A	A	A	NA	A	<p>RATIONALE FOR PERFORMANCE ASSESSMENT</p> <p>Waste sites in this ASCAD group contain volatile and semi-volatile organics, metals and radionuclides. All in-situ and ex-situ thermal technologies with the exception of LTTD and thermally enhanced SVE should adequately remove or destroy the organics, with subsequent off-gas treatment. Note that additional soil treatment such as solidification/stabilization will probably be required for the solid residue from ex-situ technologies other than vitricification.</p> <p>Waste sites in this ASCAD group contain volatile organics, metals, and radionuclides. LTTD and thermally enhanced SVE should adequately remove or destroy the organics. All other higher temperature technologies are also applicable. Note that additional solidification/stabilization will probably be required for the solid residue from ex-situ technologies other than vitricification.</p> <p>See ASCAD Group 1.</p> <p>Waste sites in this ASCAD group contain metals only and the soils are very acidic. In-situ or ex-situ vitricification are the only thermal processes applicable.</p> <p>See ASCAD Group 2.</p> <p>Waste sites in this ASCAD group contain volatile and semi-volatile organics, including pesticides, PCBs, or dioxins, and metals, including mercury. All in-situ and ex-situ thermal technologies with the exception of LTTD, and thermally enhanced SVE should adequately remove or destroy the organics, with subsequent off-gas treatment. HTTD is only potentially effective, due to the pesticides and dioxins, and should not be selected without treatability testing. Note that additional soil treatment such as solidification/stabilization will probably be required for the solid residue from ex-situ technologies other than vitricification.</p> <p>See ASCAD Group 6.</p> <p>See ASCAD Group 6.</p> <p>Waste sites in this ASCAD group contain metals only, including mercury. In-situ or ex-situ vitricification are the only thermal processes applicable.</p>
Group 2 Old Solvent Storage Tanks	✓	-	-	✓	✓	Mercury Cesium	A	A	A	A	A	A	A	
Group 3 Radioactive/Mixed Waste Serpent Basins and Pits	✓	✓	-	✓	✓	Mercury Cesium	NA	A	A	A	A	NA	A	
Group 4 Coal Fly Ash Run-off Basins	-	-	-	✓	-	Acidic Soil	NA	NA	NA	NA	A	NA	A	
Group 5 Process Sewer Lines	✓	-	-	✓	✓	-	A	A	A	A	A	A	A	
Group 6 Plutonium Pit/Pits	✓	✓	✓	✓	(1) Mercury	1,600,000	NA	P	A	A	A	NA	A	
Group 7 Non-Radioactive Basins	✓	✓	✓	✓	-	Mercury	NA	P	A	A	A	NA	A	
Group 8 Sludge Application Units	✓	✓	✓	✓	-	Chloride Mercury	NA	P	A	A	A	NA	A	
Group 9 Acid/Caustic Basins	-	-	-	✓	-	Mercury	93,000	NA	NA	NA	NA	NA	A	

(1) It is questionable whether radionuclides are of concern in ASCAD Group 6. Based on the available data shown on Table 4-1, the only waste site in ASCAD Group 6 with radionuclides detected in the soil is the Burma Road Rubble Pit (231-4F). Also, Table 4-2 does not list radionuclides as a contaminant of concern for ASCAD Group 6. This analysis assumes that radionuclides are not present in this group.

Legend:
A - Applicable
NA - Not Applicable
P - Potentially Applicable

Figure 5-1

Range of Operating Temperatures for Thermal Treatment Technologies

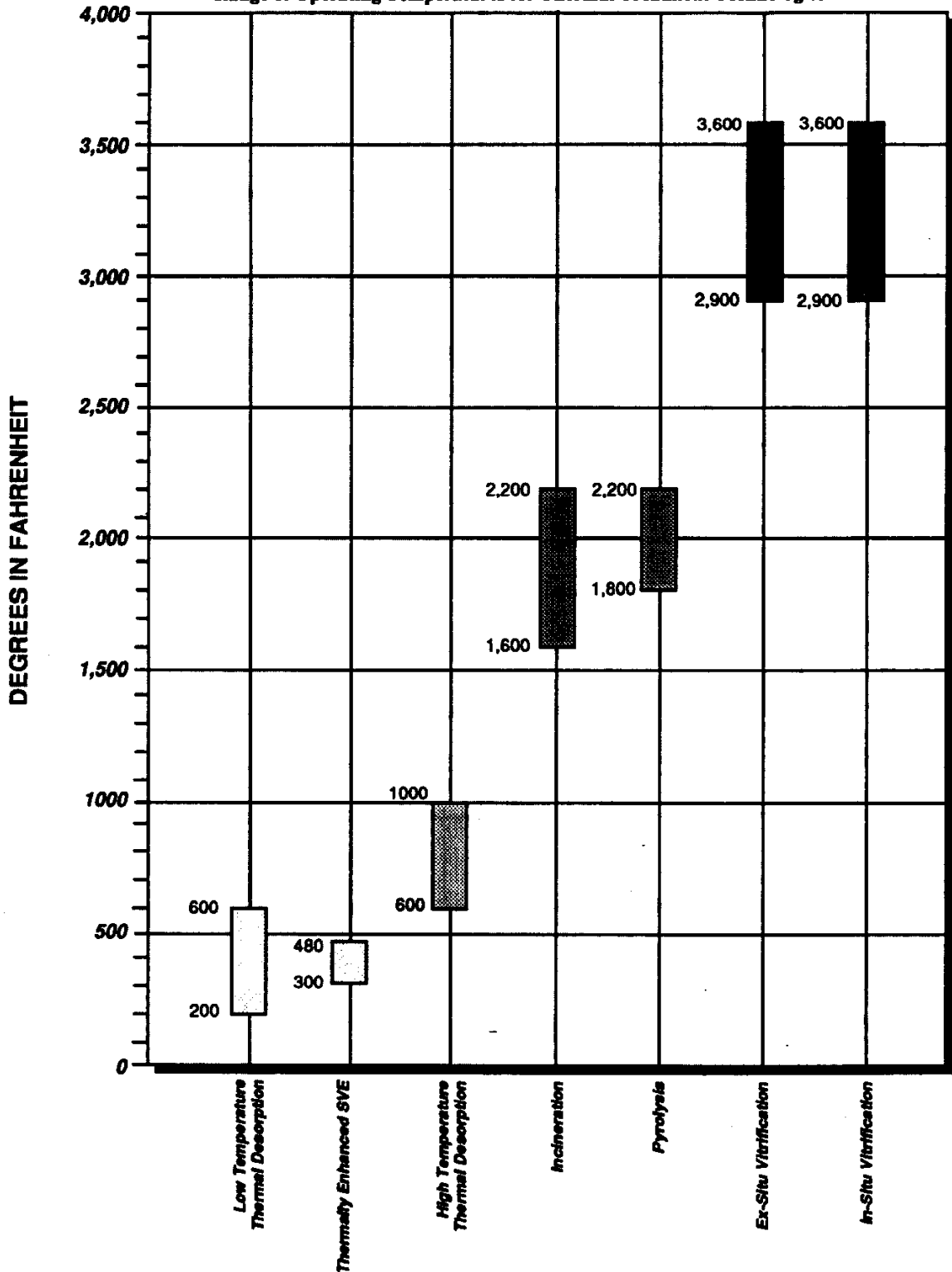


Table 5-2. Technology Applicability by Contaminant Group

Technology		Contaminant Group				
		Volatile Organics	Semi-Volatile Organics	Pesticides/PCBs/ Dioxins	Metals	Radionuclides
Ex-Situ	Low Temperature Thermal Desorption	A	P	P	NA	NA
	High Temperature Thermal Desorption	A	A	P	NA	NA
	Incineration	A	A	A	NA	NA
	Pyrolysis	A	A	A	NA	NA
	Vitrification	A	A	A	A	A
In-Situ	Thermally Enhanced Soil Vapor Extraction	A	P	NA	NA	NA
	Vitrification	A	A	A	A	A

Legend:

- A - Technology is applicable for this contaminant group.
- P - Technology is potentially applicable for this contaminant group.
- NA - Technology is not applicable for this contaminant group.

The results of the performance assessment can be summarized as follows:

- ASCAD Groups 1 and 3 have similar contaminants (VOCs, SVOCs, metals, and radionuclides). LTTD and thermally enhanced SVE are the two technologies that were excluded from consideration due to the presence of SVOCs in these soils.
- ASCAD Groups 2 and 5 have similar contaminants (VOCs, metals, and radionuclides). All seven technologies are potential candidates for consideration.
- ASCAD Groups 4 and 9 have similar contaminants (metals only). In-situ or ex-situ vitrification are the only applicable thermal treatment technologies.
- ASCAD Groups 6, 7, and 8 have similar contaminants (VOCs, SVOCs, pesticides/PCBs/dioxins, and metals). LTTD and thermally enhanced SVE are the two technologies that were excluded from consideration due to the presence of SVOCs, pesticides PCBs, and dioxins. HTTD was listed as "Potentially Applicable" due to the uncertainty of effectiveness on pesticides and dioxins.

5.2 Cost Evaluation

The cost evaluation is focused on estimated unit costs supplied by the technology vendors that are presumed to be present worth costs. These unit cost estimates do not include the cost of excavating the waste material and transporting it to the ex-situ treatment unit. The costs also exclude any estimate of solid residue treatment and/or disposal, if applicable, for ex-situ technologies. Figure 5-2 presents a summary of the range of costs for the seven technologies evaluated in this conceptual FS. This summary arrays the technologies in increasing cost from thermally enhanced SVE through incineration and ex-situ vitrification.

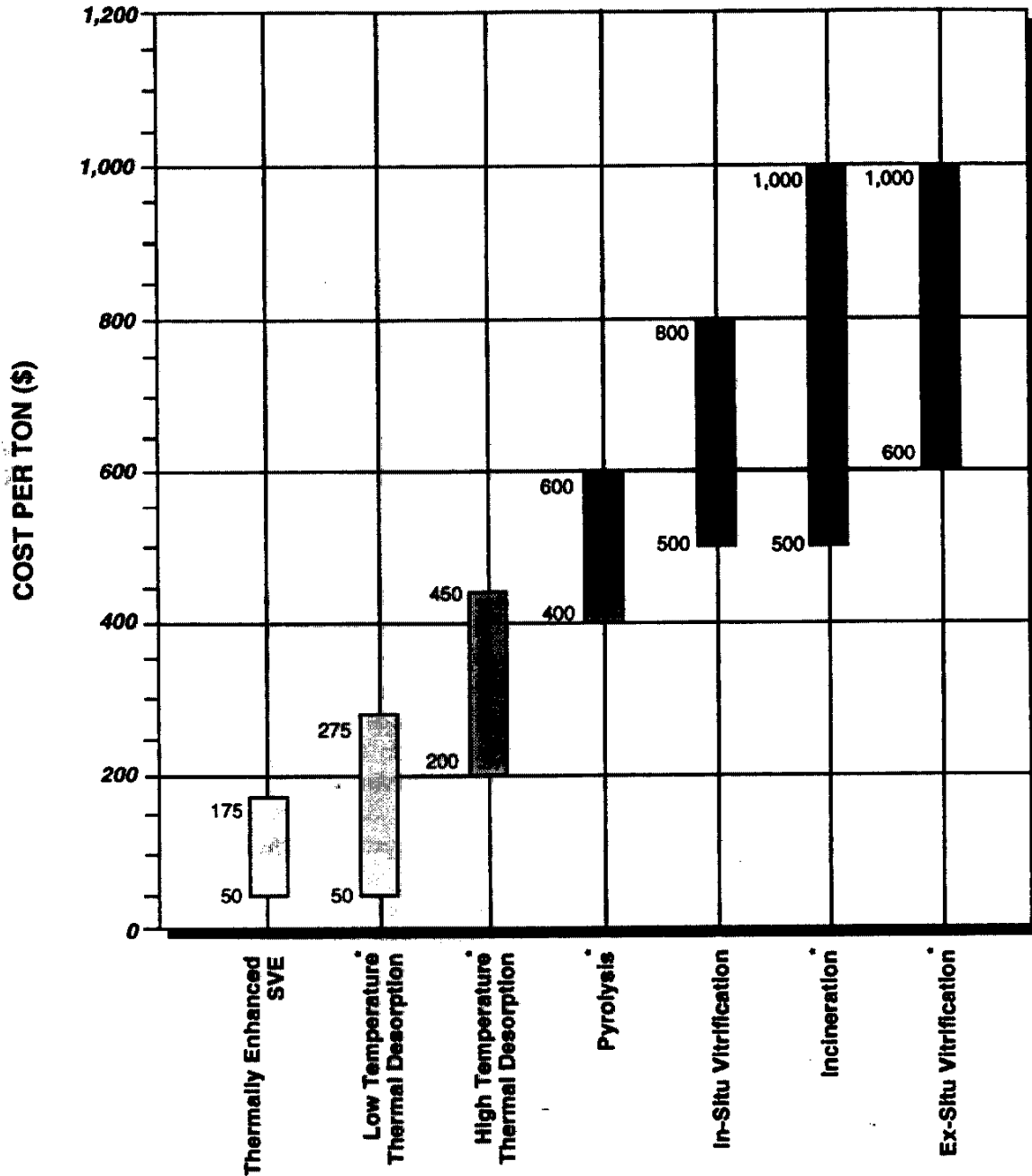
This cost information is further summarized in Table 5-3, providing the following:

- Unit costs in \$/ton categorized as high, medium, or low
- Notation whether excavation is needed (no unit costs are estimated)
- Notation whether residual solids treatment is needed (no unit costs are estimated)
- Estimated one-time mobilization/demobilization costs in thousands of dollars.

The results of the cost assessment provided in Table 5-3 can be summarized as follows:

- LTTD, HTTD, and thermally enhanced SVE have "Low" unit costs ranging from \$50/ton to \$450/ton.
- Pyrolysis and in-situ vitrification have "Medium" unit costs ranging from \$400/ton to \$800/ton.

Figure 5-2
Range in Costs for Thermal Treatment Technologies



* This cost does not include either the cost of excavating the waste material and transporting it to the ex-situ treatment unit or the cost of solid residue treatment and/or disposal, if applicable.

Table S-3. Summary Evaluation of Thermal Treatment Technologies

THERMAL TREATMENT PROCESSES	POTENTIAL APPLICABILITY						LOCALIZATION	COST						IMPLEMENTABILITY						GENERAL COMMENTS	
	Volatiles Organics	Semi-Volatile Organics	Pesticides/PCBs/Dioxins	Metals	Radionuclides	Temperature Range (°F)		On-Site	Off-Site	Low (\$ / Ton)	Medium (\$ / Ton)	High (\$ / Ton)	Excavation Needed	Solids Treatment Needed	Mob/Demob (\$ in Thousands)	Mob/Demob Effort	Public Acceptance	Availability	Air Permit Required		Demonstration Status
EX-SITU PROCESSES	1. Low Temperature Thermal Desorption	A	P	P	NA	NA	200-600	Y	-	50-275	-	-	A	A	10-100	Low	High	High	P	Full Scale	<p>GENERAL COMMENTS</p> <p>1. Well developed and widely available. Desorption process only. All org destruction occurs in offgas treatment.</p> <p>2. Well developed and widely available. Desorption process only. All org destruction occurs in offgas treatment.</p> <p>3. Well developed and widely available. Relies upon destruction and desorption in primary chamber and destruction in offgas treatment. Few record of public acceptance. Optional offsite locations.</p> <p>4. Pilot scale demonstration to date. Limited availability. In-situ system (electron pyrolysis) under development.</p> <p>5. Pilot scale demonstrations to date. Up to 50% volume reduction with single-step treatment of organics, metals, and radionuclides.</p>
	2. High Temperature Thermal Desorption	A	A	P	NA	NA	600-1000	Y	-	200-450	-	-	A	A	100-300	Low	High	High	P	Full Scale	
	3. Incineration	A	A	A	NA	NA	1600-2200	Y	Y	-	-	500-1000	A	A	3000	High	Low	High	A	Full Scale	
	4. Pyrolysis	A	A	A	NA	NA	1800-2200	Y	-	-	400-600	-	A	A	Unk.	Low	Unk.	Limited	P	Pilot Scale	
	5. Verification	A	A	A	A	A	2900-3600	Y	-	-	-	500-800	A	NA	<300 est.	Med	Unk.	Med	P	Pilot Scale	
IN-SITU PROCESSES	1. Thermally Enhanced Soil Vapor Extraction	A	P	NA	NA	NA	300-480	Y	-	50-175	-	-	NA	NA	100 est.	Low	High	High	P	Full Scale	
	2. Verification	A	A	A	A	A	2900-3600	Y	-	-	-	300-800	NA	NA	200-300	Med	Unk.	Limited	P	Full Scale	

Legend:

- A - Applicable
- Med - Medium
- NA - Not Applicable
- P - Potentially Applicable
- Unk. - Unknown

- Ex-situ vitrification and incineration have "High" unit costs ranging from \$500/ton to \$1000/ton.
- All five ex-situ technologies will require the additional cost of excavating and transporting soil to the treatment unit. The in-situ technologies do not require excavation.
- All ex-situ technologies with the exception of vitrification will likely require treatment of the solid residual prior to disposal. The two in-situ technologies and ex-situ vitrification are not likely to require solids treatment.
- Estimates of one-time mobilization and demobilization costs were consistently in the \$100,000 to \$300,000 range with the exceptions of LTDD, which may be as low as \$10,000 for simple BTEX-contaminated soils, and onsite incineration, which is estimated to cost approximately \$3,000,000 to mobilize due to the complexity of the treatment train.

5.3 Implementability Evaluation

The implementability evaluation is focused on a variety of factors that may affect ease of implementation. These factors include the following:

- Mobilization/Demobilization Effort
- Public Acceptance
- Availability
- Air Permit Required
- Demonstration Status.

Table 5-3 presents a summary of these issues for each technology. These data were extracted from the technology overviews presented in Section 3.0 and represent data available in secondary source material and best engineering judgment.

The results of the implementability evaluation provided in Table 5-3 can be summarized as follows:

- Mobilization/demobilization is expected to be of "High" complexity for onsite incineration and of "Medium" complexity for in-situ or ex-situ vitrification. It is expected to be of "Low" complexity for all other technologies.

- Public acceptance is expected to be "Low" for onsite incineration, and it is "Unknown" for in-situ and ex-situ vitrification and pyrolysis due to limited experience. It is expected to be "High" for the two thermal desorption technologies and the thermally enhanced SVE technology.
- Availability is expected to be "Limited" for pyrolysis and in-situ vitrification. It is expected that ex-situ vitrification has "Medium" availability and that the availability is "High" for the other technologies.
- Air permits will be required for onsite incineration. They are potentially required for the other technologies.
- Ex-situ vitrification and pyrolysis have only been demonstrated at the pilot scale. All other technologies have been demonstrated at full scale.

5.4 Overall Evaluation

An overall evaluation has been prepared factoring performance, cost, and implementability for each treatment technology and ASCAD group. All technologies that are expected to have effective performance are retained as potentially applicable regardless of cost or implementability factors. Table 5-4 presents this evaluation of applicable technologies for each ASCAD group.

Further evaluations of technology applicability and the need for additional performance and cost data are described in Section 6.0, Conclusions and Recommendations.

Table 5-4. Potentially Applicable Thermal Treatment Technologies for Each ASCAD Group

ASCAD GROUP	*EX-SITU PROCESSES					*IN-SITU PROCESSES	
	Low Temperature Thermal Desorption **	High Temperature Thermal Desorption **	Incineration **	Pyrolysis **	Vitrification	Thermally Enhanced Soil Vapor Extraction	Vitrification
Group 1 Burial Ground Complex	NA	A	A	A	A	NA	A
Group 2 Old Solvent Storage Tanks	A	A	A	A	A	A	A
Group 3 Radioactive/Mixed Waste Seepage Basins and Pits	NA	A	A	A	A	NA	A
Group 4 Coal Pile Run-off Basins	NA	NA	NA	NA	A	NA	A
Group 5 Process Sewer Lines	A	A	A	A	A	A	A
Group 6 Pits/Piles	NA	P	A	A	A	NA	A
Group 7 Non-Radioactive Basins	NA	P	A	A	A	NA	A
Group 8 Sludge Application Units	NA	P	A	A	A	NA	A
Group 9 Acid/Caustic Basins	NA	NA	NA	NA	A	NA	A

* Off-gas treatment will be required.

** Treatment of solid residues will be required.

Legend:

A - Applicable

NA - Not Applicable

P - Potentially Applicable

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Preliminary Thermal Treatment Technology Alternatives

The conceptual FS presented in this report is based on preliminary information regarding contaminants present at waste units and potential contaminated soil volumes. For the purposes of this report the contaminant characteristics of the individual ASCAD groups, were only looked at in broad categories, viz., organics, metals, pesticides, and radionuclides. This approach did allow for discussion of potential thermal treatment technologies for different soil contaminants. Additional data and a more detailed analysis are required to make final technology selections.

In-situ and ex-situ approaches have been considered for each ASCAD group. These alternatives are summarized in Table 6-1 and discussed more fully in the following subsections. Recommendations for the technology evaluations, treatability studies, and economic analyses that will be required in order to make final technology selections are also discussed. ASCAD groups with similar contaminant categories are listed together.

6.1.1 Alternatives for ASCAD Groups 1, 2, 3 and 5

Four ASCAD groups contain organics, metals, and radionuclides for a total estimated volume of contaminated soil of 2,700,000 ft³. These groups are:

- ASCAD Group 1 - Burial Ground Complex with 275,000 ft³
- ASCAD Group 2 - Old Solvent Storage Tanks with 71,000 ft³
- ASCAD Group 3 - Radioactive/Mixed Waste Seepage Basins and Pits with 2,300,000 ft³
- ASCAD Group 5 - Process Sewer Lines with 47,000 ft³.

These soils contain SVOCs, but they do not contain pesticides/PCBs/dioxins; therefore, organic treatment should be successful with HTTD or any thermal process operating at a higher temperature range. Because the costs of HTTD are significantly lower than other higher temperature processes with similar performance, HTTD is the most cost effective applicable technology. This conceptual FS assumes that organic, metal, and radionuclide concentrations are above action levels and therefore require treatment.

Table 6-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 1 - Burial Ground Complex	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 2 - Old Solvent Storage Tanks	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 3 - Radioactive/Mixed Waste Seepage Basins and Pits	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

Table 6-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives (Cont'd)

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 4 - Coal Pile Run-off Basins	Metals	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies (e.g., in-situ solidification/stabilization) may be more appropriate and should be evaluated.	Ex-situ vitrification with offgas treatment may be appropriate. Other non-thermal treatment technologies (e.g., ex-situ solidification/stabilization or potential extraction with soil washing) may be more appropriate and should be evaluated.
Group 5 - Process Sewer Lines	Organics, Metals, and Radionuclides	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.	High temperature thermal desorption may be appropriate followed by solidification/ stabilization, and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 6 - Pits/Piles	Organics, Pesticides, and Metals	An in-situ thermal treatment approach is not recommended due to the high volume of soils. Other non-thermal treatment technologies may be appropriate and should be evaluated.	If proven effective for pesticides, high temperature thermal desorption may be appropriate followed by solidification/ stabilization and required offgas and effluent treatment. Other thermal treatment (pyrolysis or incineration) may also be appropriate, followed by offgas, effluent, and residual treatment. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

Table 6-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives (Cont'd)

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 7 - Non-Radioactive Basins	Organics, Pesticides, and Metals	An in-situ thermal treatment approach is not recommended due to the high volume of soils. Other non-thermal treatment technologies may be appropriate and should be evaluated.	If proven effective for pesticides, high temperature thermal desorption may be appropriate followed by solidification/ stabilization and required offgas and effluent treatment. Other thermal treatment (pyrolysis or incineration) may also be appropriate, followed by offgas, effluent, and residual treatment. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
Group 8 - Sludge Application Units	Organics, Pesticides, and Metals	An in-situ thermal treatment approach is not recommended due to the high volume of soils. Other non-thermal treatment technologies may be appropriate and should be evaluated.	If proven effective for pesticides, high temperature thermal desorption may be appropriate followed by solidification/ stabilization and required offgas and effluent treatment. Other thermal treatment (pyrolysis or incineration) may also be appropriate, followed by offgas, effluent, and residual treatment. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

Table 6-1. Preliminary SRS Soil Thermal Treatment Technology Alternatives (Cont'd)

ASCAD Group	Contaminant Categories	In-Situ Thermal Treatment Approach*	Ex-Situ Thermal Treatment Approach*
Group 9 - Acid/Caustic Basins	Metals	In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies (e.g., in-situ solidification/stabilization) may be more appropriate and should be evaluated.	Ex-situ vitrification with offgas treatment may be appropriate. Other non-thermal treatment technologies (e.g., ex-situ solidification/stabilization or potential extraction with soil washing) may be more appropriate and should be evaluated.

* These alternatives are preliminary in nature, based upon a conceptual Feasibility Study that considered only thermal treatment technologies. Site characterization, treatability testing, and economic analyses are required prior to the development of final technology selections.

It is recommended that targeted characterization of the wastes for each ASCAD group be performed. Then treatability studies and economic analyses are recommended to determine the following:

- **Treatability Studies**
 - Thermal treatment effectiveness in desorbing/destroying organic contaminants with HTTD prioritized first. If successful no other ex-situ studies may be required. In-situ vitrification should also be tested.
 - Leachability of organic, metal, and radionuclide contaminants in solid residuals.
 - Effectiveness of effluent and offgas treatment systems with special attention to mercury control.
 - Effectiveness of residual treatment systems for metal and radionuclide control (e.g., soil washing, solidification/stabilization).
- **Economic Analysis**
 - Excavation costs/transportation costs
 - Mobilization/demobilization costs
 - Primary treatment costs
 - Costs of effluent, offgas, and residual treatment, if applicable.

These future analyses will provide the necessary data to make the final technology selections.

For the purposes of this conceptual FS, the following preliminary thermal treatment technology alternatives are offered:

- **In-Situ Approach** - In-situ vitrification with offgas treatment may be appropriate depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
- **Ex-Situ Approach** - HTTD may be appropriate followed by solidification/stabilization and offgas and effluent treatment, as required. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

6.1.2 Alternatives for ASCAD Groups 4 and 9

Two ASCAD groups contain metals only: ASCAD Group 4, the Coal Pile Run-Off Basins with over 3,000,000 ft³ of acid soil, and ASCAD Group 9, the Acid/Caustic Basins, with approximately 93,000 ft³ of soil. These soils require treatment for the extraction or binding of the metal contaminants only. Therefore, it is recommended that targeted characterization of the wastes for each ASCAD group be performed. Then technology evaluations, treatability studies, and economic analyses are recommended for both thermal and non-thermal technologies to determine the following:

- Technology Evaluations
 - Applicability and implementability of specific thermal and non-thermal technologies (e.g., "Can ISV be performed to the depth required? What non-thermal technologies are potentially applicable and implementable?").
- Treatability Studies
 - Technology effectiveness in extracting or binding metals including TCLP analyses. Evaluation should include but not be limited to in-situ and ex-situ vitrification, solidification/stabilization, and extraction technologies such as soil washing.
 - Leachability of metal contaminants in solid residuals.
 - Effectiveness of effluent and offgas treatment systems.
 - Effectiveness of residual treatment systems, if applicable.
- Economic Analyses
 - Excavation costs/transportation costs
 - Mobilization/demobilization costs
 - Primary treatment costs
 - Offgas, effluent, and residual treatment costs, if applicable.

These future analyses will provide the necessary data to make the final technology selections for metals-contaminated soils.

For the purposes of this conceptual FS, the following preliminary thermal treatment technology alternatives are offered:

- In-Situ Approach - In-situ vitrification with offgas treatment depending on the volume of the waste unit. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
- Ex-Situ Approach - Ex-situ vitrification with offgas treatment may be appropriate. Other non-thermal treatment technologies may be more appropriate and should be evaluated

Note that other non-thermal treatment technologies may be more appropriate, particularly because the soils in ASCAD Groups 4 and 9 contain only metal contamination. Non-thermal technologies to be considered include in-situ solidification/stabilization (s/s), ex-situ s/s, and soil washing with offgas and effluent treatment, as required.

6.1.3 Alternatives for ASCAD Groups 6, 7 and 8

Three ASCAD groups contain organics, pesticides/PCBs/dioxins, and metals for a total estimated volume of contaminated soil of over 128,000,000 ft³:

ASCAD Group 6 - Pits/Piles with 1,600,000 ft³
ASCAD Group 7 - Non-Radioactive Basins with 526,000 ft³
ASCAD Group 8 - Sludge Application Units with 126,000,000 ft³.

Due to the presence of pesticides and some dioxins and their precursors in these soils, HTTD was listed as only a potential technology. Other higher temperature thermal processes are expected to be effective on these soils. HTTD should be carefully evaluated through treatability studies involving performance optimization to determine actual effectiveness on these soils.

If HTTD proves to be effective, it could represent a significant cost advantage over other ex-situ thermal processes. This conceptual FS assumes that organic, pesticide and metal concentrations are above action levels and therefore require treatment. Given the large volumes of contaminated soils in ASCAD Groups 6, 7 and 8, in-situ technologies are not expected to be practicable; therefore they are not recommended or addressed.

It is recommended that targeted characterization of the wastes to identify hot spots be performed. All methods of reducing the volume of soils requiring treatment through statistically-based

sampling are recommended. The treatability studies and economic analyses are recommended to determine the following:

- **Treatability Studies**
 - Thermal treatment effectiveness in desorbing/destroying organic contaminants, with HTTD prioritized first. If HTTD is successful, through higher temperature operation and process optimization, additional ex-situ thermal testing would not be required. Different thermal treatment units or operating parameters may effect dioxin formation and should be evaluated.
 - Leachability of organic and metal contaminants in solid residues.
 - Effectiveness of effluent and offgas treatment systems with special attention paid to monitoring the potential for dioxin formation in the air pollution control equipment, and to mercury control.
 - Effectiveness of residual treatment systems for metals control (e.g., solidification/stabilization).
- **Economic Analyses**
 - Excavation costs/transportation costs
 - Mobilization/demobilization costs
 - Primary treatment costs
 - Costs of effluent, offgas, and residual treatment, if applicable.

These future analyses will provide the necessary data to make the final technology selections.

For the purposes of this conceptual FS, the following preliminary thermal treatment technology alternatives are offered:

- **In-Situ Approach** - An in-situ approach is not recommended due to the high volume of soil requiring treatment. Other non-thermal treatment technologies may be more appropriate and should be evaluated.
- **Ex-Situ Approach** - HTTD, may be appropriate if it is proven to be effective. Otherwise, another thermal unit that can most cost effectively treat these organic contaminants may be appropriate. Special attention should be given to the air pollution control equipment. Residue treatment such as solidification/stabilization

should be used for metals. Other non-thermal treatment technologies may be more appropriate and should be evaluated.

6.2 Recommendations for Additional Study

Examples of the types of additional information required include, but are not limited to, the following:

- Contaminant concentrations
- Lateral and vertical extents of contamination above action levels
- Soil characteristics that may affect treatment technology performance
- Treatment technology effectiveness on contaminant mixtures, determined through treatability testing
- Soil cleanup levels.

The ASCAD approach is a promising framework for streamlining this data collection effort and subsequent technology selection decision making. The following basic approaches are recommended to support the technology selection process.

1. Using the ASCAD groupings to select statistically representative soils for testing, targeted characterization should be performed including (1) total waste analyses; (2) toxicity characteristic leaching procedure (TCLP) analyses for metals and organics with TCLP limits; and (3) radioisotopic analyses. Soil physical characteristics should also be assessed.
2. An evaluation of soil action levels and cleanup levels for in-situ actions and ex-situ actions with subsequent land disposal should be performed. Action levels and cleanup levels should be compared to the soil data to support the identification of soils requiring treatment.
3. Technical evaluations of other non-thermal technologies; treatability studies of thermal and non-thermal technologies using representative soils from the ASCAD groups; and economic analyses of all components of the treatment process from excavation through offgas and residual treatment and disposal should be performed.

The final technology evaluation and selection process should be based upon the results of these studies.

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