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INITIAL SCREENING OF ALTERNATIVES FOR OPERABLE UNIT 1 TASK 12 REPORT JANUARY 1991

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TASK 12 REPORT

FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

REMEDIAL INVESTIGATION and FEASIBILITY STUDY

January 1991

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

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TABLE OF CONTENTS

	Page
List of Tables	x
List of Figures	xi
List of Acronyms	xii
Distribution List	xiv
Executive Summary	ES-1
1.0 Introduction	1-1
1.1 Background	1-3
1.1.1 Site Description	1-3
1.1.2 Site History	1-7
1.1.2.1 Waste Pit 1	1-7
1.1.2.2 Waste Pit 2	1-9
1.1.2.3 Waste Pit 3	1-9
1.1.2.4 Waste Pit 4	1-10
1.1.2.5 Waste Pit 5	1-10
1.1.2.6 Waste Pit 6	1-11
1.1.2.7 Burn Pit	1-11
1.1.2.8 Clearwell	1-12
1.1.3 Nature and Extent of Contamination	1-12
1.1.3.1 Radiological Composition	1-12
1.1.3.2 Chemical Composition	1-16
1.1.4 Contaminant Fate and Transport	1-18
1.1.5 Baseline Risk Assessment	1-19
1.2 Purpose and Organization of Report	1-19
2.0 Remedial Action Objectives	2-1
2.1 Point of Compliance	2-2
2.2 Contaminants of Concern	2-3
2.3 Remedial Action Objectives Based on Applicable or Relevant and Appropriate Requirements	2-3
2.4 Remedial Action Objectives Based on Risk Criteria	2-3
2.5 Chemical Specific Remedial Action Objectives	2-9
2.6 Summary of Operable Unit 1 Remedial Action Objectives	2-9
2.6.1 Pit Wastes	2-9
2.6.2 Air	2-9
2.6.3 Soils	2-9
2.6.4 Surface Water and Sediment	2-9
2.6.5 Groundwater	2-18
3.0 General Response Actions	3-1

TABLE OF CONTENTS
(Continued)

	Page
3.1 No Action	3-1
3.2 Institutional Actions	3-1
3.3 Containment	3-1
3.4 Removal/Disposal	3-1
3.5 Containment/Treatment	3-2
3.6 Removal/Treatment/Disposal	3-2
4.0 Identification and Screening of Technologies and Process Options	4-1
4.1 Screening Criteria	4-2
4.2 Technology Descriptions and Evaluations	4-2
4.2.1 Initial Screening: Perched Groundwater, Standing Water, and Excavation/Remediation Water	4-2
4.2.1.1 No action	4-2
4.2.1.2 Institutional Actions	4-7
4.2.1.3 Containment	4-7
4.2.1.4 Removal	4-8
4.2.1.5 Treatment	4-8
4.2.1.6 Discharge	4-9
4.2.1.7 Summary of Technology Screening for Groundwater	4-9
4.2.2 Initial Screening: Soils, Sediments, and Pit Waste	4-9
4.2.2.1 No action	4-10
4.2.2.2 Institutional Actions	4-10
4.2.2.3 Containment	4-10
4.2.2.4 Removal	4-11
4.2.2.5 Treatment	4-12
4.2.2.6 On-Property Disposal	4-13
4.2.2.7 Off-Site Disposal	4-15
4.2.2.8 Summary of Technology Screening	4-15
4.2.3 Initial Screening: Air (Fugitive Dust)	4-16
4.2.3.1 No Action	4-16
4.2.3.2 Institutional Actions	4-16
4.2.3.3 Containment	4-16
4.2.3.4 Removal	4-16
4.2.3.5 Treatment	4-17
4.2.3.6 On-Property Disposal	4-17
4.2.3.7 Off-Site Disposal	4-17

TABLE OF CONTENTS
(Continued)

	Page
4.2.3.8 Summary of Technology for Air (Fugitive Dust)	4-17
4.3 Technology Issues	4-17
4.3.1 Nonremoval Technology Issue 1: Naturally Occurring Materials Versus Synthetic Closure Cap Components	4-18
4.3.1.1 Decision Factors	4-18
4.3.1.2 Screening Results	4-18
4.3.2 Nonremoval Technology Issue 2: Physical Stabilization Versus No Stabilization of the Waste Pits	4-20
4.3.2.1 Decision Factors	4-20
4.3.2.2 Screening Results	4-20
4.3.3 Nonremoval Technology Issue 3: Dynamic Compaction as a Physical Stabilization Technology	4-22
4.3.3.1 Decision Factors	4-22
4.3.3.2 Screening Results	4-22
4.3.4 Nonremoval Technology Issue 4: The addition of Shallow Soil Mixing Technology to Physical Stabilization Options	4-23
4.3.4.1 Decision Factors	4-23
4.3.4.2 Screening Results	4-23
4.3.5 Removal Technology Issue 1: Off-Site Waste Disposal - Trucking Versus Railroad Transport	4-23
4.3.5.1 Decision Factors	4-23
4.3.5.2 Screening Results	4-26
4.4 Site Condition Assumptions	4-26
5.0 Evaluation of Process Options	5-1
5.1 Screening Criteria	5-1
5.1.1 Effectiveness Evaluation	5-1
5.1.2 Implementability Evaluation	5-1
5.1.3 Cost Evaluation	5-6
5.2 Evaluation of Process Options	5-6
5.2.1 No-Action Process Options	5-6
5.2.2 Monitoring Process Options	5-6
5.2.3 Access Control Process Options	5-7
5.2.4 Run-on/Runoff Control Process Options	5-8
5.2.5 Capping Process Options	5-9
5.2.6 Subsurface Flow Control Process Options	5-9
5.2.7 In Situ Stabilization Process Options	5-10
5.2.8 Water Treatment	5-12

000005

TABLE OF CONTENTS
(Continued)

	Page
5.2.9 Groundwater Removal	5-13
5.2.10 Mechanical Removal Process Options	5-14
5.2.11 Hydraulic Removal Process Options	5-14
5.2.12 Pneumatic Removal Process Options	5-15
5.2.13 Waste Stabilization Process Options	5-15
5.2.14 On-Property Disposal Process Options	5-17
5.2.15 Off-Site Disposal Process Options	5-17
5.2.16 Physical Treatment Process Options	5-18
5.2.17 Chemical Treatment Process Options	5-20
5.2.18 Thermal Treatment Process Options	5-21
5.2.19 Biological Treatment Process Options	5-23
6.0 Development of Remedial Action Alternatives	6-1
6.1 Alternative 0 - No Action	6-7
6.1.1 Description	6-7
6.2 Alternative 1 - Nonremoval, Slurry Wall, and Cap	6-7
6.2.1 Description	6-7
6.2.2 System Requirements	6-9
6.2.3 Size and Configuration	6-9
6.2.4 Remediation Time Frame	6-9
6.2.5 Spatial Requirements	6-9
6.2.6 Packaging/Transportation Requirements	6-9
6.2.7 Wastes Generated	6-10
6.3 Alternative 2 - Nonremoval Physical Stabilization, Slurry Wall, and Cap	6-10
6.3.1 Description	6-10
6.3.2 System Requirements	6-12
6.3.3 Size and Configuration	6-12
6.3.4 Remediation Time Frame	6-13
6.3.5 Spatial Requirements	6-13
6.3.6 Packaging/Transportation Requirements	6-13
6.3.7 Wastes Generated	6-13
6.4 Alternative 3 - Nonremoval, In Situ Vitrification, and Cap	6-13
6.4.1 Description	6-13
6.4.2 System Requirements	6-15
6.4.3 Size and Configuration	6-15
6.4.4 Remediation Time Frame	6-15

TABLE OF CONTENTS
(Continued)

		Page
6.4.5	Spatial Requirements	6-15
6.4.6	Packaging/Transportation Requirements	6-16
6.4.7	Wastes Generated	6-16
6.5	Alternative 4 - Removal, Waste Treatment, and On-Property Disposal	6-16
6.5.1	Description	6-16
6.5.2	System Requirements	6-17
6.5.3	Size and Configuration	6-18
6.5.4	Remediation Time Frame	6-18
6.5.5	Spatial Requirements	6-18
6.5.6	Packaging/Transportation Requirements	6-18
6.5.7	Wastes Generated	6-18
6.6	Alternative 5 - Removal, Waste Treatment, and Off-Site Disposal	6-18
6.6.1	Description	6-18
6.6.2	System Requirements	6-19
6.6.3	Size and Configuration	6-19
6.6.4	Remediation Time Frame	6-19
6.6.5	Spatial Requirements	6-20
6.6.6	Packaging/Transportation Requirements	6-20
6.6.7	Wastes Generated	6-20
6.7	Alternative 6 - Waste Removal, Treatment, On-Property Disposal, and Cap	6-20
6.7.1	Description	6-20
6.7.2	System Requirements	6-22
6.7.3	Size and Configuration	6-23
6.7.4	Remediation Time Frame	6-23
6.7.5	Spatial Requirements	6-23
6.7.6	Packaging/Transportation Requirements	6-24
6.7.7	Wastes Generated	6-24
6.8	Alternative 7 - Waste Removal, Treatment, On-Property Disposal, Soil Treatment, and Cap	6-24
6.8.1	Description	6-24
6.8.2	System Requirements	6-26
6.8.3	Size and Configuration	6-27
6.8.4	Remediation Time Frame	6-27
6.8.5	Spatial Requirements	6-27
6.8.6	Packaging/Transportation Requirements	6-27

TABLE OF CONTENTS
(Continued)

	Page
6.8.7 Wastes Generated	6-28
7.0 Initial Screening of Alternatives	7-1
7.1 Screening Criteria	7-1
7.1.1 Alternative Evaluation Process	7-1
7.1.2 Effectiveness Evaluation	7-1
7.1.3 Implementability and Reliability Evaluation	7-3
7.1.4 Cost Evaluation	7-3
7.1.5 Innovative Technologies	7-3
7.1.6 Compliance with ARARs	7-4
7.2 Alternative 0 - No Action	7-4
7.2.1 Effectiveness	7-4
7.2.1.1 Protection of Human Health	7-4
7.2.1.2 Protection of Environment	7-4
7.2.1.3 Reduction in Toxicity, Mobility, and Volume	7-5
7.2.2 Implementability	7-5
7.2.2.1 Constructability	7-5
7.2.2.2 Reliability	7-5
7.2.2.3 Maintenance/Operation	7-5
7.2.2.4 Special Engineering and Equipment	7-5
7.2.3 Cost	7-5
7.2.4 Screening Summary	7-5
7.3 Alternative 1 - Nonremoval, Slurry Wall, and Cap	7-6
7.3.1 Effectiveness	7-6
7.3.1.1 Protection of Human Health	7-6
7.3.1.2 Protection of Environment	7-6
7.3.1.3 Reduction in Toxicity, Mobility, and Volume	7-6
7.3.2 Implementability	7-6
7.3.2.1 Constructability	7-6
7.3.2.2 Reliability	7-7
7.3.2.3 Maintenance/Operation	7-7
7.3.2.4 Special Engineering and Equipment	7-7
7.3.3 Cost	7-7
7.3.4 Screening Summary	7-8
7.4 Alternative 2 - Nonremoval, Physical Stabilization, Slurry Wall, and Cap	7-8
7.4.1 Effectiveness	7-8

TABLE OF CONTENTS
(Continued)

		Page
	7.4.1.1 Protection of Human Health	7-8
	7.4.1.2 Protection of Environment	7-8
	7.4.1.3 Reduction in Toxicity, Mobility, and Volume	7-8
7.4.2	Implementability	7-8
	7.4.2.1 Constructability	7-8
	7.4.2.2 Reliability	7-8
	7.4.2.3 Maintenance/Operation	7-10
	7.4.2.4 Special Engineering and Equipment	7-10
7.4.3	Cost	7-10
7.4.4	Screening Summary	7-10
7.5	Alternative 3 - Nonremoval, In Situ Vitrification, and Cap	7-11
7.5.1	Effectiveness	7-11
	7.5.1.1 Protection of Human Health	7-11
	7.5.1.2 Protection of Environment	7-11
	7.5.1.3 Reduction in Toxicity, Mobility, and Volume	7-11
7.5.2	Implementability	7-12
	7.5.2.1 Constructability	7-12
	7.5.2.2 Reliability	7-12
	7.5.2.3 Maintenance/Operation	7-12
	7.5.2.4 Special Engineering and Equipment	7-12
7.5.3	Cost	7-13
7.5.4	Screening Summary	7-13
7.6	Alternative 4 - Removal, Waste Treatment, and On-Property Disposal	7-13
7.6.1	Effectiveness	7-13
	7.6.1.1 Protection of Human Health	7-13
	7.6.1.2 Protection of Environment	7-13
	7.6.1.3 Reduction in Toxicity, Mobility, and Volume	7-14
7.6.2	Implementability	7-14
	7.6.2.1 Constructability	7-14
	7.6.2.2 Reliability	7-14
	7.6.2.3 Maintenance/Operation	7-14
	7.6.2.4 Special Engineering and Equipment	7-15
7.6.3	Cost	7-15
7.6.4	Screening Summary	7-15
7.7	Alternative 5 - Removal, Waste Treatment, and Off-Site Disposal	7-15

TABLE OF CONTENTS
(Continued)

		Page
7.7.1	Effectiveness	7-15
7.7.1.1	Protection of Human Health	7-15
7.7.1.2	Protection of Environment	7-15
7.7.1.3	Reduction in Toxicity, Mobility, and Volume	7-15
7.7.2	Implementability	7-16
7.7.2.1	Constructability	7-16
7.7.2.2	Reliability	7-16
7.7.2.3	Maintenance/Operation	7-16
7.7.2.4	Special Engineering and Equipment	7-16
7.7.3	Cost	7-16
7.7.4	Screening Summary	7-16
7.8	Alternative 6 - Waste Removal, Treatment, On-Property Disposal, and Cap	7-16
7.8.1	Effectiveness	7-16
7.8.1.1	Protection of Human Health	7-16
7.8.1.2	Protection of Environment	7-17
7.8.1.3	Reduction in Toxicity, Mobility, and Volume	7-17
7.8.2	Implementability	7-17
7.8.2.1	Constructability	7-17
7.8.2.2	Reliability	7-17
7.8.2.3	Maintenance/Operation	7-18
7.8.2.4	Special Engineering and Equipment	7-18
7.8.3	Cost	7-18
7.8.4	Screening Summary	7-18
7.9	Alternative 7 - Waste Removal, Treatment, On-Property Disposal, Soil Treatment, and Cap	7-19
7.9.1	Effectiveness	7-19
7.9.1.1	Protection of Human Health	7-19
7.9.1.2	Protection of Environment	7-19
7.9.1.3	Reduction in Toxicity, Mobility, and Volume	7-19
7.9.2	Implementability	7-20
7.9.2.1	Constructability	7-20
7.9.2.2	Reliability	7-20
7.9.2.3	Maintenance/Operation	7-20
7.9.2.4	Special Engineering and Equipment	7-20
7.9.3	Cost	7-20

000010

TABLE OF CONTENTS
(Continued)

	Page
7.9.4 Screening Summary	7-20
7.10 Alternative Ranking	7-21
8.0 Alternatives Retained for Detailed Analysis	8-1
8.1 Presentation of Alternatives Recommended for Detailed Analysis	8-1
8.2 Detailed Analysis of Alternatives (Task 13) Preview	8-1

References

Appendix A - Description of Technologies and Process Options

Appendix B - Applicable or Relevant and Appropriate Requirements (ARARs)

Appendix C - Waste Pits, Burn Pit, and Clearwell Characteristics

LIST OF TABLES

Table	Title	Page
ES-1	Alternative Rankings	ES-7
1-1	Summary of FMPC Pit Information	1-8
2-1	Radionuclides and Chemicals of Potential Concern for Operable Unit 1	2-4
2-2	Operable Unit 1 ARARs and TBCs	2-7
2-3	Operable Unit 1 Groundwater Remedial Action Objectives for Radionuclides	2-10
2-4	Operable Unit 1 Groundwater Remedial Action Objectives for Inorganic Chemicals	2-11
2-5	Operable Unit 1 Groundwater Remedial Action Objectives for Organic Chemicals	2-12
2-6	Remedial Action Objectives for Protection of Aquatic Life In Surface Waters	2-14
4-1	Risk Factors for Waste Transportation - Operable Unit 1	4-24
4-2	Risk of Transportation Waste - Operable Unit 1	4-25
5-1	Metal Concentrations in Silos and Pits	5-22
7-1	Alternative Rankings	7-9

LIST OF FIGURES

Figure	Title	Page
ES-1	Remedial Action Alternatives and Process Options	ES-4
1-1	Five-Mile Radius Map, Feed Materials Production Center	1-2
1-2	Major Features of the Feed Materials Production Center	1-4
1-3	Waste Storage Area	1-5
1-4	Source Operable Units	1-6
2-1	Remedial Action Objectives and Associated General Response Actions	2-15
4-1	Initial Screening of Technologies and Process Options for Operable Unit 1	4-3
4-2	Typical Cross Section Before/After Closure	4-19
4-3	Typical Cross Section During Surcharging	4-21
5-1	Evaluation of Process Options	5-2
6-1	General Alternative Development Process	6-2
6-2	Remedial Action Alternatives and Process Options	6-6
7-1	Relationship of Screening Criteria to the Nine Evaluation Criteria	7-2
8-1	Screened Response Actions Flow Chart	8-2

LIST OF ACRONYMS

AEA	Atomic Energy Act
ARARs	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIS	Characterization Investigation Study
COE	U.S. Army Corps of Engineers
CSF	cancer slope factor
CWA	Clean Water Act
DCG	derived concentration guides
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EDF	engineered disposal facility
EPA	U.S. Environmental Protection Agency
EPDM	ethylene-propylene-diene monomer
EP Toxicity	extraction procedure toxicity
FFCA	Federal Facilities Compliance Agreement
FML	flexible membrane liners
FMPC	Feed Materials Production Center
FS	feasibility study
HCL	Hazardous Substance List
HDPE	high density polyethylene
HI	hazard index
LC/DS	leachate collection/detection systems
LLW	low level waste
LSA	low specific activity
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MPRSA	Marine Protection Research and Sanctuaries Act
NAAQS	National Ambient Air Quality Standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NESHAP	National Emission Standards for Hazardous Air Pollutants

LIST OF ACRONYMS
(Continued)

NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
O&M	operation and maintenance
OSHA	Occupational Health and Safety Administration
OSWER	Office of Solid Waste and Emergency Response
PCB	polychlorinated biphenyls
PMCL	proposed maximum contaminant level
QA/QC	quality assurance/quality control
RA	Risk Assessment
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RO	reverse osmosis
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SSM	shallow soil mixing
TBC	to be considered
TSCA	Toxic Substances Control Act
UIC	underground injection control
USC	U.S. Code
WMCO	Westinghouse Materials Company of Ohio

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EXECUTIVE SUMMARY

On March 9, 1985, the U.S. Environmental Protection Agency (EPA) issued a Notice of Noncompliance to the U.S. Department of Energy (DOE) identifying EPA's major concern about potential environmental impacts associated with the Fernald, Ohio, Feed Materials Production Center's (FMPC's) past and present operations. On July 18, 1986, DOE and EPA jointly signed a Federal Facility Compliance Agreement (FFCA) pertaining to environmental impacts associated with the FMPC. In response to the FFCA, a site-wide Remedial Investigation and Feasibility Study (RI/FS) was initiated pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The RI/FS is an established EPA procedure used to identify and select an action plan for the cleanup of CERCLA sites. A Work Plan for the site-wide RI/FS was originally issued to EPA in December 1986. After a series of technical discussions and negotiations, the Work Plan received EPA approval in May 1988.

On April 9, 1990 DOE and EPA Region V amended the 1986 FFCA by a Federal Facility Consent Agreement (Consent Agreement) to achieve overall consistency in the program, including the operable unit concept. The Consent Agreement, persuant to CERCLA Sections 120 and 106 (a), became effective in June 1990.

This Task 12 Report presents the initial screening of alternatives for Operable Unit 1 at the FMPC. The report documents the refinement, evaluation, and screening of the remediation alternatives for Waste Pits 1 through 6, the Burn Pit, and the Clearwell, all components of Operable Unit 1. The remedial task objectives from the RI/FS Work Plan directly applicable to Operable Unit 1 were to:

- Prevent ingestion of or direct contact with chemical and radiological wastes
- Prevent release of airborne contaminants from wastes (including radon)
- Prevent migration of contaminants to environmental media that would exceed public health or environmental standards, criteria, or guidance

These remedial action objectives were kept general. They were formulated to protect human health and the environment by isolating, removing, or treating the source of contamination. Because they were not action levels, they did not specify the acceptable levels for pathways and receptors for the contaminants of concern.

ALTERNATIVE EVALUATION PROCESS

Technologies have now been re-evaluated and screened, eliminating a number of alternatives due to concerns about implementability and reliability. The alternatives that remain have been further developed and refined to provide the necessary differentiation for evaluation.

In an initial screening of alternatives, three broad criteria have been used for evaluation:

- Effectiveness
- Implementability
- Cost

Consideration was given to two threshold factors:

- Overall protection of human health and environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)

ARARs are to be progressively developed and applied on a site-specific basis as the RI/FS proceeds. The initial step in the process entailed the listing of all potential ARARs for the FMPC site. The comprehensive listing was developed as part of the RI/FS Work Plan. These potential ARARs are categorized as chemical specific, location specific, and action specific. Because ARARs do not cover every circumstance, it may also be necessary to consult other reliable information. Therefore, a "To Be Considered" (TBC) category has also been established for the RI/FS. A listing of potential ARARs and TBCs is included in an appendix to this report.

OTHER CONSIDERATIONS

The alternatives have been evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. However, because the intent of this evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives are evaluated more generally in this phase than during the subsequent detailed analysis task. Therefore, in an effort to gain a sense of direction as to the decision requirements of the detailed analysis phase, five primary balancing factors have been established for preliminary consideration; these include:

- Long-term effectiveness and permanence
- Reductions in toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost

These factors have been considered with caution since they are dependent upon treatability studies that have not been completed. However, the primary balancing factors will become more prominent in the decision processes which will evolve in the detailed analysis.

SUMMARY OF ALTERNATIVES

In addition to the no-action alternative, five distinct remedial action alternatives are developed for Operable Unit 1. These alternatives are briefly described in the following sections. The process options involved with each alternative are summarized in Figure ES-1.

Alternative 0 - No Action

The no-action alternative provides no remediation of any sort and simply leaves the waste pits in their present condition.

Alternative 1 - Nonremoval, Slurry Wall, and Cap

The first nonremovable alternative for Operable Unit 1 is intended to isolate the waste from the environment and to minimize the generation and release of contaminated leachate to the underlying Great Miami Aquifer. This alternative includes removing and treating any standing water, installing subsurface flow control measures, building closure cap, and providing storm water runoff and run-on control measures. The subsurface flow control measures combine a slurry wall, subsurface drains, and a temporary groundwater extraction system.

Alternative 2 - Nonremoval Physical Stabilization, Slurry Wall, and Cap

The second nonremoval alternative for Operable Unit 1 is identical to Alternative 1 with the addition of a waste stabilization step. The purpose of this additional process is to promote the compaction (densification) of the waste to minimize both the potential for long-term settlement and the release of contaminated waste pit water into the underlying till. The need for continuing maintenance of the cap due to settling will be correspondingly reduced.

Alternative 3 - Nonremoval, In Situ Vitrification, and Cap

Because a waste immobilization step has been incorporated into the nonremoval scenario, this alternative is similar to Alternative 2. However, this solidification/stabilization step specifies vitrification technology be used rather than physical stabilization technologies. A second important difference: the subsurface control measures are not included in this alternative. It is reasoned that the resultant vitrified mass precludes the future release of contaminated water from the waste.

ALTERNATIVE / PROCESS OPTION	0 No Action	1 Nonremoval, Slurry Wall and Cap	2 Nonremoval, Physical Stabilization, Slurry Wall and Cap	3 Nonremoval, In-Situ Vitrification and Cap	4 Removal, Treatment and On-Property Disposal	5 Removal, Treatment, Off-Site Disposal	6 Waste Removal, Treatment, On-Property Disposal and Cap	7 Waste Removal, Treatment, On-Property Disposal, Soil Treatment and Cap
Wellpoint Monitoring	X	X	X	X	X		X	X
Grading		X	X	X	X		X	X
Multimedia Cap		X	X	X	X		X	X
Subsurface Drains		X	X					
Slurry Walls		X	X					
Groundwater Extraction		X	X					
Shallow-Soil Mixing			X					X
Vitrification (In Situ)				X				X
Surcharging			X					
Precipitation		X	X	X	X	X	X	X
Reverse Osmosis		X	X	X	X	X	X	X
Selective Ion Exchange		X	X	X	X	X	X	X
Crane w/Clamshell System					X	X	X	X
Jetting Ring w/Cutterhead					X	X	X	X
Cement-Based Solidification					X	X	X	X
Vitrification (Ex Situ)					X	X	X	X
Tumulus					X		X	X
Temporary Storage						X		
Rail Transport						X		
Waste Segregation/Separation		X	X	X	X	X	X	X

FIGURE ES-1. REMEDIAL ACTION ALTERNATIVES AND PROCESS OPTIONS

FL/MPC-0112-5/E3-1

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Alternative 4 - Removal, Waste Treatment, and On-Property Disposal

The alternatives for Operable Unit 1, which include removing the material, are intended to eliminate completely the waste source from its current location above the Great Miami Aquifer and to obviate future problems through the treatment and disposal of the wastes. This alternative utilizes technologies that include removing and treating the standing water, removing the waste, waste segregation and treatment, and on-property disposal. The waste treatment portion of this alternative retains two distinct process options: cement stabilization and continuous vitrification. Treatment of residual water and special waste packaging are potential support actions also being considered.

Alternative 5 - Removal, Waste Treatment, and Off-Site Disposal

This alternative is identical to Alternative 4 except that the treated and packaged waste is to be transported to and disposed of at an approved off-site location.

Alternative 6 - Waste Removal, Treatment, On-Property Disposal, and Cap

This alternative, like Alternative 4, addresses the removal and treatment of the waste pit caps (or standing surface water on those pits without caps) and pits waste from each of the waste pits including the Burn Pit and the Clearwell. However, in this alternative, the contaminated soils that make-up and surround the pits will be left in place and fitted with a closure cap. The treated and packaged waste is to be housed on-site in an engineered disposal facility.

Alternative 7 - Waste Removal, Treatment, On-Property Disposal, Soil Treatment, and Cap

This alternative is identical to Alternative 6, except that the soil in the pits will be treated by in situ technologies following the excavation of the waste materials.

Evaluation of Alternatives

Using the methodology defined in the EPA RI/FS Guidance Document (OSWER Directive 9355.3-01), the above alternatives were evaluated. For each criterion, each alternative was numerically rated according to the following scale.

1 = unfavorable
2 = below average
3 = average
4 = above average
5 = highly favorable

Relative performance was established. The results of this ranking are tabulated in Table ES-1 in this section.

Cost evaluations were prepared for each alternative to allow a differentiation between similar alternatives. For the purposes of this report, High (H), Medium (M), and Low (L) relative cost ranges were used in evaluating process options and actual cost estimates were incorporated into the final alternative screening table.

The cost evaluation is based on a variety of cost-estimating data including cost curves, generic unit costs, vendor information, conventional cost-estimating guides, commercial remedial costs, and previous similar estimates modified by site-specific information.

RECOMMENDED ALTERNATIVES

The screened alternatives are formally ranked according to their ability to meet the general screening criteria. The results of that ranking (Table ES-1) show that the alternatives achieved similar scores. Because of the relatively close scores of the alternatives in this ranking process, the alternatives listed below are recommended for further development and refinement in Task 13, Detailed Analysis of Alternatives:

- Alternative 2 Nonremoval - Physical Stabilization, Slurry Wall, and Cap
- Alternative 4 Removal - Waste Treatment and On-Property Disposal
- Alternative 5 Removal - Waste Treatment and Off-Site Disposal
- Alternative 6 Removal - Waste Treatment, On-Property Disposal, and Cap
- Alternative 7 Removal - Waste Treatment, On-Property Disposal, Soil Treatment, and Cap

Alternative 0 (No Action) will also be included in Task 13. The no-action alternative is retained as a baseline against which the other alternatives are compared.

The following alternatives were removed from further consideration because of concerns about technology implementability and reliability:

- Alternative 1 Nonremoval - Slurry Wall and Cap
- Alternative 3 Nonremoval - In Situ Vitrification and Cap

Appendix A is a description of technologies that have been evaluated for further consideration. Appendix B identifies a comprehensive list of potentially ARARs. A tabulation of characteristics of the waste pits, Clearwell, and Burn Pit is contained in Appendix C.

TABLE ES-1.
ALTERNATIVE RANKINGS

Alternative Number		0	1	2	3	4	5	6	7
Short-Term Human Health		1	3	4	3	3	2	3	3
Short-Term Environmental Protection		1	2	3	3	3	2	3	3
Long-Term Human Health		1	2	3	3	4	5	3	4
Long-Term Environmental Protection		1	2	3	3	4	5	3	4
Reduction in Mobility, Toxicity, and Volume		1	2	3	4	4	5	3	4
Contructability		5	3	4	2	3	3	3	3
Reliability		1	2	4	2	3	3	3	3
Maintenance		1	2	3	2	4	5	3	3
Special Engineering & Equipment		5	4	4	2	3	3	3	3
Summation		17	22	31	24	31	33	27	30
Relative Cost (Millions of Dollars)	Capital	$ 0	$ 100	$ 139	$ 500	$ 1500	$ 2000	$ 1353	$ 1592
	Long-Term O&M	$ 9	$ 66	$ 66	$ 66	$ 20	$ 0	$ 86	$ 86

RATING SCALE

1 = Unfavorable
2 = Below Average
3 = Average
4 = Above Average
5 = Highly Favorable

ALTERNATIVE DESCRIPTIONS

Alternative 0 - No Action
Alternative 1 - Nonremoval, Slurry Wall, and Cap
Alternative 2 - Nonremoval, Physical Stabilization, Slurry Wall, and Cap
Alternative 3 - Nonremoval, Vitrification, and Cap
Alternative 4 - Removal, Sludge Treatment, and On-Property Disposal
Alternative 5 - Removal, Sludge Treatment, and Off-Property Disposal
Alternative 6 - Waste Removal, Treatment, On-Property Disposal and Cap
Alternative 7 - Waste Removal, Treatment, On-Property Disposal, Soil Treatment and Cap

FU/FMPC-0112-5/7-1

1.0 INTRODUCTION

The Feed Materials Production Center (FMPC) is a contractor-operated federal facility for the production of pure uranium metals for the U.S. Department of Energy (DOE). The FMPC site is located on 1050 acres in a rural area approximately 18 miles northwest of Cincinnati, Ohio. The production area is limited to an approximate 136-acre tract near the center of the FMPC site. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant (Figure 1-1).

On March 9, 1985, the U.S. Environmental Protection Agency (EPA) issued a Notice of Noncompliance to DOE identifying EPA's major concerns over potential environmental impacts associated with the FMPC's past and present operations. Between April 1985 and July 1986, conferences were held between DOE and EPA representatives to discuss the issues and to identify the steps DOE proposed to take to achieve and maintain environmental compliance.

On July 18, 1986, a Federal Facilities Compliance Agreement (FFCA) pertaining to environmental impacts associated with the FMPC was signed by DOE and EPA. The FFCA was entered into pursuant to Executive Order 12088 (43CFR47707) to ensure compliance with existing environmental statutes and implementing regulations such as the Clean Air Act, the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In particular, the FFCA was intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented. In response to the FFCA, a Remedial Investigation/Feasibility Study (RI/FS) was initiated pursuant to CERCLA, as amended by the Superfund Amendment and Reauthorization Act (SARA). All RI/FS activities are being conducted in conformance with EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988).

The 1986 FFCA was amended by a Consent Agreement under Sections 120 and 106(a) of CERCLA (Consent Agreement) in order to achieve consistency with the operable unit concept and the current commitments of the RI/FS program without modifying the underlying objectives. The Consent Agreement was signed on April 9, 1990 and became effective on June 29, 1990.

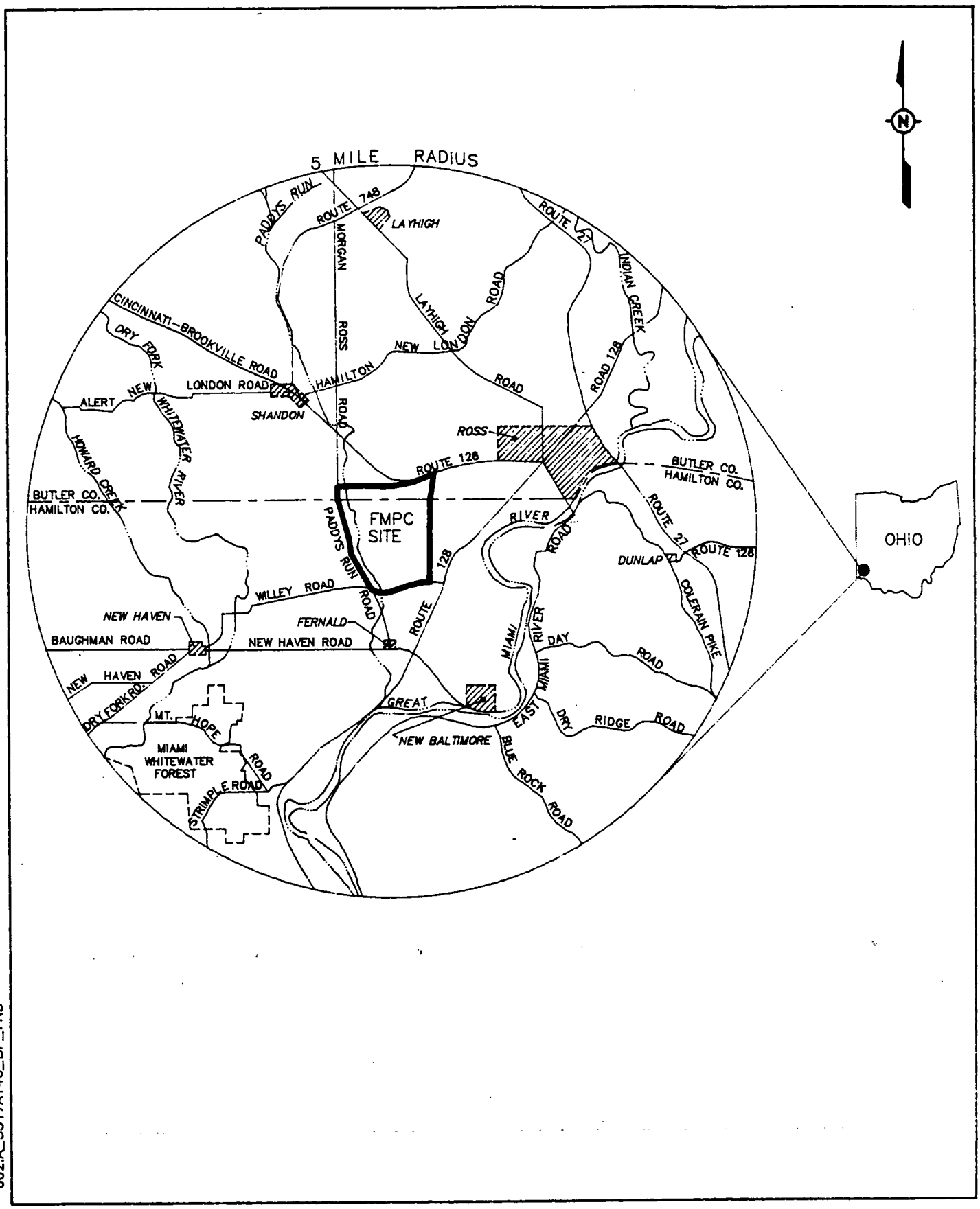

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FIGURE 1-1. FIVE-MILE RADIUS MAP, FEED MATERIALS PRODUCTION CENTER

1.1 BACKGROUND

1.1.1 Site Description

The FMPC site covers approximately 1050 acres and is used for the production of uranium metal cores, target element cores, and the interim storage of low-level radioactive/hazardous wastes. In addition to uranium production facilities, the site contains waste storage facilities including waste pits, storage silos, a Burn Pit, a Clearwell, fly ash disposal areas, a sanitary landfill, and lime sludge ponds (Figure 1-2). The waste pits and the Clearwell (Figure 1-3), located west of the production plant, cover approximately 23 acres. The area is relatively flat with gentle slopes resulting from the emplacement of final soil covers over buried wastes. Paddys Run, an intermittent tributary of the Great Miami River, runs along the west side of the FMPC property between the waste storage area and the site boundary.

To expedite remediations, the site has been divided into five operable units that compose the total scope of the Remedial Action Program (Figure 1-4). Operable units are distinctive groupings of facilities and environmental media that will enable DOE to expedite remedial actions on the highest priority operable units while awaiting necessary data and related analyses on other operable units. These operable units are:

- Operable Unit 1 - Waste Pits 1 through 6, Clearwell, and Burn Pit
- Operable Unit 2 - Other waste units
- Operable Unit 3 - Production and suspect areas
- Operable Unit 4 - Silos 1, 2, 3, and 4
- Operable Unit 5 - Environmental media

Per the Consent Agreement, the technical strategy adopted for the RI/FS is to issue distinct reports for each of the five operable units at the FMPC. The subject of this project is Operable Unit 1, which includes Waste Pits 1 through 6, the Burn Pit, and the Clearwell. The pits and Clearwell contain approximately 467,392 cubic yards of solid/sludge wastes and 2.3 million gallons of surface water waste to be remediated. Included in the remediation will be soil between the pits and contaminated soil surrounding the boundary of Operable Unit 1. The depth of contaminated soil is assumed to extend to the Great Miami Aquifer. The addition of soil and the contaminated portion of cap material brings the amount of material to be removed, treated, or capped to approximately 1.4 million cubic yards. Perched groundwater within the waste pit area is also within the scope of Operable Unit 1. Per the references given in Appendix C, Table C-8, Pits 1, 2, 3, 5, 6, the Clearwell, and the Burn Pit contain hazardous constituents (which do not necessarily cause the

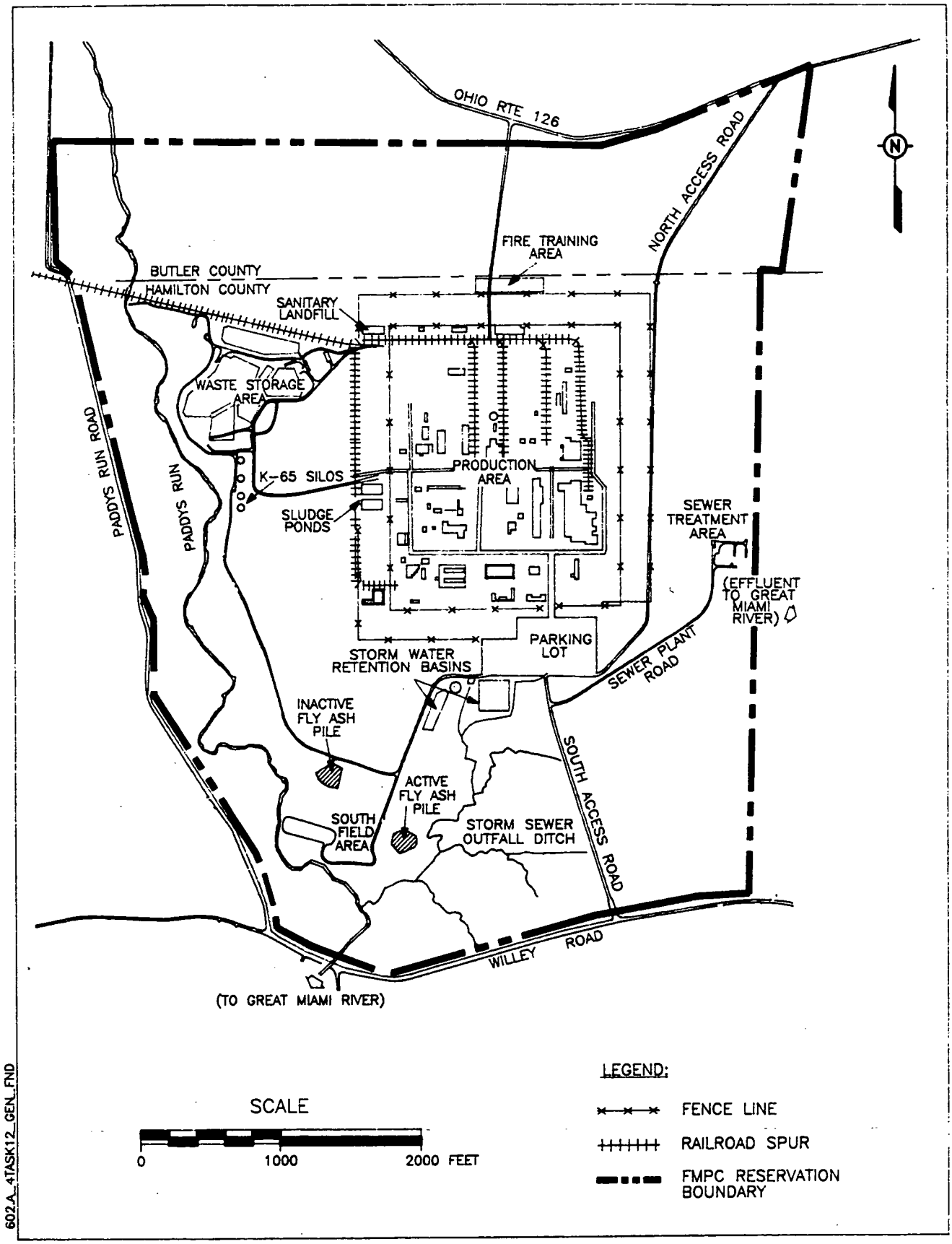
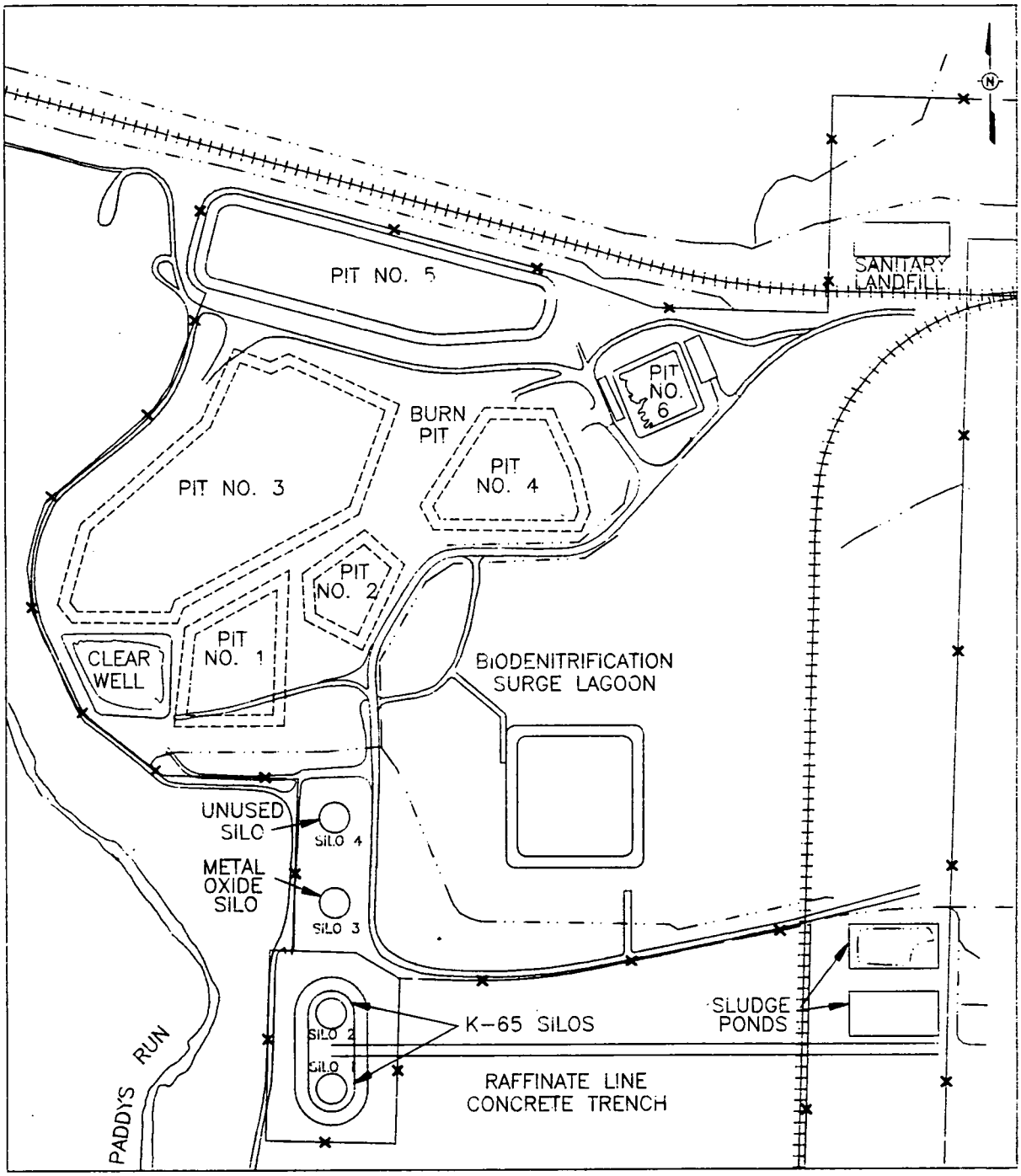


FIGURE 1-2. MAJOR FEATURES OF THE FMPC



NOTES:

PITS 1, 2, 3 AND THE BURN PIT ARE COVERED.

PIT 4 HAS AN INTERIM CAP.

LEGEND:

- RAILROAD
- DRAINAGEWAYS
- FENCELINE
- ROADWAY

SCALE

0 175 350 FEET

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FIGURE 1-3. WASTE STORAGE AREA

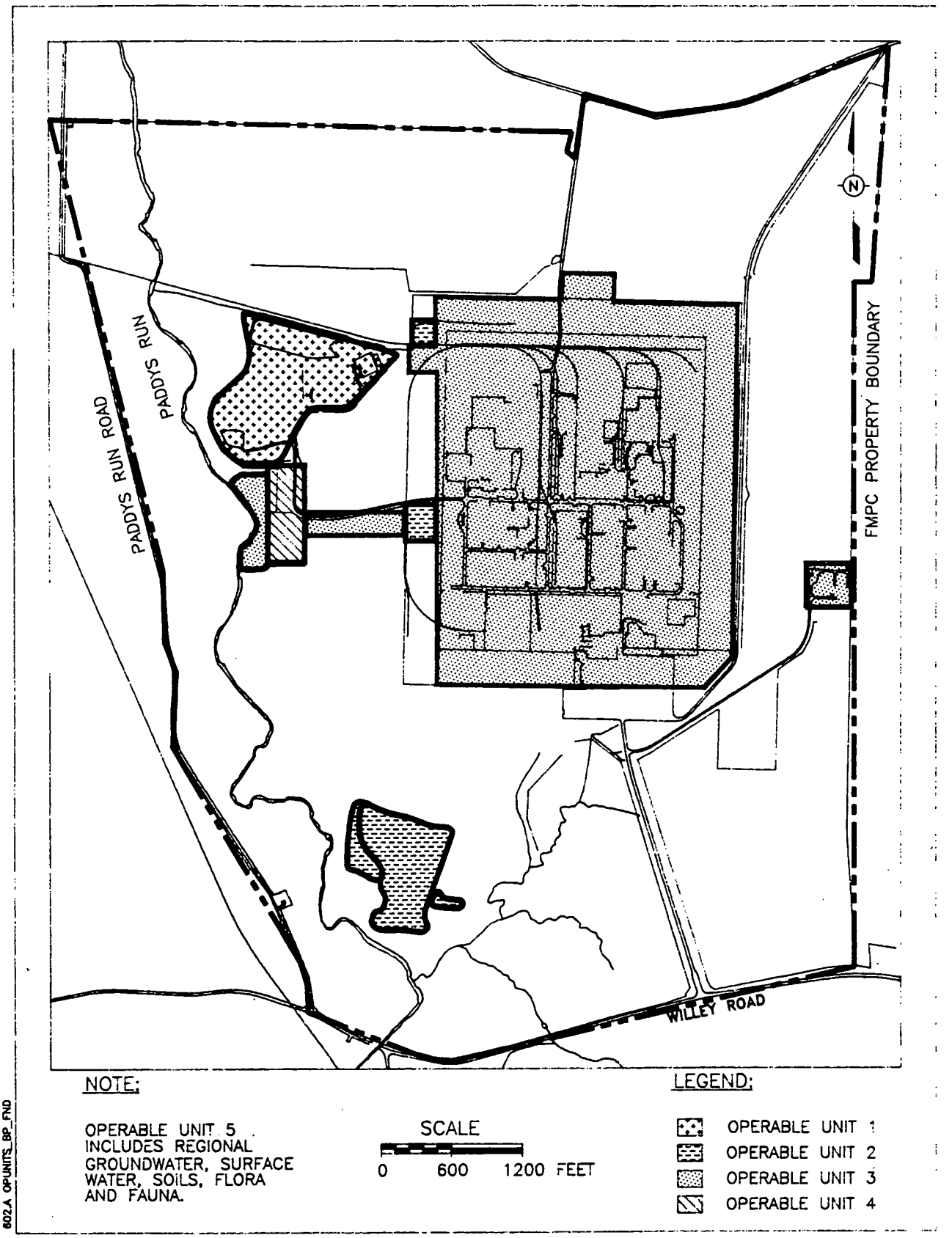

FIGURE 1-4. SOURCE OPERABLE UNITS

material to be a hazardous waste) and radiological substances; Pit 4 contains mixed waste (classified as a mixture of radiological and hazardous waste). Section 1.1.2 presents historical disposal practices and more detailed descriptions of the waste pits, Burn Pit, and Clearwell.

1.1.2 Site History

Since the beginning of uranium production operations in 1952, on-property storage facilities at the FMPC have been used for the storage of low-level radioactive wastes generated by the various chemical and metallurgical processes utilized at the facility. Specifically, these wastes have been deposited in one of six waste pits, a clearwell, or burned in a burn pit. The six pits, the Clearwell, and the Burn Pit make up the 37.7 acres of the FMPC identified as Operable Unit 1.

By completing a comprehensive investigation of historical records, topographical maps, and pit construction drawings, a reasonable estimation of the quantities of materials associated with the various components of the waste pits, Clearwell, and Burn Pit have been calculated. Table 1-1 summarizes these calculations and provides essential information on each of the waste pits, the Clearwell, and the Burn Pit. The soil volumes estimated in Table 1-1 reflect the quantity of soils outside the pit liner surrounding the respective pit extending downward to the top of the Great Miami Aquifer located at an approximate elevation of 548 feet. Soil volumes (in Table 1-1) are reported as measured in situ. Further historical and detailed descriptions of the six waste pits, the Clearwell, and the Burn Pit are presented in the following paragraphs.

1.1.2.1 Waste Pit 1

Waste Pit 1, constructed in 1952, was excavated to a maximum depth of 17 feet into an existing clay lens and lined with additional clay obtained from the Burn Pit. A portion of the clay liner is reported to be up to four and one-half feet thick on the bottom and one and one-half to two feet thick on the sides. Waste Pit 1 has an 82,693-square-foot surface area with an estimated 33,676 cubic yards of buried waste. It contains neutralized waste filter cake, fly ash, 55-gallon drums, scrap graphite, brick scraps, sump liquor, sump cake, and depleted slag (by-product of the chemical reaction between uranium tetrachloride and magnesium). Within these materials is an estimated 115,352 pounds of uranium. The presence of a large (but unknown) quantity of drums in Waste Pit 1 was evident in photographs taken during the years of active pit operation. Although the photographs indicate that most drums are empty, neither the origin nor the nature of the materials stored in these drums is known. In 1959, Waste Pit 1 was backfilled and covered with clean soil. Surface water runoff is diverted to the Clearwell before discharge to the Great Miami River. The

TABLE 1-1.

SUMMARY OF FMPC DERIVED PIT INFORMATION[a]

Pit No.	Average Pit Design Depth (ft)	Waste (cu. yd.)	Percent Total Waste	Water (cu. yd.)	Cap (cu. yd.)	Soils[b] (cu. yd.)	Total (cu. yd.)	Percent Total Material	Cap Thickness Range (ft)	Estimated Liner Thickness (ft)
1	14.3	33,676	7.2	—	3,063	98,341	135,080	9.6	0.5 - 1.0	4.5' clay lined
2	13.8	18,478	4.0	—	1,247	57,430	77,156	5.5	0.5 - 1.5	4' clay lined
3	27	237,053	50.7	—	71,518	150,738	459,309	32.8	7.0 - 9.0	1' clay lined
4	24	53,706	11.5	—	17,070	159,887	230,663	16.5	5.0 - 6.0	2' clay lined
5	30	98,841	21.1	3,704 (748,060 gal)	—	229,336	331,881	23.7	No Cap	60 mil EPDM elastomeric membrane
6	24	11,556	2.5	Unknown	—	79,467	91,023	6.5	No Cap	60 mil EPDM elastomeric membrane
Burn Pit	20	9,074	1.9	—	805	17,477	27,356	2.0	0.0 - 2.0	no liner
Clear Well	27	5,008	1.1	7,656 (1,546,265 gal)	—	37,047	49,711	3.5	No Cap	1' clay lined
TOTALS	N/A	467,392	100 %	11,360	93,703	829,723	1,402,179	100 %	N/A	N/A

a - Calculations obtained from recent and historical data as supplied by WMCO, Weston, and Dames & Moore.

b - Soil volumes have been calculated as those soils outside the pit liner surrounding the respective pit.
Soil volume calculations include those soils which extend in depth to the Great Miami Aquifer (approximate elevation is 548 ft).

Note: All volumes have been calculated as in situ.

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general consistency of the contents in Waste Pit 1 is semisolid to saturated eight feet below the pit surface. Additional characteristics of Waste Pit 1, including the chemical nature of the pit materials, are summarized in Appendix C, Table C-1.

1.1.2.2 Waste Pit 2

Waste Pit 2, constructed in 1957, was excavated to a maximum depth of 17 feet into native clay and lined with compacted native clay at the site of a small pond east of Waste Pit 1. Waste Pit 2 has a 44,896-square-foot surface area with an estimated 18,478 cubic yards of buried waste. It contains neutralized waste filter cake, graphite, fly ash, 55-gallon drums, brick scrap, sump liquor, sump cake, and depleted slag. An estimated 2.66 million pounds of uranium and 890 pounds of thorium are contained within these materials in Waste Pit 2. A large quantity of concrete and other construction rubble is buried in the pit.

In 1964 the pit was taken out of service, backfilled, and covered with clean soil. Waste Pit 2 is overgrown with grass and is fairly level with a gentle slope toward a drainage ditch running alongside Waste Pit 4 on the east. Surface water runoff is diverted to the Clearwell before being discharged to the Great Miami River. The general consistency of the contents of Waste Pit 2 indicates semisolid and wet conditions eight feet below the present pit surface. Appendix C, Table C-2, provides additional data on Waste Pit 2 and the material disposed of in the pit.

1.1.2.3 Waste Pit 3

Waste Pit 3, with a 27-foot depth, was constructed in 1959 by excavating into the underlying till and adding a clay layer along the pit walls. Waste Pit 3 has a 241,373-square-foot surface area with an estimated 237,053 cubic yards of buried waste. The pit contains lime-neutralized raffinate, raffinate concentrate, slag, slag leach residues, filter cake, fly ash, lime sludge, and 55-gallon drums. Within this material are an estimated 288,041 pounds of uranium and 881 pounds of thorium.

The pit was taken out of service as a wet pit in the fall of 1968. Subsequent usage was confined to adding dry material until 1977, at which point the pit was taken completely out of service, backfilled, and covered with clean soil. Waste Pit 3 is overgrown with grass and is fairly level. The western side of the pit slopes steeply down to the perimeter fence and road, while a gentle slope extends toward a drainage ditch running alongside the Burn Pit on the east. Surface water is diverted to the Clearwell before discharge to the Great Miami River. Wet to saturated conditions

exist eight feet below the pit surface. Appendix C, Table C-3, provides additional data on Waste Pit 3 and the materials disposed of in the pit.

1.1.2.4 Waste Pit 4

Waste Pit 4, with a 24-foot depth, was constructed in 1960 in a manner similar to Waste Pit 3, using a clay layer approximately two-feet-thick along the pit walls. Waste Pit 4 has an 83,799-square-foot surface area with an estimated 53,706 cubic yards of buried waste. The pit contains process residues, filter cake, slurries, raffinates, scrap graphite, noncombustible trash, asbestos, and an estimated 23,500 pounds of barium chloride. Within the materials is an estimated 6.7 million pounds of uranium; 136,000 pounds of thorium metal in 55-gallon drums were placed in Waste Pit 4 as well. Samples collected from borings exhibited levels of barium in the parts-per-thousand range. The presence of barium at these levels led to a mixed waste classification for Waste Pit 4.

In 1986 the pit was covered with clean soil and graded for surface water diversion. Waste Pit 4 was level and had no vegetative cover at the time of the Characterization Investigation Study (CIS). An earthen berm surrounds the pit to retain surface water runoff. The general consistency of the contents indicates semisolid and wet to saturated conditions nine feet below the present surface. In December 1988, an interim RCRA cap consisting of compacted clay overlain by a 45-mil-thick Hypalon, chlorosulfinated polyethylene (reinforced) liner was installed on Waste Pit 4. Appendix C, Table C-4, presents additional information on the physical and chemical characteristics of the material in Waste Pit 4.

1.1.2.5 Waste Pit 5

Waste Pit 5, with a 30-foot depth, was constructed in 1968 and lined with a 60-mil-thick Royal-Seal ethylene-propylene-diene monomer (EPDM) elastomeric membrane. Occasional joint failures and tears occurred at the surface and were noticed during routine inspections at various times and ascribed to weathering effects (Weston 1987). The corrective action has been to glue the seam and patch the tears. Waste Pit 5 has a 161,103-square-foot area with an estimated 98,841 cubic yards of disposed waste. The pit contains solids from neutralized raffinate, slag leach slurry, sump slurry, and lime sludge. Within these materials are an estimated 111,737 pounds of uranium and 37,445 pounds of thorium. The pit was taken out of service in 1987 but remains open. The effluent tower, which was collapsed into the pit, is estimated to contain 8000 pounds of steel and 64,000 pounds of concrete.

The pit is partially covered with an estimated 750,000 gallons of water ranging in depth from three feet near the west end to zero feet over one-third of the length of the pit to the east. Therefore, at the time of the CIS sampling, the waste materials were exposed over the eastern third of the pit. The surface elevation of water in Pit 5 varies depending on the precipitation and evaporation rates. Additional information on Waste Pit 5 is provided in Appendix C, Table C-5.

1.1.2.6 Waste Pit 6

Waste Pit 6, with a 24-foot depth, was constructed in 1979 in a manner similar to Waste Pit 5 and is lined with an EPDM elastomeric membrane. Minor tears above the water line have been observed and repaired. Waste Pit 6 has a 32,400-square-foot surface area with an estimated 11,556 cubic yards of disposed waste. It contains green salt (uranium tetrafluoride), filter cake, slag, process residues, and asbestos. Within these materials is an estimated 1.9 million pounds of uranium. The pit was taken out of service in 1985 but remains open. The pit surface is presently covered with up to two feet of standing water, the surface elevation of which varies depending on the amount of rainfall and evaporation rates. Until March 1987, rainfall that had collected in the pit was pumped to Waste Pit 5 for settlement before being discharged via the Clearwell. Presently, collected rainfall is transferred to nearby wastewater treatment facilities before discharge. Appendix C, Table C-6, summarizes additional information on Waste Pit 6.

1.1.2.7 Burn Pit

The Burn Pit was constructed in 1957 at the site previously used to excavate the clay liner material for Waste Pits 1 and 2. The boundaries of the Burn Pit are no longer discernible from the boundaries of covered Waste Pit 4. Therefore, the area of the Burn Pit is suspected and assumed to be bounded by Pits 2, 3, 4, and 5 (approximately 21,724 square feet). The depth of the Burn Pit varies because of the sloping bottom used for access during excavation and disposal operations. The maximum depth is believed to be about 20 feet. The disposed waste quantities are estimated to be 9074 cubic yards. The pit was used to dispose of and burn laboratory chemicals, including pyrophoric and reactive chemicals, as well as waste oils and other low-level contaminated combustible materials such as wooden pallets. The Burn Pit is overgrown with grass and is fairly level. A two- to three-foot deep ditch cuts across the area on the west side and drains toward Waste Pit 2.

During the CIS, six borings were completed in the Burn Pit. These borings were made using the drill rig and split-spoon sampling method. Based on the presumed maximum depth of the pit, the

borings extended no deeper than 16 feet and ended on the first indication that natural, underlying material had been penetrated. In all the borings an apparent cover layer was observed. It varied in thickness to a maximum of two feet, and consisted of yellowish brown clay with some fine- to coarse-grained sand, trace gravel, and abundant rootlets.

Overall data from the borings indicate that the waste ranges in thickness from 9 to 16 feet. The consistency of the contents is of varying character. Preliminary sampling indicates that glass, organic materials (e.g., wood, grass, and roots), metals, silt-sized particles, semisolids, and carbonized residues are in the Burn Pit. Additional data on the Burn Pit are provided in Appendix C, Table C-7.

1.1.2.8 Clearwell

Constructed at the time of the Waste Pit 1 excavation, the Clearwell currently receives surface water runoff from the surfaces of Pits 1, 2, and 3, as well as excess impounded storm water from Pit 5. Before March 1987, the Clearwell was used as a final settling basin for process water that passed through Waste Pits 3 and 5 before discharge to the Great Miami River, a National Pollutant Discharge Elimination System (NPDES) discharge point. Water of varying depth remains in the Clearwell at all times. The depth of sediment remaining in the Clearwell is presently estimated at 11 feet. Additional information on the Clearwell is provided in Appendix C, Table C-8.

1.1.3 Nature and Extent of Contamination

The RI data and data from previous studies conclusively show that releases to the environment from Operable Unit 1 have occurred. The surface soils, the glacial overburden, and the groundwater beneath the waste pits are contaminated. The principal environmental concern associated with Operable Unit 1 is contaminant migration and transport in surface water and groundwater. Results from the RI are briefly presented in the following paragraphs.

1.1.3.1 Radiological Composition

Waste Pit Contents

Waste inventory records for the waste pits indicate that: Pit 1 contains 115,352 pounds of uranium; Pit 2 contains 2,662,004 pounds of uranium and 890 pounds of thorium; Pit 3 contains 288,041 pounds of uranium and 881 pounds of thorium; Pit 4 contains 6,726,026 pounds of uranium and 136,123 pounds of thorium; Pit 5 contains 110,737 pounds of uranium and 37,445 pounds of

thorium; Pit 6 contains 1,860,973 pounds of uranium; and the Burn Pit and Clearwell contain unknown amounts of uranium.

The contents of the waste pits have been sampled under the CIS program. Data from the CIS sampling program indicate that the concentration of uranium-238 was relatively high in Pits 2, 4, and 6 with concentrations ranging between 53 to 17,900 picocuries/gram (pCi/g), 509 to 15,800 pCi/g, and 12,500 to 18,700 pCi/g, respectively. Samples from the Burn Pit contained the lowest uranium concentrations that ranged from 22 to 454 pCi/g. Pits 3 and 5 contained higher concentrations of thorium-230 than the other pits with concentrations ranging from 15 to 21,900 pCi/g and 3080 to 20,200 pCi/g, respectively. The Clearwell and Pit 5 contained higher concentrations of radium-226 than the other pits with concentrations ranging between 21.9 to 458 and 235 to 999 pCi/g, respectively.

The sampling of the waste pits conducted under the CIS program did not, however, confirm the amounts of waste reported in the waste inventory records. This resulted because of the inability to sample the full waste column in the pits. A review of the CIS data revealed additional data requirements that must be met to complete the Risk Assessment (RA) and the FS. Consequently, a sampling plan for the waste pits was prepared.

Surface Soils

A review of the surface soil data obtained during the CIS program shows that uranium and thorium are the predominant and most widespread radionuclides in the waste pit area. Uranium-238 concentrations in surface soils are elevated around the perimeter of Pit 6 and east of Pits 1 and 2. Several locations within the waste pit area had concentrations above 35 pCi/g and at some locations as high as 10,900 pCi/g. The majority of sampling locations show Th-232 concentrations to range between 1 and 5 pCi/g. Locations that are associated with elevated U-238 activity show Th-232 concentrations ranging from 5 to 15 pCi/g. The areal extent of Ra-226 concentrations above background levels of 1.5 pCi/g is quite low.

The surface soil samples collected within Operable Unit 1 during the RI/FS were mostly from the north and northwest perimeter of the waste pit area, which was not covered under the CIS program. Radium-226, Ra-228, Th-228, Th-230, Th-232, U-234, and U-238 were consistently detected in these samples. The observed concentrations for radium were at or slightly above background levels.

Uranium and thorium concentrations were above background with concentrations ranging from 1.0 to 62.0 and 0.6 to 13.6 pCi/g, respectively.

Subsurface Soils

A total of 26 subsurface soil samples were collected from various depths from the wells installed within the Operable Unit 1 study area during the RI/FS. These samples were analyzed for a full range of radionuclides. Radium-226, Ra-228, Th-228, Th-230, Th-232, U-234, and U-238 were consistently detected in these samples. The concentration ranges for these radionuclides in pCi/g are: 0.4 to 1210 for Ra-226; 0.5 to 160 for Ra-228; 0.6 to 22.9 for Th-228; 0.6 to 710 for Th-230; 0.6 to 33.1 for Th-232; 0.6 to 112 for U-234; and 0.6 to 320 for U-238.

Samples collected from the 1000-series wells contain higher concentrations of radionuclides than those from the 2000- and 3000-series wells. Uranium is present in higher concentrations than the other radionuclides in the upper 15 feet of the glacial overburden. Radium and uranium concentrations in samples from the 2000-series and 3000-series wells are generally within background levels. Thorium concentrations are within or slightly above background levels.

Surface Water

Surface water samples were collected at 12 locations along drainageways within Operable Unit 1. Data from this RI sampling program, as well as data from previous studies, indicate the presence of radionuclides in the storm water runoff from the waste pits. Most of the radionuclides are present at background concentrations. Total uranium concentrations range from 54 to 9318 micrograms/liter (µg/L). Concentrations of U-234 and U-238 in two samples exceed the DOE-Derived Concentration Guide (DCG) limit of 500 pCi/L and 600 pCi/L, respectively. These samples contained 597 and 653 pCi/L of U-234; 2840 and 2506 pCi/L of U-238. Radium and thorium were not detected in any surface water samples with the exception of the sample collected from location ASI-29, which had a radium level of 6.1 pCi/L. Thorium was not detected in any samples.

Sediments

No sediment samples were collected within Operable Unit 1 during the RI. However, several drainage ditches within Operable Unit 1 were sampled during the CIS program. Review of the CIS data indicates widespread uranium contamination in most of the drainage ditches. A sample from a drainage that flows parallel and adjacent to the south berm of Pit 5 contained U-238 activity concentrations ranging from 46 to 728 pCi/g. The radium and thorium concentrations were low in

all of the drainageway samples, with the concentrations ranging from nondetectable to slightly above detection limits (approximately 1 pCi/g). A shallow drainage flowing north and south over the Burn Pit area contained U-238 activity concentrations ranging from 170 to 408 pCi/g. A minor drainage flowing east of Pit 4 contained U-238 activity concentrations ranging from 96 to 746 pCi/g.

Groundwater

The perched groundwater in the glacial overburden is heavily contaminated with uranium as a result of the waste pits having leaked. The highest concentration of uranium was detected in Well 1021 on the south edge of Pit 4. A sample from this well contained 15,330 µg/L of total uranium. Other wells containing high concentrations of uranium above 1000 µg/L are Wells 1022, 1073, and 1082. All the wells that contain high concentrations of uranium are located in the east central part of the waste storage pits, with the exception of Well 1073. Leakage from the waste pits is suspected of being the source of contamination in the eastern groundwater plume.

The 2000-series wells are screened at the water table of the Great Miami Aquifer and sample groundwater from the uppermost part of the aquifer. Contaminants from the heavily contaminated glacial overburden infiltrate from the perched groundwater zones to the Great Miami Aquifer. Compared to background levels of total uranium of less than <1 to 2 µg/L, elevated concentrations appear in all wells except Well 2011. The highest concentration of 78.8 µg/L was present in Well 2021. Uranium concentrations in the 3000-series wells were also found to be elevated as in the 2000-series wells. Wells 3001, 3004, 3019, and 3084 had high uranium concentrations, more than 10 times the background, with the highest concentration of 110.0 µg/L in Well 3084. However, at the deepest levels of the aquifer monitored by the 4000-series wells, uranium concentrations do not exceed background levels.

Biological Resources

The investigation of biological resources conducted during the RI determined that there is uptake of radionuclides by both plants and animals within the FMPC. Total uranium concentrations in samples of vegetation roots collected within the Operable Unit 1 study area ranged from 1.8 to 31.3 pCi/g. Other radionuclides were present in concentrations either below detection limits or at background levels. A composite macroinvertebrate sample from Paddys Run at a site near the Operable Unit 1 study area contained 6.4 pCi/g of total uranium; a crayfish sample had 4.4 pCi/g of total uranium. Other radionuclide concentrations in these samples were below the detection limit.

1.1.3.2 Chemical Composition

No background soil data were available in the CIS (Weston 1987) report to compare with soil sample data from the waste storage pits. However, the U.S. Geological Survey (Shacklette and Boerngen 1984) lists the range and mean concentration of metals in U.S. soils. Data for the eastern United States listed in this report were utilized as background values for comparison with the CIS (Weston 1987a) soil data from the waste storage pits. Background concentrations for organic chemicals in soil from the waste storage pits were assumed to be nondetectable. (Detailed tables outlining the extent of chemical contamination of Pits 1 through 6, the Burn Pit, and the Clearwell can be found in Section 4.0 of the Remedial Investigation Report.)

Inorganic Constituents

Aluminum - Aluminum was found in measurable amounts in all the samples collected from the waste pits with concentration levels ranging from 1703 to 64,100 parts per million (ppm). However, only one sample collected from Pit 3 exceeded the average background concentration of 57,000 ppm.

Barium - The average background concentration for barium is 420 ppm. The highest concentration level for barium was 36,939 ppm, collected from Pit 5. All samples collected from this pit had relatively high barium concentrations ranging from 15,800 to 36,939 ppm, which is well above the background level. All but one sample collected from Pit 3 exceeded the average background concentration. All three samples collected from the Clearwell exceeded the average background concentration. Also, all four samples collected from Pit 4 exceeded the average background concentration level. Out of six samples collected from the Burn Pit, only one sample exceeded the average background with a concentration of 7097 ppm. Samples collected from Pits 1, 2, and 6 contained barium in concentrations below background levels.

Calcium - All samples taken exceeded the average background concentration of 6300 ppm, except for two in Pit 1, but no sample exceeded the upper bound of the background range (280,000 ppm). Of the areas sampled, the Clearwell and Pits 3 and 5 appear to contain more calcium than the other pits, as indicated by results that exceeded 100,000 ppm.

Fluoride - This constituent was quantitatively analyzed only in Pit 4. Very high concentration levels were found in all of the three samples collected, with the highest concentration being

124,576 ppm. No background samples were analyzed for this parameter.

Iron - For all samples collected, only one sample from Pit 3 exceeded the average background concentration of 25,000 ppm with a value of 26,919 ppm. Sample results indicate the Clearwell and Pits 2 and 3 have relatively higher concentrations of iron than the other areas.

Magnesium - Magnesium concentrations in three samples collected from Pit 5 exceeded the 50,000 ppm upper bound of the background range of 50 to 50,000 ppm (Shacklette and Boerngen 1984). The highest level was 63,200 ppm. The remaining three out of the six samples collected from Pit 5 exceeded the average background concentration of 4600 ppm. Samples collected from Pits 1, 2, 4, and the Clearwell did not exceed the background upper bound but were above average background concentration. Only one out of six samples from the Burn Pit was more than 50,000 ppm but the rest of the samples were above the average background concentrations. Similarly, only one sample collected from Pit 3 was above the background upper bound and the rest were above the average background concentration. Overall, all the samples contained magnesium in concentrations that exceeded the average background level.

Inorganics - HSL

Arsenic in some of the samples collected from Pits 3 and 5 exceeds the average background concentration of 7.4 ppm. Cobalt in all samples exceeded the average background concentration of 9.2 ppm. Copper was found in many samples to be above the average background concentration of 22.0 ppm. All samples collected from the Clearwell, and Pits 2, 3, 4, and 5 exhibited lead concentrations which exceeded the average background concentration of 17 ppm. Silver was found in concentrations exceeding the average background concentration of 2.8 in most samples. Vanadium was in concentrations above the average background in all the samples collected.

Organics - Volatiles HSL

Samples from Pits 1, 2, 3, 4, and 6 exhibited relatively higher concentrations of volatile organics than those from Pit 5, the Burn Pit, and the Clearwell. Pit 6 had the highest acetone concentration, ranging from 0.7 to 3.2 ppm. Pit 3 had the highest butanone concentration of 4.3 ppm. Methylene chloride was found in measurable amounts in all the pits.

Pit 4 contained tetrachloroethane in concentrations ranging between 0.5 and 30 ppm. Pit 6 contained 1,1,2,2-tetrachloroethane in amounts as high as 29 ppm. Background values for organics are not available. They are assumed to be zero for comparison purposes.

Organics - Semivolatiles HSL

Fluoranthene, naphthalene, phenanthrene, pyrene, and bis(2-ethylhexyl)phthalate appeared to be in higher concentrations than the other semivolatiles detected in the pits. Fluoranthene and naphthalene were highest in Pit 2 with a concentration range of 0.16 to 2.3 and 0.09 to 80 ppm, respectively. Phenanthrene and pyrene were highest in Pit 4 with concentration ranges of 0.11 to 2.7 and 0.09 to 1.8 ppm, respectively. Bis(2-ethylhexyl)phthalate was highest in concentrations in Pit 5, and pentachlorophenol was highest in the Burn Pit.

Polychlorinated Biphenyls/Pesticides - HSL

Polychlorinated biphenyls (PCBs) were detected in all the pits with the highest amounts in samples from Pit 1, ranging between 0.7 and 10 ppm. Samples collected from Pits 2 and 3 had PCBs in concentrations ranging between 0.3 and 1.8 and 0.1 and 1.3 ppm, respectively. Samples from the Burn Pit contained PCBs in the range of 0.07 to 2.7 ppm. Pits 1 and 2 contained dichlorodiphenyl trichloroethane (DDT) at concentrations ranging from 0.02 to 1.6 ppm. The CIS found herbicides (methyl- and ethyl-parathion) in Pit 4 with a concentration ranging between 0.08 and 2.1 ppm. Background values for PCBs/pesticides are not available.

1.1.4 Contaminant Fate and Transport

The principal contaminants associated with Operable Unit 1 are long-half-life radionuclides, their short-lived progeny and stable decay products, and numerous inorganic and organic chemicals. Currently, uranium is the major site-related chemical of concern. Unlike many organic compounds, the radionuclide constituents of concern for Operable Unit 1 do not degrade into less toxic compounds. However, they do undergo transformation by radioactive decay that will ultimately reduce their active concentration. The rate of decay is expressed as the "half-life" of the radionuclide. For all practical purposes, the radioactivity associated with radionuclides present in Operable Unit 1 can be considered constant due to the long half-lives of the isotopes present. Under baseline conditions they will persist at current levels for hundreds of years.

When released from the waste storage pits, the radionuclides and nonradioactive chemicals from the Operable Unit 1 study area would contaminate the environment of the FMPC. The radiological and

chemical hazard would be attributable to contaminant transport through environmental media such as air, soils, surface water, or groundwater. Contaminants may migrate from the Operable Unit 1 waste pit area by several different mechanisms:

- Dissolved contaminants may flow through tears or cracks in pit liners into the surrounding glacial overburden. From there, migration within perched groundwater zones may occur, either as lateral movements toward seeps in the banks along Paddys Run, through contaminated soils, or as infiltration into the underlying Great Miami Aquifer.

- Dissolved or particulate contaminants may be carried by surface water runoff into Paddys Run, where a portion will be trapped by the sediments, a portion will be transported downstream, and part of the dissolved phase will infiltrate through the streambed directly into the Great Miami Aquifer.

- Wind action may transport contaminant particulates from the pit area as fugitive dust emissions.

- Radon emissions may exit the upper layer of cover material on the waste pits.

1.1.5 Baseline Risk Assessment

Uranium is the principal contaminant of concern for Operable Unit 1 in the sediment and surface water runoff pathways. The baseline risk assessment has determined that the risks of cancer from the current potential exposure to uranium from Operable Unit 1 are:

- 9×10^{-7} from ingestion of sediment by children
- 3×10^{-4} from ingestion of groundwater contaminated by surface water runoff
- 3×10^{-5} from inhalation of airborne emissions
- 2.5×10^{-2} from ingestion of groundwater contaminated by waste pit leachate

These risks are from exposure to radionuclides. Low cancer risks from chemical exposure were calculated. The estimated chemical carcinogenic risks associated with the sediment ingestion pathway and the groundwater/waste pit leachate pathway are 1×10^{-10} and 1.4×10^{-7}, respectively. There is no cancer risk from chemical exposure associated with any other pathway.

The estimated risks of cancer under future land-use conditions are the same as those for current exposure via sediment and surface water runoff pathways. It is assumed that airborne emissions are eliminated by vegetative growth over the next 100 years. The estimated risks associated with the groundwater/pit leachate pathway are 1.0 for radiocarcinogenicity and 9.8×10^{-7} for chemically induced carcinogenicity.

The acceptable cancer risk range as stated in 40CFR300 Subpart E is 1×10^{-4} to 1×10^{-6}. Therefore, the total estimated cancer risks associated with Operable Unit 1, 2.5×10^{-2} under current land-use conditions and 1.0 under future land-use conditions, are unacceptable.

1.2 PURPOSE AND ORGANIZATION OF REPORT

The purpose of this report is to document the development, evaluation, and initial screening of remediation alternatives for Waste Pits 1 through 6, the Burn Pit, and the Clearwell of Operable Unit 1. This report has been structured to closely follow the EPA guidance, CERCLA/SARA, and considerations set forth in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

The RI/FS Guidance on the development and screening of alternatives follows six general steps:

- Develop remedial action objectives
- Develop general response actions
- Identify volumes or areas of media to which response actions might be applied
- Identify and screen technologies
- Identify and evaluate technology process options
- Assemble selected representative technologies into alternatives

This report consists of eight sections plus appendices that address each of the six general steps in the EPA RI/FS Guidance. Section 1.0 presents the summary of the RI findings. Section 2.0 defines remedial action objectives. Section 3.0 presents general response actions. Section 4.0 addresses the identification and screening of technologies and process options. Section 5.0 presents the evaluation of process options. Sections 6.0 and 7.0 develop alternatives in detail and provide a thorough discussion on their screening. Appendix A is a description of technologies that were evaluated for further consideration. Appendix B identifies a comprehensive list of potentially applicable or relevant and appropriate requirements (ARARs). A tabulation of characteristics of the waste pits, Clearwell, and Burn Pit is contained in Appendix C.

It should be noted that a hybrid alternative may be used for the remediation of Operable Unit 1. It is possible that some of the pits could be remediated in situ, although the contents of the balance of the pits are remediated by one of the remove-and-treat alternatives. The specifics of such a hybrid alternative will be investigated in more depth in the Task 13 presentation. For the purpose of costing this Task 12 report, it will be assumed that only one alternative for the entire Operable Unit will be utilized.

2.0 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are contaminant-specific, medium-specific goals for protecting human health and the environment (EPA 1990a,b), thus they are an integral part of evaluating the ability of a remedial alternative to achieve an acceptable risk level. The Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA states that "objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited."

RAOs are normally determined on the basis of the results of the baseline risk assessment. The objectives must address the contaminants of concern and the exposure routes and receptors identified for Operable Unit 1. However, in a situation where a site is divided into operable units, the operable unit-specific RAOs must also be based on knowledge of the site-wide risks.

The goal of the FMPC RI/FS is to manage risk from a site-wide perspective. Because many preliminary RAOs are being developed before the completion of site characterization and a site-wide risk assessment and because of the possibility of exposure via multiple pathways, it is difficult to apportion risk levels among operable units. For example, it is not known how many operable units contribute chemical "x" via exposure pathway "y" to receptor "z."

The interim policy for developing preliminary remediation goals is to make use of "readily available ARARs...and other criteria, advisories or guidance" as specified in the preamble to the 40CFR300 (EPA 1990a). Where ARARs or TBCs are not available, preliminary remediation goals will be developed based on a 1×10^{-6} risk level. Effort is underway to develop final remediation goals based on the results of a site-wide baseline risk assessment. This will ensure that final remediation goals account for such concerns as multiple contaminants, multiple exposure pathways, and multiple sources.

When characterization of individual operable units and the site-wide risk assessment are complete, the risk distribution will be evaluated and appropriate adjustments will be made in the operable unit-specific RAOs.

As stated in the preamble to the NCP (EPA 1990a), chemical-specific ARARs will be used to the degree possible to determine remediation goals for the operable unit. Where ARARs do not exist

for a constituent, risk-based cleanup goals will be developed. Remediation goals may be set below ARARs, if multiple contaminants or pathways of exposure exist.

2.1 POINT OF COMPLIANCE

The point of compliance is the geographical location at which the RAOs must be achieved. At most hazardous waste sites, the point of compliance is the nearest identified receptor location for each exposure pathway. The point of compliance must be identified for each operable unit at the FMPC.

The baseline risk assessment for Operable Unit 1 identifies two major human exposure scenarios: current land use exposures and future potential land use exposures. The current exposure setting at the site includes active institutional controls (e.g., fencing, restricted access, security measures, etc.). It is assumed that these controls will remain in place for 100 years, as required by DOE Order 5820.2A. The point of compliance under current exposure conditions would be the FMPC property boundary.

However, to be health protective in developing RAOs for future potential exposures after institutional controls are lost, the point of compliance for each medium becomes the following:

- Groundwater - the point in the regional aquifer immediately below the waste unit
- Soil - the point at which direct contact with the wastes may occur. Assuming some passive controls are implemented for the waste pit area, this point is conservatively set at the boundary of the waste unit.
- Surface water - the point in Paddys Run where runoff from the waste pits may enter the creek
- Air - the point of maximum exposure at the boundary of the waste unit

These points of compliance were developed in accordance with proposed regulations under 40CFR Parts 264, 265, 270, and 271 (EPA 1990a). Passive control measures would be implemented for each alternative except no action. These measures include deed restrictions, well drilling prohibitions, and monolith-type markers that warn against human intrusion. It is reasonable to assume that these measures will prevent direct contact with the wastes and that RAOs for soil do not assume future exposures of this type.

2.2 CONTAMINANTS OF CONCERN

Contaminants of concern for Operable Unit 1 are identified in the baseline risk assessment. Those associated with significant current and future exposure pathways are listed by corresponding medium in Table 2-1.

2.3 RAOs BASED ON ARARs

The development of RAOs is concurrent with the identification of frequently used standards or ARARs. These standards may be altered to ensure sufficient health protection based on multiple sources and pathways.

Chemical-specific ARARs have been identified for airborne uranium and radon and for some of the waste pit constituents that may reach the groundwater or surface waters. The chemical-specific ARARs and TBCs are listed in Table 2-2. If both a maximum contaminant level (MCL) and a proposed MCL (PMCL) exist for a constituent, then the PMCL is used to develop the RAO. Promulgation of these MCLs is expected to occur in the near future.

2.4 RAOs BASED ON RISK CRITERIA

For many of the waste pit constituents, no MCLs or PMCLs have been developed. In these cases, the RAOs are based on available toxicity information. EPA provides guidance on the use of toxicity-based factors. The method is similar to the manner used to develop MCLs (EPA 1989). The toxicity-based factors are reference doses (RfDs) and cancer slope factors (CSFs). The RfD is an estimate of the daily exposure to the human population that is not likely to cause an appreciable risk of deleterious effects over a lifetime. The CSF or risk is characterized as an upper-bound estimate, i.e., the true risk to humans, although not identifiable, is not likely to exceed the upper-bound estimate and in fact may be lower. Briefly, the RAO is estimated using the following steps:

- Determine the RfD based on dose response data and appropriate safety factors
- Determine the acceptable water concentration (C) based on the assumption that a 70-kilogram adult drinks two liters of water per day, such that:

  [(C milligram/liter)(2 liter/day)] / 70 kilogram = RfD (milligram/kilogram/day) for noncarcinogens, or

  [(C milligram/liter)(2 liter/day)] / 70 kilogram = (acceptable risk level)/CSF milligram/kilogram/day for carcinogens
- Apply any site-specific or operable unit-specific relative source contribution factors

TABLE 2-1

RADIONUCLIDES AND CHEMICALS OF POTENTIAL CONCERN FOR OPERABLE UNIT 1

Radionuclides	Inorganics	Organics
Waste Pits:		
U-234	Arsenic	Acenaphthene
U-235	Barium	Anthracene
U-238	Beryllium	Benzo(a)anthracene
Th-228	Cadimium	Benzo(b)fluoranthene
Th-230	Chromium	Benzo(k)fluoranthene
Th-232	Cobalt	Benzo(g,h,i)perylene
Pu-238	Copper	Benzo(a)pyrene
Pu-239/240	Lead	Chrysene
Tc-99	Magnesium	Ethyl benzene
Sr-90	Manganese	Fluoranthene
Np-237	Mercury	Fluorene
Cs-137	Nickel	Indeno(1,2,3-cd)pyrene
Ra-226	Selenium	2-Methylnapthalene
	Silver	Naphthalene
	Thallium	Pentachlorophenol
	Vanadium	Phenanthrene
	Zinc	Phenol
		Pyrene
		Toluene
		Total Xylenes
		Acetone
		2-Butanone
		PCBs (Aroclors-1242, 1248, 1254, 1260)
		DDT
		Ethyl parathion
		Methyl parathion
		Bis(2-ethylhexyl)phthalate
		Di-n-butyl phthalate
		Di-n-octyl phthalate
		Chloroform
		Methylene chloride
		1,1,1-trichloroethane
		Trichloroethene

TABLE 2-1
(Continued)

Radionuclides	Inorganics	Organics
Groundwater:		
U-234	Aluminum	Butyl benzyl phthalate
U-235	Arsenic	Di-n-butyl phthalate
U-238	Barium	1,1-dichloroethane
Total uranium	Copper	1,1,1-trichloroethane
Th-228	Magnesium	Trichloroethene
Th-230	Manganese	Toluene
Th-232	Molybdenum	Acetone
Tc-99	Nickel	cis-1,2-dichloroethene
Sr-90	Vanadium	2-propanol
Ra-226	Zinc	Tetrachloroethene
		2-butanone[a]
		Chloroform[a]
		Ethyl parathion[a]
		Methyl parathion[a]
		Phenol[a]
		Methylene chloride[a]
Surface Water:		
U-234	Aluminum	Bis(2-ethylhexyl) phthalate
U-235	Beryllium	Di-n-butyl phthalate
U-238	Cobalt	
Total uranium	Manganese	
Tc-99	Vanadium	
Ra-226		
Ra-228		
Surface Soil:		
U-238	(No data available)	(No data available)
Th-232		
Ra-226		
Subsurface Soil:		
U-234	(No data available)	2-Butanone[b]
U-235		Carbon disulfide[b]
U-238		Ethyl benzene[b]
Total uranium		Acetone[b]

TABLE 2-1
(Continued)

Radionuclides	Inorganics	Organics
Subsurface Soil (cont.):		
Th-228 Th-230 Th-232 Tc-99 Sr-90 Ra-226	(No data available)	Total Xylenes[b]
Sediment:		
Total uranium	None	Acetone Methylene chloride
Direct Radiation:		
Penetrating radiation	Not applicable	Not applicable
Air:		
U-238 Th-232 Ra-226 Radon	(No data available)	(No data available)

[a] Chemicals expected to reach aquifer within 500 years.
[b] Organic data for surface soil were taken from the one sample available.

TABLE 2-2

OPERABLE UNIT 1 ARARs AND TBCs

Chemical-Specific	Standard	ARAR/TBC	Regulation
Airborne Radionuclide Emission (Except Airborne Rn-222)	Public Dose <10 mrem/yr	Applicable	40CFR61, Subpart H
Radon -222 Emissions	No Source >20 pCi/m²/s	Applicable	40CFR61, Subpart Q
Radiation Dose Limits (All Pathways)	100 mrem/year	To Be Considered	DOE Order 5400.5
Chemicals or Radionuclides in Drinking Water	Arsenic <0.05 mg/L Barium <1.00 mg/L Cadmium <0.01 mg/L Chromium <0.05 mg/L Lead <0.05 mg/L Mercury <0.002 mg/L Selenium <0.01 mg/L Silver <0.05 mg/L	Applicable	40CFR141.11 OAC3645-81-11[a]
	Chloroform <0.1 mg/L PCBs <0.0005 mg/L Trichloroethene <0.005 mg/L		
	Radium <5 pCi/L	Applicable	40CFR141.15
	Beta-emittors 4 mrem/year (whole body or to any organ)	Applicable	40CFR141.16
Chemicals in Drinking Water	Barium <5.0 mg/L Cadmium <0.005 mg/L Chromium <0.1 mg/L Selenium <0.05 mg/L Mercury <0.002 mg/L Methylene Chloride <0.005 mg/L Nickel <0.1 mg/L Benzo(a)pyrene <0.0002 mg/L Benzo(a)anthracene <0.0001 mg/L Benzo(b)fluoranthene <0.0002 mg/L Benzo(k)fluoranthene <0.0002 mg/L Chrysene <0.0002 mg/L Dibenzo(a,h)anthracene <0.0003 mg/L Indenopyrene <0.0004 mg/L PCBs <0.0005 mg/L Pentachlorophenol <0.2 mg/L Selenium <0.05 mg/L 2,3,7,8-TCDD <5 x 10^{-8} mg/L Thallium <0.001 mg/L Ethyl benzene <0.7 mg/L Tetrachloroethene <0.005 mg/L Toluene <2.0 mg/L Xylenes <10 mg/L	To Be Considered	40CFR Parts 141,142, 143 Proposed Rule[b]

TABLE 2-2
(Continued)

Chemical-Specific	Standard	ARAR/TBC	Regulation
Chemicals in Drinking Water (Continued)	Barium <5.0 mg/L Cadmium <0.005 mg/L Chromium <0.01 mg/L Mercury <0.002 mg/L Ethyl benzene <0.7 mg/L Nickel <0.1 mg/L Pentachlorophenol <0.2 mg/L Selenium <0.05 mg/L Thallium <0.0005 mg/L Toluene <2.0 mg/L	To Be Considered	Safe Drinking Water Act Section 1412(b)[c]
Radionuclides in Drinking Water	4 mrem (whole body)	To Be Considered	DOE Order 5400.5
Chemicals in Surface Water	Arsenic <190µg/L Cadmium <1.1µ/L Chromium <11µg/L Copper <12µg/L DDT <0.001µg/L Lead <3.2µg/L Mercury <0.012µg/L Nickel <160µg/L	To Be Considered	40CFR131.21 Quality Criteria for Water
	Parathion <0.013µg/L PCBs <0.014µg/L Pentachlorophenol <13µg/L Phenol <2580µg/L Selenium <36µg/L Silver <0.12µg/L Zinc <110µg/L	To Be Considered	40CFR131.21 Quality Criteria For Water
Chemicals in Surface Water		Applicable	OAC3745-1-01(c)

[a] MCLs

[b] PMCLs

[c] MCLGs

000051

2.5 CHEMICAL-SPECIFIC RAOs

The RAOs for each radionuclide or chemical found at above-background concentrations are listed in Tables 2-3 through 2-6. The RAOs for protection of human health are listed in Tables 2-3 through 2-5. Table 2-6 lists the RAOs for protection of aquatic life in fresh water.

2.6 SUMMARY OF OPERABLE UNIT 1 RAOs

The RAOs for the protection of human health and the environment are summarized in Figure 2-1 for all relevant media associated with Operable Unit 1. The RAOs by media type are then developed into general response actions which are discussed in greater detail in Section 3.0. General descriptions of contaminants of concern, exposure routes and receptors, and acceptable contaminant levels are also supplied in Figure 2-1. Many of the RAOs are based on ARARs and TBCs; others are risk-based. Total cancer risk must fall within the goal set forth in the NCP of 10^{-4} to 10^{-6}. This is being addressed by setting risk levels for individual carcinogen exposure at the 10^{-6} "point of departure" risk level. The resulting site-wide cumulative risk of all carcinogen exposures not previously regulated should fall below 10^{-4} as suggested by the new RCRA regulations (EPA 1990b). Also, the total hazard index (HI) for each operable unit must be below one. The HI is an indicator of potential toxicity and is equal to the intake divided by the RfD.

2.6.1 Pit Wastes

The qualitative RAOs for the pit wastes are to prevent direct contact with the wastes and to prevent migration of the waste pit constituents to the surrounding environmental media.

2.6.2 Air

Two ARARs have been considered applicable to Operable Unit 1 airborne emissions: 40CFR61 Parts 102 and 192. Part 102 allows a 10 mrem/year dose limit to the public for all airborne nuclides except Rn-222. Part 192 requires that radon flux from a single source cannot exceed 20 $pCi/m^2/s$.

2.6.3 Soils

The qualitative RAOs for soils surrounding the waste pits are to prevent direct contact with soils and to prevent soil constituents from migrating to surface waters and sediments.

2.6.4 Surface Water and Sediment

The RAOs for surface water and sediment are based on the same criteria used to determine RAOs for soil.

TABLE 2-3

OPERABLE UNIT 1
GROUNDWATER REMEDIAL ACTION OBJECTIVES FOR RADIONUCLIDES

Radionuclide	Drinking Water Concentration Corresponding to 4 mrem/yr (pCi/L)
Cs-137	102[a]
Ra-224	15[a]
Ra-226	5[a]
Ra-228	5[a]
Ru-106	70[b]
Sr-90	8[a]
Tc-99	914[a]
Th-228	14[b]
Th-230	10[b]
Th-232	2[b]
U-234	19[b]
U-235	21[b]
U-238	21[b]

[a]Values listed are the MCLs for radionuclides as defined in 40CFR141.15 and 40CFR141.16.

[b]Values listed are calculated from DOE Order 5400.5.

TABLE 2-4

OPERABLE UNIT 1
GROUNDWATER REMEDIAL ACTION OBJECTIVES FOR INORGANIC CHEMICALS

Chemical	Basis for Remedial Objective[a]	Acceptable Water Concentration (mg/L)
Arsenic	0.05 mg/L MCL	0.05
Barium	1.0 mg/L PMCL	1.0
Beryllium	0.001 mg/L PMCL	0.001
Cadmium	0.01 mg/L MCL	0.01
Chromium	0.05 mg/L MCL	0.05
Cobalt[b]	-	-
Copper	1.3 mg/L HA[c]	1.3
Lead	0.05 mg/L[d] MCL	0.05
Manganese	0.2 mg/kg/d RfD	7.0
Mercury	0.002 mg/L MCL	0.002
Nickel	0.1 mg/L PMCL	0.1
Selenium	0.01 mg/L MCL	0.01
Silver	0.05 mg/L MCL	0.05
Thallium	0.001 mg/L PMCL	0.001
Vanadium	0.007 mg/kg/d RfD	0.2
Zinc	0.2 mg/kg/d RfD	7.0

[a] MCLs and PMCLs from 40CFR141.11 or 40CFR141, 142, and 143; RfDs and CSFs from Health Effects Assessment Summary Tables, EPA 1990.

[b] No MCL, PMCL, RfD, or CSF has been developed by EPA

[c] Drinking Water Health Advisory

[d] EPA is considering a substantially lower number

TABLE 2-5

OPERABLE UNIT 1
GROUNDWATER REMEDIAL ACTION OBJECTIVES FOR ORGANIC CHEMICALS

Chemical	Basis for Remedial Objective[a]	Acceptable Water Concentration (mg/L)
Acenaphthene[b]	0.06 mg/kg/d RfD	2.1
Acetone	0.1 mg/kg/d RfD	3.5
Anthracene	0.3 mg/kg/d RfD	10.5
Aroclor-1242	0.0005 mg/L MCL	5.0×10^{-4}
Aroclor-1248	0.0005 mg/L MCL	5.0×10^{-4}
Aroclor-1254	0.0005 mg/L MCL	5.0×10^{-4}
Aroclor-1260	0.0005 mg/L MCL	5.0×10^{-4}
Benzo(a)anthracene	-	-
Benzo(a)pyrene	0.0001 mg/L PMCL	1.0×10^{-4}
Benzo(b)fluoranthene	-	-
Benzo(ghi)perylene[b]	-	-
Benzo(k)fluoranthene[b]	-	-
Bis(2-ethylhexyl) phthalate	0.014 $(mg/kg/d)^{-1}$ CPF	2.5×10^{-3}
2-Butanone	0.05 mg/kg/d RfD	1.75
Chloroform	0.1 mg/L MCL	1.0×10^{-1}
Chrysene	0.0002 mg/L PMCL	2.0×10^{-4}
Dibenzofuran[b]	-	-
1,1-Dichloroethane	0.091 $(mg/kg/d)^{-1}$ CSF	3.8×10^{-4}
Di-n-butylphthalate[b]	0.1 mg/kg/d RfD	3.5
Di-n-octylphthalate[b]	0.02 mg/kg/d RfD	0.7
DDT	0.34 $(mg/kg/d)^{-1}$ CSF	1.0×10^{-4}
Ethylbenzene	0.7 mg/L PMCL	7.0×10^{-1}
Methyl parathion[b]	-	-
Fluoranthene	0.04 mg/kg/d RfD	1.4
Fluorene	0.04 mg/kg/d RfD	1.4
Indeno(1,2,3-cd)pyrene	0.0004 mg/L PMCL	4.0×10^{-4}
Methylene chloride	0.0075 $(mg/kg/d)^{-1}$ CSF	4.7×10^{-3}
Methyl parathion	0.00025 mg/kg/d RfD	8.75×10^{-3}
2-Methylnaphthalene[b]	-	-
Naphthalene	0.004 mg/kg/d RfD	1.4×10^{-1}
Pentachlorophenol	0.2 mg/L PMCL	2.0×10^{-1}
Phenanthrene[b]	-	-
Phenol	0.6 mg/kg/d RfD	21.0
Pyrene	0.03 mg/kg/d RfD	1.0
Tetrachoroethene	0.005 mg/L PMCL	5.0×10^{-3}
Toluene	2.0 mg/L PMCL	2.0
Trichloroethene	0.005 mg/L MCL	5.0×10^{-3}
1,1,1-Trichloroethane	0.2 mg/L MCL	2.0×10^{-1}
Xylenes (Total)	10.0 mg/L PMCL	10.0

See footnotes at end of table.

TABLE 2-5
(Continued)

[a]MCLs and PMCLs from 40CFR141.11 or 40CFR Parts 141, 142, and 143; RfDs and CSFs from Health Effects Assessment Summary Tables, EPA 1990.

[b]No MCL, PMCL, RfD, or CSF has been developed by EPA.

TABLE 2-6

REMEDIAL ACTION OBJECTIVES FOR PROTECTION OF AQUATIC LIFE IN SURFACE WATERS

Chemical	Acceptable Water Concentration (µg/L)
Arsenic	190[a]
Cadmium	1.1[a]
Chromium	11[a]
Copper	12[a]
DDT	0.001[a]
Lead	3.2[a]
Mercury	0.012[a,b]
Nickel	160[a,b]
Parathion	0.013[a]
PCBs	0.014[a]
Pentachlorophenol	13[a]
Selenium	36[c]
Silver	0.12[c,d]
Zinc	110[b,c]

[a]Source: U.S. EPA, Office of Water Regulations and Standards, 1986, "Quality Criteria for Water 1986, (Chronic Exposure)," EPA 440/5-86-001, Washington, DC.

[b]Hardness dependent criteria (100 mg/L used)

[c]Source: U.S. EPA, Office of Solid Waste and Emergency Response, 1990, "ARARs Q's & A's: Compliance with Federal Water Quality Criteria (Continuous Concentration)," EPA 9234.2-09/FS, Washington DC.

[d]Maximum concentration

MEDIA		REMEDIAL ACTION OBJECTIVES	GENERAL RESPONSE ACTIONS
1. PIT WASTES	1-1	For Human Health: Prevent inhalation of/ingestion of/direct contact with pit wastes which would result in doses of non-carcinogens greater than the RfDs or in doses of carcinogens posing cancer risk levels greater than 1.0E-04 to 1.0E-06.	No Action Institutional Actions Containment Containment/Treatment Removal/Treatment/Disposal
	1-2	Prevent migration of contaminants (Tables 2-4 through 2-6) which would result in groundwater concentrations greater than the MCLs or that would result in doses of carcinogens posing cancer risk levels greater than 1.0E-04 to 1.0E-06 or in doses of non-carcinogens greater than the RfDs.	
	1-3	For Environmental Protection: Prevent migration of contaminants that would result in surface water levels greater than ambient water quality criteria (Table 2-3).	
2. AIR	2-1	For Human Health: Prevent inhalation of contaminants (Table 2-1) which would result in doses greater than the RfD or doses which pose cancer risk levels greater than 1.0E-04 to 1.0E-06.	No Action Institutional Actions Containment Containment/Treatment Removal/Disposal/Treatment
	2-2	Prevent inhalation of airborne radiation from exceeding a 10 mrem dose, and radon flux from exceeding 20pCi/square meter/second.	
	2-3	For Environmental Protection: Prevent current and future radiation emissions from causing detectable chronic effects.	

FIGURE 2-1. REMEDIAL ACTION OBJECTIVES AND ASSOCIATED GENERAL RESPONSE ACTIONS

FL/FMPC-0115-2/2-1a

MEDIA		REMEDIAL ACTION OBJECTIVES	GENERAL RESPONSE ACTIONS
3. SOIL	3-1	For Human Health: Prevent inhalation of/ingestion of/direct contact with soils surrounding the waste pits which would result in doses of non-carcinogens greater than the RfDs or doses of carcinogens posing cancer risk levels greater than 1.0E-04 to 1.0E-06 (Table 2-1).	No Action Institutional Actions Containment Containment/Treatment Removal/Disposal/Treatment
	3-2	Prevent migration of contaminants (Tables 2-4 through 2-6) which would result in groundwater concentrations greater than the MCLs or that would result in doses of carcinogens posing cancer risk levels greater than 1.0E-04 to 1.0E-06 or doses of non-carcinogens greater than the RfDs.	
	3-3	Prevent contact with radium and thorium above 5 pCi/g in the first 15 cm of soil, and 15 pCi/g at lower depths. Prevent contact with other nuclides at concentrations resulting in doses greater than 100 mrem/yr.	
	3-4	For Environmental Protection: Prevent migration of contaminants that would result in surface water levels greater than ambient water quality criteria (Table 2-3).	
4. SEDIMENT	4-1	For Human Health: Prevent ingestion of/direct contact with sediment contaminants (Table 2-1) which would result in doses of non-carcinogens greater than the RfDs or doses of carcinogens posing cancer risk levels greater than 1.0E-04 to 1.0E-06.	No Action Institutional Actions Containment Containment/Treatment Removal/Disposal/Treatment
	4-2	For Environmental Protection: Prevent releases of contaminants from sediments that would result in surface water levels greater than ambient water qualtiy criteria (Table 2-3).	

FL/FMPC-0115-2/2-1b

FIGURE 2-1.
(CONTINUED)

MEDIA		REMEDIAL ACTION OBJECTIVES	GENERAL RESPONSE ACTIONS
5. SURFACE WATER	5-1	For Human Health: Prevent ingestion of water having contaminants greater than the MCLs or which would result in doses of non-carcinogens greater than the RfDs or doses of carcinogens posing cancer risk levels greater than 1.0E-04 to 1.0E-06 (Tables 2-4 through 2-5).	No Action Institutional Actions Containment Containment/Treatment Removal/Disposal/Treatment
	5-2	For Environmental Protection: Restore surface water to below ambient water quality criteria (Table 2-3).	
6. GROUNDWATER	6-1	For Human Health: Prevent ingestion of water having contaminant levels greater than the MCLs or TBCs (Table 2-2), or which would result in doses of non-carcinogens greater than the RfDs or doses of carcinogens posing cancer risk levels greater than 1.0E-04 to 1.0E-06 (Tables 2-3 through 2-5).	No Action Institutional Actions Containment Containment/Treatment Removal/Disposal/Treatment
	6-2	For Environmental Protection: Restore groundwater aquifer to contaminant concentrations below the MCLs (Tables 2-4 through 2-6).	
7. DIRECT RADIATION	7-1	For Human Health: Prevent current and future radiation doses from exceeding 100 mrem/year.	No Action Institutional Actions Containment Containment/Treatment Removal/Disposal/Treatment
	7-2	For Environmental Protection: Prevent current and future radiation emissions from causing detectable chronic effects.	

FL/FMPC-0115-2/2-1c

FIGURE 2-1.
(CONTINUED)

2.6.5 Groundwater

Waste pit constituents may leach into the regional aquifer sometime in the future. RAOs for groundwater specify that MCLs specified in 40CFR141 should not be exceeded due to migration of waste pit constituents into the regional aquifer. The risk-based RAOs should not be exceeded regarding chemicals for which no MCL has been established. Fate and transport modeling for Operable Unit 1 as reported in the RI report (DOE 1990) suggests that very few of the constituents will reach the regional aquifer in deleterious concentrations within a 500-year period.

3.0 GENERAL RESPONSE ACTIONS

General response actions describe actions that will satisfy the RAOs. General response actions may include treatment, containment, excavation, extraction, disposal, institutional actions, or a combination of these. The relationship of the general response actions to the RAOs is shown in Figure 2-1.

3.1 NO ACTION

The no-action alternative is retained throughout the FS process as a comparative baseline against which other alternatives will be evaluated. In the no-action alternative, Pits 1 through 6, the Clearwell, and the Burn Pit would be left "as is."

3.2 INSTITUTIONAL ACTIONS

Institutional actions include access controls and monitoring. Although institutional actions do not reduce the volume, mobility, or toxicity of the wastes, they can be helpful in reducing direct exposure pathways and the resultant risk to the public.

3.3 CONTAINMENT

One method of reducing the risk to the public is by reducing the mobility of the waste. To reduce waste mobility, the waste must be separated from the primary transport mechanisms, which include wind, surface water, groundwater, and biological and mechanical means. The isolation of the waste would be accomplished by the installation of surface and subsurface barriers to either block or redirect the transport mechanism away from the waste. This containment of the waste can be done by run-on/runoff controls, capping, subsurface flow control, or any combination of these.

3.4 REMOVAL/DISPOSAL

A general response action of removal/disposal was considered and rejected for Operable Unit 1. The removal/disposal option would consist of simply removing the waste from the pits by various hydraulic, pneumatic, or mechanical means and directly disposing of the waste to either an on-property or off-site facility. The removal/disposal option was rejected due to the high moisture content of the waste in the pits. Disposal without first treating the waste to solidify the free liquids would result in large quantities of leachate being generated and would not meet the RAOs. For this reason the removal/disposal response action by itself was not included in Figure 2-1.

The removal/disposal response action is, however, a viable response when combined with treatment actions.

3.5 CONTAINMENT/TREATMENT

The containment/treatment general response action contains the same containment technologies and related process options as the containment general response action (run-on/runoff control, capping, and subsurface flow control). Added to containment is an in situ treatment response action to reduce the toxicity, mobility, or volume of waste present in and around the pits. The in situ treatment would consist of any one of a variety of chemical and/or physical treatment methods. The combination of a treatment action combined with containment would further reduce the potential of a release from the facility.

3.6 REMOVAL/TREATMENT/DISPOSAL

The last general response action is similar to removal/disposal with the added remedial technology of waste stabilization. The process options associated with waste stabilization include the following:

- Asphalt-based solidification in which asphalt is mixed with the soil and waste and solidified
- Cement-based solidification in which cement and fly ash are mixed with the waste and soil
- Thermoplastic encapsulation where polymers are mixed with the waste and soil and solidified
- Vitrification in which high-temperature crystallization/glassification of waste is performed in batch vitrifiers
- Activated carbon reagents which use lime, fly ash, and activated carbon reagents to stabilize the waste and soil

The addition of the treatment component to the removal/disposal action would eliminate the problem of free liquids in the waste stream.

4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

The objective of Section 4.0 is to identify and screen the technologies and process options. Before the identification and screening of technologies and process options can be accomplished, it is necessary to identify the media, associated areas, and volumes to which response actions might be applied. The characteristics, volumes, and areas of Waste Pits 1 through 6, the Clearwell, and the Burn Pit are included in Table 1-1 and Appendix C.

The following are the identified media:

- Storm/surface water
- Perched groundwater
- Excavation/remediation water
- Standing water (Pits 5 and 6, Clearwell)
- Air (fugitive dust)
- Soils and sediments
- Pit wastes

The storm/surface water will be handled by the existing on-site water treatment facilities including the advanced wastewater treatment system and other modifications/applicable interim removal actions. There is a plan to integrate the water treatment requirements of this operable unit into the site-wide water treatment system. Due to the large quantities of soil, sediment, and accompanying contaminated water with high solid content, a conceptual, self-sustaining modular water treatment system is proposed. If the site-wide water treatment can accommodate the needs of this operable unit, this separate water treatment system and its associated costs will be deleted. It may also develop that the site-wide water treatment system can use some of the proposed pretreatment or other treatment modules. In this case, the overall cost of the water treatment system will be reduced.

Based on available information, media-specific potentially feasible remedial technologies and process options were identified for each of the relevant response actions. These technologies were compiled by utilizing technologies described in various EPA documents as well as other applicable references. Each of these technologies and process options underwent an initial screening for technical feasibility. The goal of the screening process was to reduce the original number of possible technologies to a smaller and more workable number of individual technologies that were considered applicable or appropriate for the various media. In this step, both process options and entire technology types could be eliminated based on technical implementability criteria.

4.1 SCREENING CRITERIA

The identification and screening of technologies and process options consist of the following general steps:

- Review the RAOs specifying the contaminants and media of interest, exposure pathways, and preliminary remediation goals that permit a range of treatment and containment alternatives to be developed. The preliminary remediation goals are developed on the basis of chemical-specific ARARs, when available, other available information (e.g., RfDs), and site-specific, risk-related factors.

- Review general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the RAOs for the site.

- Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements as identified in the RAOs and the chemical and physical characterization of the site.

- Identify and screen the technologies and process options applicable to each general response action to eliminate those that cannot be implemented technically at the site.

4.2 TECHNOLOGY DESCRIPTIONS AND EVALUATIONS

4.2.1 Initial Screening: Perched Groundwater, Standing Water, and Excavation/Remediation Water

The applicable general response actions for these media include no action, institutional actions, control/containment, removal, treatment, and discharge. A summary of the screening process based on available information is shown in Figure 4-1. The following sections provide a discussion of this screening process. Technologies and process options that are considered to be implementable at the site are further evaluated in Section 5.0 of this document.

4.2.1.1 No Action

The no-action response was retained for consideration during the development and analysis of alternatives as required by the NCP. The no-action response does not provide additional remediation, monitoring, or security activities at the site to further minimize risk to public health or the environment. This no-action response will be further evaluated as a baseline for comparison with other remedial alternatives developed for Operable Unit 1.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
No Action	None	Not Applicable	Required for consideration by NCP	Required for consideration by NCP
Institutional Actions	Monitoring	Radon Monitoring	Installation of appropriate environmental monitoring	Potentially applicable
		Wellpoint Monitoring	Installation of wells for monitoring groundwater	Potentially applicable
		Leachate Monitoring	Installation of leachate collection/detection system	Potentially applicable
	Access Control	Physical Barriers	Fencing, security, limited road access, etc.	Potentially applicable
		Administrative Controls	Restricted access only, posted signs, etc.	Potentially applicable
Containment	Run-On/Runoff Control	Sedimentation Basin	Temporary storage of runoff to allow settling	Potentially applicable
		Diversion/Collection	Surface water routing controls	Potentially applicable
		Grading	Topography modification for route control	Potentially applicable
		Revegetation	Vegetative cover provides surface stability	Potentially applicable
	Capping	~~Synthetic Cover~~	Synthetic liner placed over area of concern	Not applicable, because of design life
		Concrete-Based Cover	Concrete slab poured over area of concern	Potentially applicable
		Asphalt-Based Cover	Asphalt poured over area of concern	Potentially applicable
		Soil-Based Cover	Compacted soil/bentonite cover over area of concern	Potentially applicable
		Chemical Sealant	Chemical stabilizers mixed with surface soils	Potentially applicable
		Multimedia Cap	Cap formed with various layers (see above)	Potentially applicable
	Subsurface Flow Control	Subsurface Drains	Gravity driven collection system	Potentially applicable
		Groundwater Extraction Wells	Extraction/injection of water into ground	Potentially applicable
		Slurry Walls	A soil/bentonite grout wall emplacement	Potentially applicable
		~~Sheet Pilings~~	Steel forms driven into ground and joined	Not applicable at required depths
		Grout Curtains	Close-spaced grout injections isolate area	Potentially applicable

FL/FMPC-0112-5/4-1a

FIGURE 4-1. INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
Containment/ Treatment	Run-On/Runoff control	Sedimentation Basin	Temporary storage of runoff to allow settling	Potentially applicable
		Diversion/Collection	Surface water routing controls	Potentially applicable
		Grading	Topography modification for route control	Potentially applicable
		Revegetation	Vegetative cover provides surface stability	Potentially applicable
	Capping	Synthetic Cover	Synthetic liner placed over area of concern	Not applicable, because of design life
		Concrete-Based Cover	Concrete slab poured over area of concern	Potentially applicable
		Asphalt-Based Cover	Asphalt poured over area of concern	Potentially applicable
		Soil-Based Cover	Compacted soil/bentonite cover over area of concern	Potentially applicable
		Chemical Sealant	Chemical stabilizers mixed with surface soils	Potentially applicable
		Multimedia Cap	Cap formed with various layers (see above)	Potentially applicable
	Subsurface Flow Control	Subsurface Drains	Gravity driven collection system	Potentially applicable
		Groundwater Extraction Wells	Extraction/injection of water into ground	Potentially applicable
		Slurry Walls	Grout walls formed by trenching and filling	Potentially applicable
		Sheet Pilings	Steel forms driven into ground and joined	Not applicable at required depths
		Grout Curtains	Close-spaced grout injections isolate area	Potentially applicable
	In Situ Stabilization	Shallow-soil mixing	Chemical-, and/or fly ash-based stabilization	Potentially applicable
		Vitrification	High temperature crystallization/glassification of solids	Potentially applicable
		Surcharging	Compaction of material by addition of soil cover	Potentially applicable
		Dynamic Compaction	Mechanical compaction of material	Potentially applicable
	Water Treatment	Precipitation	Removal of metals by solubility adjustments	Potentially applicable
		Reverse Osmosis	Diffusion through semipermeable membrane	Potentially applicable
		Selective Ion Exchange	Ion-specific ion exchange process	Potentially applicable

FL/FMPC-0112-5/4-1b

FIGURE 4-1.
(CONTINUED)

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
Removal/ Treatment/ Disposal	Groundwater Removal	Groundwater Extraction Wells	Extraction/injection of water into ground	Potentially applicable
		Subsurface Drains	Gravity driven collection system	Potentially applicable
	Mechanical Removal	Loader/Dozer	Tractor- or wheel-mounted excavation vehicles	Potentially applicable
		Crane w/Clamshell System	Tractor-, wheel-, or skid-mounted hoisting system	Potentially applicable
		Conveyor System	Belt-type conveyor system excavates material	Potentially applicable
		Backhoe	Tractor- or wheel-mounted excavation vehicles	Potentially applicable
		Dragline System	Excavating tool pulled across material	Potentially applicable
	Hydraulic Removal	Jetting Ring w/Cutterhead	Water pump and vacuum system	Potentially applicable
	Pneumatic Removal	Pneuma/Dozer Dredging	In situ sludge pumping system	Not applicable because of limited availability
		Airlift Dredging	Expanding air pulls material behind it	Not applicable, requires depths > 20-30 ft
		Vacuum w/Cutterhead	Negative pressure displacement system	Potentially applicable
	Waste Stabilization	Asphalt-Based Solidification	Asphalt mixed with soil and solidified	Potentially applicable
		Cement-Based Solidification	Cement and fly ash mixed with soil and solidified	Potentially applicable
		Thermoplastic Encapsulation	Polymers mixed with soil and solidified	Potentially applicable
		Vitrification	High temperature crystallization/glassification	Potentially applicable
	On-Property Disposal	Above/Below Grade Vault	Above- or below-ground engineered facility	Potentially applicable
		Tumulus	Engineered facility, capped when filled	Potentially applicable
		Temporary Storage	Interim on-site storage facility	Potentially applicable
		Lined/Unlined Pits/Trenches	Simple non-structural disposal units	Not applicable for remediation
	Off-Site Disposal	Rail Transport	Railroad transportation along available routes	Potentially applicable
		Truck Transport	Truck transportion along available routes	Not applicable because of determined risk

FL/FMPC-0112-5/4-1c

FIGURE 4-1.
(CONTINUED)

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING COMMENTS
Removal/ Treatment/ Disposal (Cont)	Physical Treatment	~~Air Stripping~~	Volatile mass transfer process	Not applicable for inorganic materials
		Waste Segregation/Separation	Separation of solids and liquids	Potentially applicable
		~~Oil/Water Separation~~	Gravity differential separates free oil and water	Not applicable, no free oil phase
		~~Polymerization~~	Combines monomers to form polymers	Not applicable, few polymerizable materials
		Reverse Osmosis	Diffusion through semipermeable membrane	Potentially applicable
		Selective Ion Exchange	Ion-specific ion exchange process	Potentially applicable
		~~Soil Aeration~~	Air injectors remove volatile organics	Not applicable for inorganic materials
		~~Steam Stripping~~	Steam injection removes volatile organics	Not applicable for inorganic materials
	Chemical Treatment	~~Chemical Dechlorination~~	Reduces the amount of chlorinated compounds	Not applicable, few chlorinated compounds
		~~Oxidation/Ozonation/Photolysis~~	Organics destroyed by chemical oxidants	Not applicable for inorganic materials
		~~Hydrolysis~~	Decomposition of compounds using water	Not applicable, material fully hydrolized
		Leaching/Extraction	Impurities removed through solubility/affinity	Potentially applicable
		Neutralization	Acid or base addition to adjust pH	Potentially applicable
		Precipitation	Removal of metals by solubility adjustments	Potentially applicable
		~~Reduction~~	Reduction of the ionic state of a compound	Not applicable, few reducable materials
	Thermal Treatment	Drying/Calcination	Removes water and decomposes carbonates	Potentially applicable
		~~Incineration~~	Destroys hazardous organics and reduces volume	Not applicable for inorganic materials
		~~Thermal Desorption~~	Heating of a solid to drive off volatile organics	Not applicable for inorganic materials
	Biological Treatment	Biodenitrification	Nitrates/nitrites reduced to molecular nitrogen	Potentially applicable
		~~Biological Detoxification~~	Microbial action degrades organics	Not applicable for inorganic materials
		~~Land Farming~~	Microorganisms cultured in soil	Not applicable for inorganic materials
		~~Permeable Treatment Beds~~	Destroy and remove biodegradable organics	Not applicable for inorganic materials

FL/FMPC-0112-5/4-1d

FIGURE 4-1.
(CONTINUED)

4.2.1.2 Institutional Actions

The institutional actions screened for the groundwater medium include monitoring and use of access restrictions. Both of these actions are applicable for groundwater. Monitoring includes the use of existing wells or the installation of new wells. These well networks can be used to monitor the performance of collection/treatment systems for groundwater, to detect changes in contaminant releases from the site, and/or for compliance monitoring. Use/access restrictions include access control and deed restrictions. Each of these actions is retained for further evaluation.

The access control technology includes the following process options:

- Physical barriers such as fencing, security, limited road access
- Administrative controls such as restricted access and posted signs

Process options for monitoring technology include:

- Radon monitoring
- Wellpoint monitoring, involving the installation of wells for monitoring groundwater
- Leachate monitoring, which involves the installation of leachate collection and detection systems

4.2.1.3 Containment

The waste containment measures screened for the perched groundwater medium include primarily physical measures that restrict contaminant migration and minimize potential impacts on receptors. The control and containment technologies evaluated include subsurface drains, groundwater extraction wells, capping, alteration of the natural drainage system, and vertical and horizontal barriers.

Groundwater extraction wells, vertical barriers, and capping are retained for consideration for use in extracting uncontaminated perched groundwater from the aquifer for purposes of modifying groundwater flow patterns or to provide water for injection to direct flow away from receptors.

Process options retained include:

Run-on/runoff control process options include:

- Sedimentation basin for the temporary storage of runoff to allow settling
- Surface water routing controls for diversion and/or collection
- Grading the topography for route control
- Vegetative cover to provide surface stability

Capping process options include:

- Concrete-based cover in which a concrete slab is poured over the area of concern
- Asphalt-based cover in which asphalt is poured over the area of concern
- Soil-based cover in which only naturally occurring soils are used
- Chemical sealant
- Multimedia cap that combines materials to form various layers

Subsurface flow control process options include:

- Slurry walls
- Grout curtains
- Subsurface drains
- Groundwater extraction wells

The process options eliminated from further consideration include sheet piles and synthetic liners (by themselves). A detailed discussion on the screening results is included in Section 4.3, Technology Issues.

4.2.1.4 Removal

The technology retained for perched groundwater removal is groundwater extraction wells. Groundwater extraction wells will be used in extracting contaminated perched groundwater within the operable unit for subsequent treatment and discharge. The technology for removing the additional water mentioned above is by using conventional pumping equipment.

4.2.1.5 Treatment

The treatment response action includes the technologies of biological, physical, physiochemical, and chemical processes that reduce the volume, toxicity, or mobility of a contaminant by altering its physical or chemical properties.

A majority of the technologies and process options considered in the initial screening are ineffective for removing uranium from the groundwater. Although they may be effective for treatment of organics, uranium is most prevalent in the water; therefore, technologies applicable for uranium removal will be used in the initial development and screening of alternatives. The uranium treatment process options would remove most other contaminants along with uranium. If necessary, a pretreatment stage will be used to remove other contaminants.

Aerobic and anaerobic biological treatment processes are ineffective for removing inorganic compounds, particularly chemical elements such as uranium. The processes of oxidation and chemical reduction are also ineffective for treating uranium. All of these technologies and process options have been eliminated at this phase of the study. The potentially applicable process options retained for uranium removal include solid/liquid separation, leaching/extraction, reverse osmosis, and ion exchange precipitation. Additionally, several treatment processes were found to be potentially applicable as ancillary pre- or post-treatment processes. These include sedimentation, other solid/liquid separation techniques, biodenitrification, and neutralization. These ancillary process options are not carried through the evaluation of process options and the assembly of alternatives but may be included during the detailed analysis of alternatives as necessary for the complete conceptualization, costing, and evaluation of a groundwater treatment system.

4.2.1.6 Discharge

Discharge refers to the release of treated or untreated groundwater to either a surface water body via a permitted outfall or to the subsurface environment via deep well injection. The options of discharge to the Great Miami River via an existing or new pipeline have been retained for consideration, as well as the use of groundwater extraction wells for reinjection of treated groundwater back into the aquifer. Each is considered potentially applicable for groundwater discharge. The discharge of treated groundwater to Paddys Run represents a variation of the discharge technology and will not be independently evaluated.

4.2.1.7 Summary of Technology Screening For Groundwater

The previous sections provided a discussion of the rationale for elimination of numerous technologies and process options inapplicable for remediation of the waste pit groundwater. The technologies and related process options that have been retained for further evaluation and subsequent development of remedial action alternatives are presented in Figure 4-1. The general technologies retained for the groundwater medium include monitoring, use/access restrictions, groundwater extraction wells, physicochemical and chemical treatment processes, and discharge to surface water. The no-action response has also been retained and will be considered throughout the FS process.

4.2.2 Initial Screening: Soils, Sediments, and Pit Waste

This section includes a discussion of the initial screening of technologies and process options considered potentially applicable for remediation of site soils and sediments. This remediation includes the solids and sludges in the waste pits as well as contaminated soil that may be under

and around the waste pits. Summaries of each process for both soil and sediments are presented in Figure 4-1 and are jointly discussed in the following sections.

4.2.2.1 No Action

The no-action response is applicable to the soils and sediments as required by the NCP. The no-action response does not provide additional remediation, monitoring, or security activities at the site to further minimize risk to public health or the environment. The NCP requires that the no-action response be carried through the detailed analysis of alternatives, and, therefore, it will not be eliminated at this stage. The no-action response will be further evaluated as a baseline for comparison with other remedial action alternatives developed for the soils and sediments.

4.2.2.2 Institutional Actions

This general response action includes access/use restrictions for soils and sediments. The access/use restriction response includes fencing and deed restrictions and will minimize access to and use of the areas of concern. The implementation of this response will result in no changes to the existing site environment. Fencing may be applicable in localized areas of soil contamination. Deed restrictions and land acquisitions are also considered for soils only. Deed restrictions will be retained for further evaluation; however, land acquisition is eliminated because data have shown soil contamination within the FMPC boundary only.

4.2.2.3 Containment

The containment response is applicable for both soils and sediments. Major control and containment remedial technologies evaluated for these media include vertical barriers, capping, and surface water control systems.

Vertical barriers will be considered for the pits and can be used to divert groundwater flow away from a contaminated area and/or to isolate the waste. Vertical barriers, such as a slurry wall, will be carried forward for further evaluation.

Capping involves the installation of a barrier over the surface of the contaminated area. Capping is designed to control erosion, prevent the generation of leachate due to surface water infiltration, and alleviate or eliminate possible direct and indirect exposures to the contaminants via inhalation, ingestion, or dermal contact. Capping techniques considered for evaluation for soils and sediments include single-layer and multilayer caps. The single-layer cap is potentially applicable for types of contaminants and areas of concern for both soils and sediment. Single-layer caps may include the

use of concrete, asphalt, clay, or soil with the latter two being applicable only to soils. Multilayered caps are a regulatory requirement for mixed or hazardous waste.

Surface water control can be used to minimize contamination of surface waters by reducing the erosion and off-property transport of soils that have been contaminated. This technology includes the use of diversion and collection systems, grading, and site revegetation. Because these are considered support actions, they will not be carried further in the evaluation of process options but will be included, as necessary, during the detailed evaluation of alternatives.

4.2.2.4 Removal

Complete or partial removal of contaminated material will prevent migration of contaminants toward potential receptors. This may be accomplished using either mechanical excavation equipment or, in the case of contaminated sediments and the wet pits, dredging equipment.

Mechanical excavation involves the use of common construction equipment, such as backhoe or bulldozer, to remove the soil or sediments. These methods are potentially viable for soils, wastes, and sediments not in contact with surface waters.

The mechanical removal technology involves the following process options:

- Loader/dozer, which includes wheel- or tractor-mounted excavation vehicles
- Crane with clamshell system, which uses tractor-, wheel-, or skid-mounted hoisting system
- Conveyor system, which uses belt-type conveyor to excavate material
- Backhoe, tractor- or wheel-mounted
- Dragline system excavating bucket pulled across waste

The hydraulic removal technology involves using a mining jetting ring and pump equipped with a cutterhead, which is a water pump and suction system.

The pneumatic removal technology includes the following process options for the remediation of Operable Unit 1:

- Pneumatic/Oozer dredging, which is an in situ pumping system
- Airlift dredging, which uses expanding air to pull material behind it
- Vacuum with cutterhead, which uses negative pressure to displace the material through a pipe

Because of dependence on hydrostatic pressure, which limits the effectiveness in shallow water and has limited availability in the United States, pneumatic/Oozer dredging will be deleted as a viable process option.

4.2.2.5 Treatment

The treatment options include biological, chemical, physical, physicochemical, solidification/stabilization, and thermal measures that reduce the volume, toxicity, or mobility of a contaminant by altering its physical or chemical properties. Applicable technologies for soils and sediments are discussed below.

The three techniques of in situ bioremediation, soil aeration, and land farming are suitable for remediation of organics; however, they do not address the uranium contamination found at the site. All biological treatment methods will therefore be deleted from further consideration.

In situ vitrification was evaluated as a technology for the chemical treatment of soils and sediments. In this process, a high current of electricity is passed through the contaminated media in situ. The heat generated drives off any volatile organic compounds and water and solidifies the soils into a glassy, solid matrix resistant to deterioration from weathering or leaching. This technology may be feasible for soils.

Physical treatment technologies are applicable when the properties of the contaminant compounds make them amenable to separation, replacement, or volatilization. The following physical treatment technologies were screened for soils and sediments:

- Vapor extraction
- Volatilization
- Gravimetric separation

Vapor extraction and volatilization are applicable for volatile organics only and will not remove uranium; therefore, these options were deleted from further consideration. The process of gravimetric separation uses a pulsating sieve to separate materials by density through stratification in a fluid media. Because uranium compounds tend to fall out in the most dense fraction, this may be a viable option for minimizing the waste requiring subsequent disposal and is retained for further evaluation.

The physicochemical treatment process of soil washing was evaluated for the treatment of soils/sediments. Soil washing involves the extraction of organic and inorganic compounds from soils or sediments by leaching. Soil washing may be viable for the removal of soluble uranium compounds and is retained for further evaluation for both the surface soils and sediments.

Solidification/stabilization involves techniques to seal the contaminated soils and sediments in a solid, stable mass that reduces the mobility of the contaminants in the environment. Some of these techniques physically surround the contaminant particles with a solidifying agent. Others chemically fix the contaminants by reaction with a solidifier. The following solidification/stabilization techniques were reviewed for treatment of the surface soils and sediments:

- Cement-based
- Thermoplastic
- Vitrification

The technologies are suitable for solidifying or fixing either inorganic wastes or radioactive materials. All will be retained for further analysis. If any organics are found at the site, cement-based and thermoplastic technologies may have limited application for pretreatment of the wastes because the presence of organics may interfere with the solidification or fixation process.

Thermal treatment is a process in which molecular bonding of organic or inorganic compounds is altered through thermal decomposition and oxidation. The end products of this process typically include carbon dioxide, elemental carbon, ionized halogen, phosphorous, sulfur, and other inorganics depending on the original composition of the waste material. The following process options were evaluated for on-site thermal treatment of surface soils and sediments:

- Thermal desorption
- Mobile incinerator (rotary kiln)

These thermal treatment methods are not applicable to soils and sediments contaminated by elemental metals such as uranium and will therefore be deleted from further evaluation as a primary treatment technology but may be used as an ancillary process to remove organics before stabilization.

4.2.2.6 <u>On-Property Disposal</u>

Disposal technologies include physical measures (other than in situ) that provide a permanent preengineered environment to restrict contaminant movement or migration, thus minimizing potential

impacts on a receptor. For this screening process, an on-property landfill has been defined as an engineered disposal facility (EDF) designed to meet established federal and state regulations. On-property disposal of contaminated soils and sediments is considered applicable and has been retained for further consideration.

The on-property disposal technology contains the following process options:

- Abovegrade vault, which is simply an engineering facility built above ground level
- Belowgrade vault, which is an engineering facility built below ground level
- Temporary on-property storage
- Lined/unlined pits or trenches, which are simple nonstructural disposal units

Lined/unlined pits or trenching will not be considered further because of the possibility of contaminant migration. Lined/unlined pits are unsuitable for permanent remediation.

In accordance with current EPA guidance, ARARs are to be progressively developed and applied on a site-specific basis as the RI/FS proceeds. The potential ARARs for the EDF fall within the following EPA recommended classifications:

<u>ARARs</u> -

- Safe Drinking Water Act - 40CFR141-149
- Resource Conservation Recovery Act - 40CFR260-279
- Federal Water Pollution Control Act - 40CFR104-140
- Fish and Wildlife Coordination Act - 40CFR6.302
- Clean Air Act - 40CFR61, Subparts H and Q
- EPA Regulations for Health and Environmental Protection Standard for Uranium and Thorium Mill Tailings - 40CFR192
- NRC Regulations for Standards for Protection against Radiation - 10CFR20
- Licensing Requirements for Land Disposal of Radioactive Waste - 10CFR61
- Floodplain/Wetlands Environmental Review Requirements - 10CFR1022

<u>Ohio ARARs</u> -

- Water Quality Standards - OAC3745-1
- Water Well Installation - OAC3745-9
- Air Pollution Control - OAC3745-15, OAC3745-17
- Solid and Hazardous Waste Disposal Law - OAC3745-27 through 70
- Drinking Water Rules - OAC3745-81-01 through 55

Because ARARs may not exist or be sufficient to protect human health and the environment at a CERCLA site, it is necessary to evaluate nonlegally binding or promulgated criteria, advisories,

guidance, or policies for protective cleanup levels when determining the remedy design. The following are Federal and DOE orders to be considered in the design of the EDF:

TBCs -

- DOE Order for Radiation Protection of the Public and the Environment - 5400.5
- DOE Order for Radioactive Waste Management - 5400.2A
- DOE Plan for Implementing EPA Standards for UMTRA Sites - UMTRA-DOE/AL-163
- DOE Technical Approach Document Revision II - UMTRA-DOE/AL-050425.0002
- DOE Remedial Action Planning and Disposal Cell Design - UMTRA-DOE/AL-4000503
- DOE Project Surveillance and Maintenance Plan - UMTRA-DOE/AL-350124
- EPA Health Effect Assessment Guidance - "Health Effects Assessment Summary Tables (HEAST)" and/or "Integrated Risk Information System"
- National Primary Drinking Water Standards - 40CFR141.50 through 141.51
- Floodplain Management - Executive Order 11988
- Protection of Wetlands - Executive Order 11990

A brief discussion of each of the ARARs and TBCs is included in Appendix B.

4.2.2.7 Off-Site Disposal

Off-site disposal technologies are considered to be practiced at existing facilities that are approved by the appropriate federal and state regulatory agencies, such as the EPA. For this screening process, an off-site landfill has been defined as a preengineered disposal area that meets the applicable regulations. Off-site disposal of contaminated soils and sediments will be retained for further consideration.

4.2.2.8 Summary of Technology Screening for Surface Soils and Sediments

Based on the rationale presented in the previous sections, numerous technologies and process options were judged not to be applicable to uranium or other site-specific conditions and have been deleted from further consideration. Figure 4-1 presents the technologies and related process options that have been retained for further evaluation and for subsequent development of remedial action alternatives for soils and sediments, respectively. The retained technologies for both soils and sediments include access/use restrictions, capping, extraction, physical and physicochemical treatment, solidification/stabilization techniques, and landfilling. The no-action response has also been retained for both media and will be considered as a remedial action alternative in the next phase of the FS.

4.2.3 Initial Screening: Air (Fugitive Dust)

This section includes a discussion of the initial screening of technologies and process options considered potentially applicable for air and fugitive dust emissions. Summaries of technologies and process options are presented in Figure 4-1 and are jointly discussed in the following sections.

4.2.3.1 No Action

The no-action response is applicable to air (fugitive dust) as required by the NCP. The no-action response does not provide additional remediation, monitoring, or security activities at the site to further minimize risk to public health or the environment. The NCP requires that the no-action response be carried through the detailed analysis of alternatives, and therefore, it will not be eliminated at this stage. The no-action response will be further evaluated as a baseline for comparison with other remedial action alternatives developed for air.

4.2.3.2 Institutional Actions

This general response action includes access/use restrictions for air (fugitive dust). The access/use restriction response includes land acquisition and deed restrictions and will minimize access to and use of the areas of concern. Deed restrictions and land acquisitions will not be retained as stand-alone remediation technologies because fugitive dust could travel beyond any realistic site boundary.

4.2.3.3 Containment

The containment response is applicable for fugitive dust. Major control and containment remedial technologies evaluated for this media include capping, dust suppressing agents, and containment structures.

For fugitive dust mitigation, only the single layer cap will be retained as a representative process option for further evaluation because it is adequate to control fugitive dust and much less complex to construct than the multilayer cap.

4.2.3.4 Removal

Because the source of contamination in air is fugitive dust from the surface of the waste pits and possibly exposed sediments, the technologies retained for removal of air contaminants will be the same as those retained for the removal of contaminated soils and sediments.

4.2.3.5 Treatment

The treatment response action for air (fugitive dust) is the same as for soils and sediments. The technologies and process options retained for the treatment of the soils, sediments, and pit wastes are the same as those for the treatment of fugitive dust.

4.2.3.6 On-Property Disposal

On-property disposal technologies and process options for fugitive dust are the same as those for soils, sediments, and pit wastes.

4.2.3.7 Off-Site Disposal

Off-site disposal technologies and process options for fugitive dust are the same as those for soils, sediments, and pit wastes.

4.2.3.8 Summary of Technology Screening for Air (Fugitive Dust)

Based on the rationale presented in the previous sections, numerous technologies and process options were judged not to be applicable to uranium or other site-specific conditions and have been deleted from further consideration. Figure 4-1 presents the technologies and related process options that have been retained for further evaluation and for subsequent development of remedial action alternatives for air (fugitive dust). The retained technologies for fugitive dust include access/use restrictions, capping, extraction, physical and physicochemical treatment, solidification/stabilization techniques, and landfilling. The no-action response has also been retained for both media and will be considered as a remedial action alternative in the next phase of the FS.

4.3 TECHNOLOGY ISSUES

Based on the remedial action technology screening methodology defined in Sections 4.1 and 4.2, the technology issues presented in the following section have been assembled to provide maximum screening impact on the development of remedial action alternatives. The issues will be addressed under each of two general topics: nonremoval issues and removal issues. In addition, this section will identify the assumptions required to define site conditions in support of this Task 12 effort.

4.3.1 Nonremoval Technology Issue 1: Naturally Occurring Materials Versus Synthetic Closure Cap Components

The exclusive use of naturally occurring materials for the cap, such as aggregates (sands/gravels) and clay, versus synthetic drainage layers (geotextiles) and flexible membrane liners (FMLs), will be evaluated. Descriptions of the technologies can be found alphabetically in Appendix A.

4.3.1.1 Decision Factors

The critical decision factors used in evaluating this technology issue will be material availability, longevity, and ability to construct:

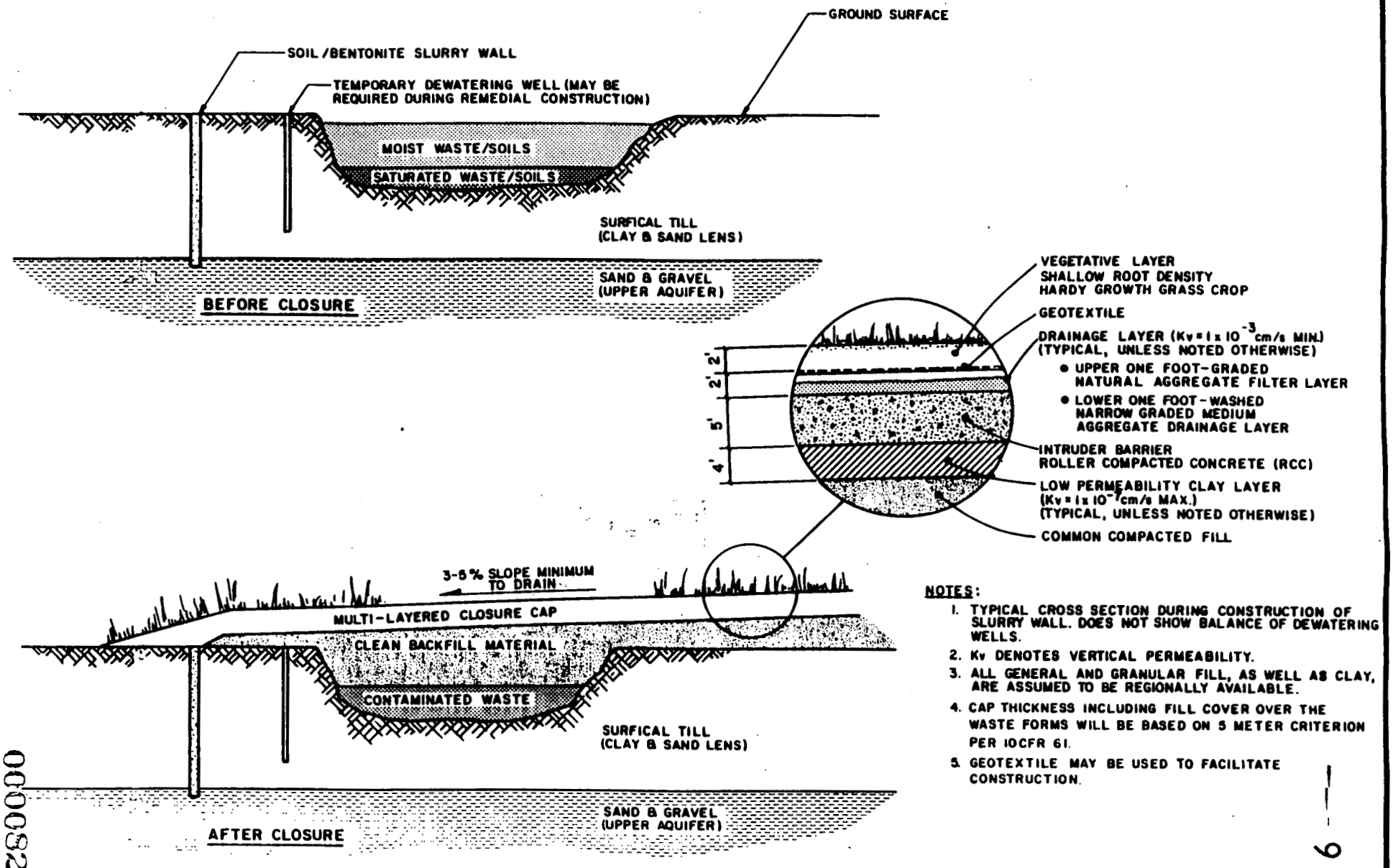
- Material availability - All materials, whether naturally occurring or synthetic, are readily available from regional vendor sources with the possible exception of clays capable of achieving an inplace vertical permeability of 1×10^{-7} centimeters per second. However, if the specified clay is not readily available, it can be produced from indigenous, sandy site soils mixed with bentonite without any special technology or significant cost increase.

- Longevity - The main advantage to the exclusive use of naturally occurring materials is longevity. If the waste is structurally stabilized to minimize future consolidation and the cap properly constructed and maintained, the service life performance can be expected to greatly exceed that of synthetic materials. Geotextiles and FMLs have a relatively short documented performance history of approximately 30 to 40 years, depending on material composition. In addition, past experience has shown that FMLs are more dramatically impacted by certain environmental stresses, such as root and burrowing animal penetration, which can further reduce the useful service life.

- Constructability - The placement of synthetic drainage layers and FMLs can significantly speed construction and reduce cost. However, FMLs specifically have the potential of being damaged during construction, if not carefully protected during storage, handling, and installation operations. An FML cannot be leak tested during and after the critical period of drainage layer installation. All cap components, both naturally occurring and synthetic materials, require that extensive quality assurance/quality control (QA/QC) programs be initiated during and after remediation.

4.3.1.2 Screening Results

Although geotextiles and FMLs may be used to facilitate natural materials placement, no synthetic materials should be relied on as a long-term component. Present regulatory criteria such as 10CFR61.7(b)(5) may require minimizing both maintenance and storm water infiltration, as well as providing structural longevity for intrusion barrier purposes in excess of 500 years. Therefore, multiple liner caps that rely on synthetic components will be screened from further consideration. The capping system evaluated as part of this task and shown in Figure 4-2 will utilize a four-foot-



NOTES:

1. TYPICAL CROSS SECTION DURING CONSTRUCTION OF SLURRY WALL. DOES NOT SHOW BALANCE OF DEWATERING WELLS.
2. Kv DENOTES VERTICAL PERMEABILITY.
3. ALL GENERAL AND GRANULAR FILL, AS WELL AS CLAY, ARE ASSUMED TO BE REGIONALLY AVAILABLE.
4. CAP THICKNESS INCLUDING FILL COVER OVER THE WASTE FORMS WILL BE BASED ON 5 METER CRITERION PER 10CFR 61.
5. GEOTEXTILE MAY BE USED TO FACILITATE CONSTRUCTION.

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FIGURE 4-2. TYPICAL CROSS SECTION BEFORE/AFTER CLOSURE

thick clay layer, five-foot-thick roller compacted concrete intrusion barrier, and a combination two-foot natural aggregate filter blanket/drainage layer design.

4.3.2 Nonremoval Technology Issue 2: Physical Stabilization Versus No Stabilization of the Pit Wastes

The generic use of in situ physical stabilization treatments versus no in situ treatment before closure cap placement is examined in the following section. Examples of in situ physical stabilization treatments include surcharging, dynamic compaction, vacuum extraction, vertical drains, and shallow soil mixing. Descriptions of the technologies can be found in Appendix A.

4.3.2.1 Decision Factors

The critical decision factors used in this technology issue evaluation will be short-/long-term closure cap structural integrity and discharge of waste/soil matrix pore water into the groundwater:

- Closure cap structural integrity - Although the Clearwell and Pits 5 and 6 will require removal and treatment of the standing waters, the CIS data indicate that most pit wastes are extremely wet and compressible. As the closure cap is placed, the induced load will initiate waste compression (consolidation). Dependent on factors such as total cap weight, time to construct, water content of the waste, and porosity of the surrounding pit soils, the cap may experience considerable settlement for years after completion. This extended settlement period will require considerable cap maintenance and possible reconstruction efforts. Therefore, the potential exists for increased worker and public exposure to the pit contaminants because of infiltration of storm water through the waste. In time, the waste will achieve stability relative to the surrounding environment and the closure cap will become structurally stable. However, if the waste is fully or partially stabilized during remediation, as in Alternative 2, then the need for future cap maintenance, repair, and the associated costs are greatly reduced. One method of physical stabilization, surcharging, is shown in Figure 4-3.

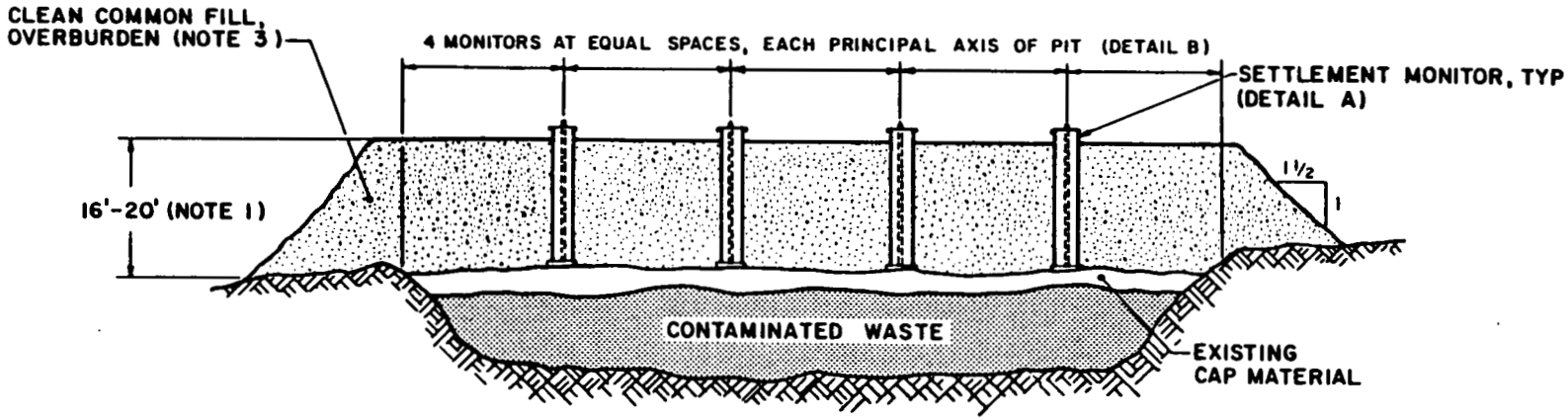
- Discharges into groundwater - As the waste consolidates under the cap loads, pore water will be squeezed out of the waste/soil matrix into the surrounding soils and ultimately into the perched groundwater. As discussed in the short-/long-term closure cap structural stability decision factor, waste consolidation may be experienced for years after the completion of cap construction. This may lead to the long-term introduction of contaminated pore water into the perched groundwater and potentially the Great Miami Aquifer. Physical stabilization of the pit wastes before cap placement would minimize, to the extent practical, the introduction of contaminated pore water into the perched groundwater.

4.3.2.2 Screening Results

The generic use of in situ waste stabilization, as compared to no stabilization, will minimize the potential of long-term exposure to the environment and the general public because of a reduction in leachate (pore water) introduced into the groundwater. In addition, physical stabilization will more

NOTES:

1. HEIGHT OF SURCHARGE AND TIME TO MAINTAIN IN PLACE ARE DEPENDENT ON THE RESULTS OF ONE-DIMENSIONAL CONSOLIDATION TESTS PER ASTM D2435-80.
2. FOR CLARITY, LEACHATE (WASTE PORE WATER) COLLECTION SYSTEM DETAILS, NOT SHOWN.
3. CLEAN COMMON FILL ASSUMED TO BE REGIONALLY AVAILABLE.
4. SURCHARGED AREAS TO BE SURROUNDED BY SILT FENCING.



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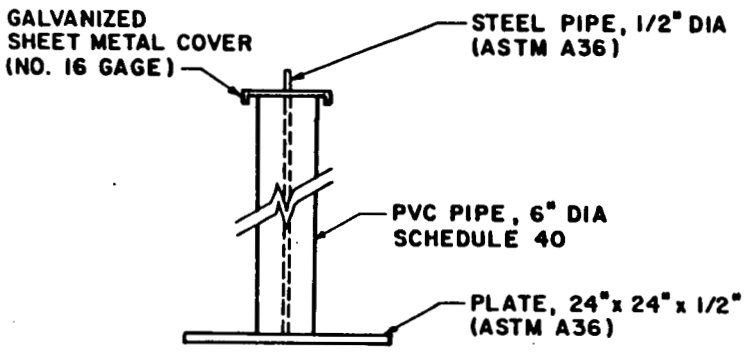

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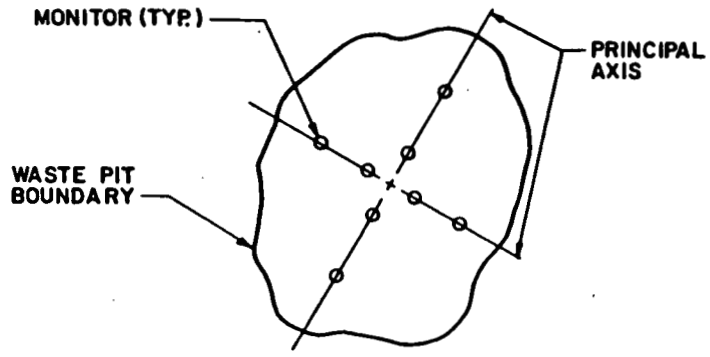

DETAIL B
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FIGURE 4-3. TYPICAL CROSS SECTION DURING SURCHARGING

effectively provide long-term closure cap structural stability, thus reducing future maintenance/repair costs and potential worker exposure.

4.3.3 Nonremoval Technology Issue 3: Dynamic Compaction as a Physical Stabilization Technology

4.3.3.1 Decision Factors

The critical decision factors used in this technology issue evaluation will be public health and environmental protection. Dynamic compaction, as defined in Appendix A, involves dropping 5- to 40-ton-weights from heights of 20 to 100 feet, resulting in compaction of surface and subsurfacewastes and soils. Although this technology has been proven effective and economical as a physical stabilization technique, it can produce seismic-type vibrations radiating out from the point of impact. Depending on distance from impact (wave form attenuation), soil/waste being compacted, and height/weight of drops, nearby structures may experience physical damage ranging from minor cracking to structural failure.

The K-65 silos of Operable Unit 4 are located immediately south of the waste pits. The structural integrity of the K-65 silos was examined (Camargo 1985; Bechtel 1990); the findings indicated the silos are in a deteriorated state with little or no remaining service life safely assigned. If the silos failed or were damaged during nearby dynamic compaction efforts, radon gas and/or the presently stored radium and thorium-bearing ores could be released into the environment. Any unexpected or unintended silo release would negatively impact public health and increase worker exposure risks, as well as increase overall FMPC environmental remediation costs.

4.3.3.2 Screening Results

Because of the structurally deteriorated condition of the K-65 silos, in situ densification (stabilization) using dynamic compaction could cause vibratory-induced structural damage to the K-65 silos with resultant contaminant releases to the environment. This would negatively affect public health and environmental protection. Therefore, dynamic compaction should only be considered if the K-65 silos have been remediated or removed before implementation of the compaction.

4.3.4 Nonremoval Technology Issue 4: The Addition of Shallow Soil Mixing Technology to Physical Stabilization Options

4.3.4.1 Decision Factors

The decision factor used for this technology issue consists of a viable technology inadvertently overlooked in previous Task 12 reports, specifically a shallow soil mixing (SSM) technique. SSM is a method of mixing soils or sludges with dry or fluid treatment chemicals to produce a solidified or stabilized end product. SSM can mix soils and sludges of varying moisture contents, ranging from dry soils to fluid sludges, to depths of 30 feet or more. Excluding Pits 1 through 4 and the Burn Pit, which contain actual or assumed quantities of drums, construction rubble, and/or miscellaneous site debris, CIS data indicate Pits 5 and 6 and the Clearwell exclusively contain sludges from plant production and/or site surface soil sediments. Therefore Pits 5 and 6 and the Clearwell are acceptable candidates for shallow soil mixing, although preliminary field testing may be required to verify and specify mixing requirements. For a more complete evaluation see Appendix A, Description of Technologies.

4.3.4.2 Screening Results

SSM will be added to the potential physical stabilization options uniquely applicable to Pits 5 and 6 and the Clearwell.

4.3.5 Removal Technology Issue 1: Off-Site Waste Disposal - Trucking Versus Railroad Transport

4.3.5.1 Decision Factors

The critical factors used for this technology issue include short-term public health, environmental safety, political acceptance, and cost.

- Public health and environmental safety - As discussed in Appendix A, Description of Technologies, off-site waste disposal by truck or rail transport (with installation of a suitable spur line) can provide portal-to-portal service between an assumed disposal facility and FMPC. However, preliminary occupational and public risk calculations, based on published injury/fatality statistics (Table 4-1), found that shipping by truck presents a significantly greater risk to public and worker safety (Table 4-2). For cement stabilization, the estimated 1,970,150 miles required by rail to deliver an estimated 2.24 million cubic yards of waste is a fraction of the 915,200,000 miles required by truck transport. Approximately the same ratio of rail versus truck transport miles exists for the vitrification process. Therefore, the cumulative risk or potential for accidents becomes greater, as noted from the previously cited table.

TABLE 4-1.
RISK FACTORS FOR WASTE TRANSPORTATION - OPERABLE UNIT 1

Group at Risk	Fatalities[a]		Injuries[a]	
	Truck[b]	Rail[c]	Truck[b]	Rail[c]
Occupational	0.0021131	0.0000460	0.0412245	0.0045968
Public	0.0128553	0.0018331	0.1178261	0.0067484

[a] 4,400 round trip miles assumed
[b] Risk Factor per million vehicle miles @ 30 tons of waste per haul load
[c] Risk Factor per thousand railroad miles @ 90 tons of waste per car and 120 cars per haul load

SOURCES:

U.S. Dept. of Transportation, Federal Highway Administration, Office of Motor Carriers, Accidents of Motor Carriers of Property, Washington, D.C., (Publication No. FHWA-MC-88-008), 1986.

U.S. Dept. of Transportation, Federal Highway Administration, Office of Highway Information Management, Federal Highway Statistics Report, Washington, D.C., 1988.

U.S. Dept. of Transportation, Federal Railroad Administration Office of Safety, Accident/Incident Bulletin, Washington, D.C., (Publication No. 157), 1988.

TABLE 4-2.
RISK OF TRANSPORTING WASTE - OPERABLE UNIT 1

	MILEAGE		PUBLIC	OCCUPATIONAL	TOTAL
CEMENT STABILIZATION					
TRUCK	915,200,000	INJURIES	108.83	37.73	146.56
		FATALITIES	11.77	1.93	13.70
TRAIN	1,970,150	INJURIES	13.30	9.06	22.36
		FATALITIES	3.61	0.09	3.70
VITRIFICATION					
TRUCK	598,400,000	INJURIES	70.50	24.67	95.17
		FATALITIES	7.69	1.26	8.95
TRAIN	1,287,650	INJURIES	8.69	5.92	14.61
		FATALITIES	2.36	0.06	2.42

SOURCES: See Table 4-1.

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- Cost - The following evaluation is based on vendor source information and excludes waste handling, packaging, decontamination, and general contract management fees.

- Rail	
Assumed rail spur installation	$ 40,000,000
Transport (1,970,150 miles)	$ 371,002,273
Total cost	$ 411,002,273
- Truck	
FMPC to waste disposal facility (457,600,000 miles)	$ 801,212,996
Return trip (457,600,000 miles)	$ 457,600,000
Total cost	$1,258,812,996

- Political acceptance - While local opposition should be expected, the mass transportation required to implement off-site disposal could be challenged in numerous local political jurisdictions along the proposed transportation route, creating unacceptable site cleanup delays. However, it is felt that political liabilities associated with rail transport would be less than truck transport based on public health issues, including: number of trips, inspection and selection of routes, and general public perception of transport safety, specifically during inclement weather.

4.3.5.2 Screening Results

Based on the preliminary risk assessment, the extremely large difference in waste transport as well as the varying degree of political liability associated with transport modes, truck transport will be deleted as a viable off-site technology option. Therefore, only direct rail transport and rail transport with a truck transfer station near the disposal site will be retained for further consideration.

4.4 SITE CONDITION ASSUMPTIONS

The following assumptions will be used until more operable-unit-specific data become available:

- Assumption 1: For costing purposes, an approved waste disposal facility is assumed to be available in the western United States at a 2200-mile distance from the FMPC.

- Assumption 2: When considering the extent of contaminant migration into the surrounding pit soils, the following is considered contaminated:
  - A 5-foot-wide remediation buffer around the outer perimeter of the Operable Unit 1 pits and/or their respective berms. This buffer will be extended to 10 feet horizontally on the southwest side of the operable unit area because of assumed groundwater flow in the glacial till cap.
  - The areas between the various pits
  - The soils below the bottom of all pits to the top of the sand and gravel unit containing the Great Miami Aquifer

- Assumption 3: Pit source term definition (i.e., the quantity of both radiological and hazardous chemical wastes) is based on the statistical 95 percent confidence level of all CIS boring data.

- Assumption 4: Pits 1 through 6, the Clearwell, and the Burn Pit are classified as radioactive waste. Regarding hazardous wastes, Pit 4 has been determined to contain mixed waste. The balance of Operable Unit 1 wastes contains hazardous constituents that do not necessarily cause the waste to be designated as mixed waste.

5.0 EVALUATION OF PROCESS OPTIONS

The purpose of this section is to evaluate the various process options that are considered implementable (Figure 4-1). This evaluation process will lead to the selection of one representative process option for each type of technology. These evaluations were based upon engineering judgement and not detailed analysis. Figure 5-1 presents the results of evaluating the process options.

5.1 SCREENING CRITERIA

The process options were evaluated using effectiveness, implementability, and cost as the criteria. Also, these criteria were applied only to the technologies and the general response actions that they were intended to satisfy; they were not applied to the site as a whole. However, this evaluation process will primarily focus on effectiveness factors with less emphasis on the implementability and cost evaluations. A description of each evaluation criterion used in developing Figure 5-1 is presented below.

5.1.1 Effectiveness Evaluation

The various process options that have been identified under each type of technology in Section 4.0 were evaluated for effectiveness based on the following:

- The potential effectiveness of the process option for handling the estimated areas or volumes of media and meeting the remedial action objectives
- The potential impacts to human health and the environment during the construction and implementation phase
- The reliability of the process option as it relates to the contaminants and conditions at the site

5.1.2 Implementability Evaluation

As per the EPA RI/FS Guidance Document, evaluation of process options based on implementability was not weighed as heavily as the effectiveness evaluation. The implementability evaluation includes both the technical and administrative feasibility of implementing a process option. Because Section 4.0 has already screened process options based on technical implementability, the implementability evaluation in this section will place greater emphasis on the institutional aspects. Examples of institutional implementability are factors such as the availability of skilled workers to implement the process option; ability to obtain permits for off-site actions; and the availability and capacity of treatment, storage and disposal facilities.

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
No Action	None	Not Applicable	Does not achieve remedial action objectives	Not acceptable to public/local government	Very Low Capital Very Low O & M
Institutional Actions	Monitoring	Radon Monitoring	Helpful for monitoring conditions but does not meet RAO alone	Readily implementable	Very Low Capital Very Low O & M
		Wellpoint Monitoring	Helpful for monitoring conditions but does not meet RAO alone	Readily implementable	Low Capital Very Low O & M
		Leachate Monitoring	Helpful for monitoring conditions but does not meet RAO alone	Readily implementable	Low Capital Very Low O & M
	Access Control	Physical Barriers	Effective as long as in place	Readily implementable	Low Capital Low O & M
		Administrative Controls	Effective as long as in place	Readily implementable	Low Capital Low O & M
Containment	Run-On/Runoff Control	Sedimentation Basin	Not effective in directing flow	Moderately difficult to implement	High Capital Low O & M
		Diversion/Collection	Effective in directing flow, but subject to erosion	Readily implementable	Moderate Capital Low O & M
		Grading	Effective in directing flow, but subject to erosion	Readily implementable	Low Capital Very Low O & M
		Revegetation	Effective in controlling erosion	Readily implementable	Low Capital Low O & M
	Capping	Concrete-Based Cover	Effective but susceptible to weathering and cracking	Moderately difficult to implement	Low Capital Low O & M
		Asphalt-Based Cover	Effective but susceptible to weathering and cracking	Moderately difficult to implement	Moderate Capital Low O & M
		Soil-Based Cover	Not effective in preventing erosion or reducing permeability	Easiest to implement	Low Capital Low O & M
		Chemical Sealant	Moderately effective if maintained	Moderately difficult to implement	Moderate Capital Moderate O & M
		Multimedia Cap	Most effective and protective against weathering and cracking	Easy to implement	High Capital Low O & M
	Subsurface Flow Control	Subsurface Drain	Effective when applied to shallow contamination problems	Readily implementable	High Capital Moderate O & M
		Groundwater Extraction Wells	Most effective in controlling lateral diffusion and flow	Deep trenching requirements	Moderate Capital Very Low O & M
		Slurry Walls	Moderately effective in controlling subsurface flow and diffusion	Easy to implement	High Capital Low O & M
		Grout Curtains	Moderately effective in controlling lateral diffusion and flow	Requires extensive drilling	High Capital Very Low O & M

FL/MPC-0112-5/5-1a

FIGURE 5-1. EVALUATION OF PROCESS OPTIONS

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
Containment/ Treatment	Run-On/Runoff control	Sedimentation Basin	Not effective in directing flow	Moderately difficult to implement	High Capital Low O & M
		Diversion/Collection	Effective in directing flow, but subject to erosion	Readily implementable	Moderate Capital Low O & M
		Grading	Effective in directing flow, but subject to erosion	Readily implementable	Low Capital Low O & M
		Revegetation	Effective in controlling erosion	Readily implementable	Low Capital Low O & M
	Capping	Concrete-Based Cover	Effective but susceptible to weathering and cracking	Moderately difficult to implement	Low Capital Low O & M
		Asphalt-Based Cover	Effective but susceptible to weathering and cracking	Moderately difficult to implement	Moderate Capital Low O & M
		Soil-Based Cover	Not effective in preventing erosion or reducing permeability	Easiest to implement	Low Capital Low O & M
		Chemical Sealant	Moderately effective if maintained	Moderately difficult to implement	Moderate Capital Moderate O & M
		Multimedia Cap	Most effective and protective against weathering and cracking	Easy to implement	High Capital Low O & M
	Subsurface Flow Control	Slurry Walls	Moderately effective in controlling lateral diffusion and flow	Deep trenching requirements	High Capital Very Low O & M
		Groundwater Extraction Wells	Moderately effective in controlling subsurface flow and diffusion	Moderately difficult to implement	High Capital Moderate O & M
		Subsurface Drains	Effective when applied to shallow contamination problems	Readily implementable	High Capital Moderate O & M
		Grout Curtains	Less effective in controlling lateral diffusion and flow	Requires extensive drilling	High Capital Very Low O & M
	In Situ Stabilization	Shallow-Soil Mixing	Effective when using proper additives	Readily implementable	Moderate Capital Low O & M
		Vitrification	Lowest leachable waste form	Not proven on large scale	Very High Capital Low O & M
		Surcharging	Reversible waste form	Needs good water collection system	Moderate Capital Low O & M
		Dynamic Compaction	Proven and accepted method	Readily implementable	Moderate Capital Low O & M
	Water Treatment	Precipitation	Proven commercial technology	Readily implementable	Low Capital Low O & M
		Reverse Osmosis	Moderately effective for separation	Readily implementable	Moderate Capital Moderate O & M
		Selective Ion Exchange	Effective on specific ions only	Requires ion-specific resins	High Capital Moderate O & M

FL/FMPC-0112-5/5-1b

FIGURE 5-1.
(CONTINUED)

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
Removal/ Treatment/ Disposal	Groundwater Removal	Groundwater Extraction Wells	Effective where hydraulic gradient is relatively flat	Location and arrangement dependent on depth of contamination	Moderate Capital Very Low O & M
	Mechanical Removal	Loader/Dozer	Capable of excavating any type of material	Readily implementable	Moderate Capital Low O & M
		Crane w/Clamshell System	Effective in removing sludges/soils, but provides little personnel protection	Readily Implementable	Moderate Capital Moderate O & M
		Conveyor System	Capable of moving high volumes of material	Limited by material consistency	High Capital Moderate O & M
		Backhoe	Capable of excavating almost any type of material	Readily Implementable	Moderate Capital Low O & M
		Dragline System	Low production greater potential for material less than clamshell	Support equipment required for successful operation	High Capital Moderate O & M
	Hydraulic Removal	Jetting Ring w/Cutterhead	Effective in removing most materials	Not readily available	Moderate Capital Moderate O & M
	Pneumatic Removal	Vacuum w/Cutterhead	Effective with dry materials	Readily Implementable	Moderate Capital Moderate O & M
	Waste Stabilization	Asphalt-Based Solidification	Effective form of stabilization, but subject to leaching	Readily implementable	Moderate Capital Moderate O & M
		Cement-Based Solidification	Effective form of stabilization, but large volume increase	Readily implementable	Moderate Capital Moderate O & M
		Thermoplastic Encapsulation	Effective form of stabilization but not proven on large scale	Requires treatability studies	High Capital Moderate O & M
		Vitrification	Very effective form of stabilization, but not proven on large scale	Requires large voltages	Very High Capital High O & M
	On Property Disposal	Above/Below Grade Vault	Very effective storage	Requires large amount of space	High Capital Low O & M
		Tumulus	Very effective storage	Readily implementable	High Capital Moderate O & M
		Temporary Storage	Effective but temporary storage, does not meet RAO requirements	Requires large amount of space, and future plan for storage	Low Capital High O & M
	Off-Site Disposal	Rail Transport	Effective form of transportation	Requires dedicated line and route availability	Moderate Capital Low O & M

FL/FMPC-0112-5/5-1c

FIGURE 5-1.
(CONTINUED)

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
Removal/ Treatment/ Disposal (Cont)	Physical Treatment	Waste Segregation/Separation	Effective in separating materials based on various physical characteristics	Multiple units required	Moderate Capital Moderate O & M
		Reverse Osmosis	Moderately effective for separation	Readily implementable	Moderate Capital Moderate O & M
		Selective Ion Exchange	Effective on specific ions only	Requires ion-specific resins	High Capital Moderate O & M
	Chemical Treatment	Leaching/Extraction	Effective in removing heavy metals	Requires large amounts of acids	High Capital High O & M
		Neutralization	Effective in treating acids/bases	Requires addition of acids/bases	Moderate Capital Low O & M
		Precipitation	Effective in removing metals dissolved in solution	Readily implentable	Moderate Capital Moderate O & M
	Thermal Treatment	Drying/Calcination	Not effective for remediation, does not treat radioactives	Readily implementable	Moderate Capital Moderate O & M
	Biological Treatment	Biodenitrification	Effective for water treatment only	Readily implementable	Low Capital Low O & M

FL/MPC-0112-5/5-1d

FIGURE 5-1.
(CONTINUED)

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5.1.3 Cost Evaluation

In general, evaluation of process options based on costs was not weighed as heavily as the effectiveness evaluation. Moreover, the costs were based on engineering judgement. Each process option was evaluated as to whether its operation and maintenance (O&M) and capital costs are high, low, or medium relative to other process options in the same technology group.

5.2 EVALUATION OF PROCESS OPTIONS

5.2.1 No-Action Process Options

The no-action response does not provide additional remediation activities at the site to further minimize risk to the environment or public health, and will not achieve the remedial action objectives. The NCP, however, requires the no-action response to be carried through the detailed analysis of alternatives; therefore, it will not be eliminated at this stage. The no-action response will be further evaluated as a baseline for comparison with other remedial action alternatives.

5.2.2 Monitoring Process Options

As shown in Figure 5-1, there are three process options being considered within the monitoring technology:

- Radon monitoring
- Well point monitoring
- Leachate monitoring

Although each of the three process options is applicable to Operable Unit 1, well point monitoring was selected as the representative process option. Monitoring wells, when properly placed and installed, are highly effective in detecting migration of contaminants, are easy to implement, and are cost effective. Wells are also applicable to all stages of site operation including initial investigations, remediation, and postclosure monitoring. Monitoring wells are also applicable to a wide range of contaminants.

Although radon monitoring will probably be used at some point during remediation, it was not selected as the representative process option because it is a highly specialized method of monitoring and therefore viewed as too restrictive to be representative of this technology.

Leachate monitoring will also be incorporated into certain alternatives but is not as flexible or broadly applicable as monitoring wells. Monitoring wells can also be utilized for leachate migration detection.

The evaluation of monitoring wells as a representative process option is summarized below:

- Effectiveness (high): Although monitoring wells alone will not meet the remedial action objectives, they are highly effective in determining contaminant migration and in evaluating the effectiveness of other remedial measures. The potential impact on human health and the environment during the construction and implementation phase of this option is negligible. The only additional exposure to the contaminated groundwater is by sampling and analytical personnel.

- Implementability (high): A large number of monitoring wells currently exist at and near the FMPC site. Also, additional wells can be installed quickly, and equipment and services are readily available. This process option may not, however, be acceptable to the agencies without additional remedial response.

- Capital Costs (low): This item includes only additional monitoring wells and public notice.

- O&M Costs (low): Major cost items include well maintenance, sampling and analysis, and payments to landowners.

Groundwater monitoring will be retained for incorporation into the remedial action alternatives. Monitoring may be appropriate as either compliance monitoring or corrective action monitoring.

5.2.3 Access Control Process Options

Two process options are being retained under the technology of access control:

- Physical barriers
- Administrative controls

Although both of these process options are applicable to the site, neither option by itself will meet the remedial action objectives; therefore, they will only be considered as being applied in conjunction with other remedial measures.

Administrative control was chosen as the representative process option because it has the widest range of flexibility and application. Administrative controls can include active controls such as restricted access and passive controls that include deed restrictions, well drilling prohibitions, and monolith-type markers that warn against human intrusion.

Physical barriers such as fences, while effective during active facility operation, may deteriorate and lose long-term effectiveness. Therefore, physical barriers will only be used as a short-term option and will not be selected as the representative process option.

A brief evaluation of administrative control is summarized below:

- Effectiveness (high): Administrative controls can be highly effective in reducing contact between contaminants and receptors but cannot be relied on as the sole method of remediation.
- Implementability (high): Administrative controls are easy to implement and are standard requirements at hazardous waste management facilities.
- Capital Costs (low): Costs would be higher for active administrative controls than for passive controls.
- O&M Costs (low): Depending on the controls chosen, the O&M costs would be low or nonexistent.

5.2.4 Run-On/Runoff Control Process Options

As shown in Figure 5-1, there are four process options for run-on/runoff control;

- Sedimentation basin
- Diversion/collection
- Grading
- Revegetation

At some point in the remediation process, each of these process options will be used to control stormwater at the site.

Although grading has been selected as the representative process option, the final stormwater control plan as determined by the detailed design will incorporate multiple process options regardless of the alternative chosen. A brief evaluation of grading as a process option is summarized below:

- Effectiveness (high): Grading is a highly effective method of promoting and controlling site drainage and, therefore, minimizing infiltration of water into contaminated areas. Grading can be used with in situ remediation alternatives as well as removal/treatment and disposal alternatives. Some form of site grading will be used with any remediation alternative.
- Implementability (high): Grading can be easily implemented at the site and does not require specialized equipment.
- Capital Costs (low): Capital costs are relatively low. Required equipment can be either purchased or leased.

- O&M Costs (low): If properly constructed and sloped, there is very little O&M required to maintain drainage.

5.2.5 Capping Process Options

Process options evaluated for use in capping the site included:

- Concrete-based cover
- Asphalt-based cover
- Soil-based cover
- Chemical sealant
- Multimedia cap

Of these five options, a multimedia cap was chosen as the representative process option. The multilayer cap was chosen because it offers the best performance and most versatility of the options evaluated. The multimedia cap incorporates the best characteristics from several capping designs. It allows incorporation of an intrusion barrier comparable to a concrete cap, provides the permeability of natural soil-based covers, and has greater long-term durability than chemical sealants or asphalt-based covers. A typical multimedia cap as proposed for the site is shown in Figure 4-2.

The evaluation of a multimedia cap is summarized below:

- Effectiveness (high): A multimedia cap is a highly effective method of preventing contaminant migration. A well-constructed cap significantly reduces infiltration into waste and therefore minimizes leachate generation. It promotes surface drainage and prevents erosion and sediment transport of waste. It also acts as an intrusion barrier to prevent direct contact between receptors and waste.

- Implementability (high): Multimedia caps are readily constructed and require only standard construction equipment. Availability of construction materials such as suitable clays is the primary consideration for construction.

- Capital Costs (high): A multimedia cap involves significantly more capital equipment costs than other types of caps because it includes both earth moving equipment as well as concrete batch plant facilities.

- O&M Costs (low): Costs for operation and maintenance for multimedia caps are higher than concrete caps because the exposed surface is a vegetative layer that requires mowing and maintenance.

5.2.6 Subsurface Flow Control Process Options

Process options evaluated for control of subsurface flow control include:

- Groundwater extraction wells
- Slurry walls

- Grout curtains
- Subsurface drains
- Groundwater discharge

These options can be further divided into two types of groundwater control: (1) Subsurface barriers and (2) hydraulic control methods. Subsurface barriers are represented by slurry walls and grout curtains that are used to block or redirect groundwater flow by installation of vertical barriers of low permeability. Subsurface flow can also be controlled hydraulically by removing or redirecting groundwater through a series of subsurface drains or wells.

Although both types of subsurface control will be carried into final design, the slurry wall was chosen as the representative process option. The slurry wall was chosen because it is better suited to site conditions than a grout curtain and offers a more stable long-term control than pumping wells. The slurry wall could also be constructed in conjunction with either dewatering wells or subsurface drains. The exact configuration of the system would be determined during final design.

A summary of the slurry wall evaluation is discussed below:

- Effectiveness (moderate): Slurry walls can be very effective in controlling groundwater movement but are subject to several limiting criteria including quality of construction, types of waste to be contained, and site geology.

- Implementability (high): A slurry wall can be easily constructed at the site using standard slurry wall equipment.

- Capital Costs (high): Compared to other subsurface flow control methods, slurry walls have a relatively high capital cost.

- O&M Costs (low): O&M costs for slurry walls are very low because they require no maintenance if properly constructed.

5.2.7 In situ Stabilization Process Options

Process options considered for in situ stabilization include:

- SSM
- Vitrification
- Surcharging
- Dynamic compaction

Because of the differences in pit construction characteristics (depth, volume, etc.) and pit contents (drums, construction rubble, etc.), three of the four process options will be retained and carried into alternatives development. Only dynamic compaction will not be considered further. However, as

discussed in Section 4.3.3, if the K-65 silos have been removed before implementation, the use of dynamic compaction would still be a feasible alternative. The remaining three process options (SSM, vitrification, and surcharging) will be applied on individual pits based on specific pit characteristics.

Because each of the three remaining process options has distinctive characteristics, a single representative process option was not selected for in situ stabilization. Instead, each of the three alternatives was evaluated as discussed below:

- Effectiveness
  - SSM (high)
  - Vitrification (high)
  - Surcharging (low)

  SSM and vitrification are superior methods of stabilization because they result in a more rigid and irreversible waste form than surcharging, which is primarily consolidation (densification).

- Implementability
  - SSM (high)
  - Vitrification (low)
  - Surcharging (moderate)

  SSM and surcharging are the two options most easily implemented because they are a more proven technology than vitrification. However, shallow soil mixing does have limitations on stabilizing pits that contain significant debris such as drums, concrete and metal ingots. In situ vitrification has limitations on effective depth, use in areas containing debris, and is a relatively new technology. Surcharging is the easiest process option to implement and can be used on all types of pits because it consists of mounding soil over an area to force consolidation of the waste.

- Capital Costs
  - SSM (moderate)
  - Vitrification (high)
  - Surcharging (moderate)

  Vitrification has the highest capital cost because it involves the design and construction of very specialized equipment. Surcharging costs include earth moving equipment and significant quantities of soil from off site. Capital costs for SSM are moderate.

- O&M Costs
  - SSM (low)
  - Vitrification (low)
  - Surcharging (low)

5.2.8 Water Treatment

Surface water, storm water runoff and perched groundwater can be treated by the following process options:

- Precipitation
- Reverse osmosis
- Selective ion exchange

There are other water treatment technologies that may be used in combination with these process options or as ancillary treatments to these options.

Precipitation is a form of clarification where chemicals are added to the water to form compounds with the targeted impurity that precipitate out and are separated from the water.

Precipitation can be used as an effective pretreatment to reverse osmosis or ion exchange or it can be used as a final polishing before discharge. It is a common process with moderate costs and is an effective part of a water treatment system. It will be retained as a representative process option.

Reverse osmosis involves diffusion of water through a semipermeable membrane by means of a pressure differential. Removal efficiency for uranium by reverse osmosis is typically 70 percent. But 90 percent removal efficiency can be achieved. A limitation of reverse osmosis is the tendency of the membranes to fowl. For this reason it is important to have a pretreatment to remove most of the contamination.

The cost of reverse osmosis is relatively high but the cost can be reduced with proper pretreatment of the waste stream. It is a proven and widely used component of water treatment systems and will be retained as a representative process option.

Ion exchange is a process in which certain dissolved are removed from water by exchanging them with other (counter) ions held by an insoluble solid (resin). Ion exchange resins are typically polymer beads that have been modified by the addition of chemical groups which attract various ionic species. The resins can be regenerated for reuse with a strong solution of the exchangeable counter ion. Resin types range from general purpose demineralization resins that remove nearly all salts to selective chelating resins that have high affinities for specific ions.

Ion exchange is used extensively for water and wastewater treatment. It is used also for treatment of a variety of industrial wastes to allow for the recovery of materials or by-products. Additionally, ion exchange has been used in waste treatment for removal and recovery of radioactive materials from contaminated streams. It is usually used to remove low levels of ionic species (generally between 100 and 500 ppm) and is not cost-effective at higher concentrations. Treatment of water with ion exchange can achieve very low effluent concentrations of contaminants.

Ion exchange may be used as a final treatment to remove trace metals and radionuclides from dilute wastewater. The resins may be used once and disposed of or they may be regenerated, which will produce a concentrated waste stream for treatment and disposal; the concentrated regenerate may be treated with the sludge. Ion exchange is an easily implemented, reliable, commercial technology. Treatment cost is moderately expensive and will depend on the type of resin employed and the quantity of the various ionic species removed from the wastewater.

5.2.9 Groundwater Removal

Process options considered for groundwater removal include:

- Groundwater extraction well
- Subsurface drains

Although both process options are applicable to the site, groundwater extraction wells were chosen as the representative process option based upon versatility to extract contaminated perched groundwater. Groundwater extraction wells are frequently used at sites subject to variations in geologic and topographic settings. The number of required wells and placement would be determined during final design.

A summary of the groundwater extraction wells are discussed below:

- Effectiveness (high): Groundwater extraction wells are very effective in removing contaminated perched groundwater due to versatility of Operable Unit 1 geology.

- Implementability (high): A groundwater extraction well can easily be installed using standard drilling equipment.

- Capital Costs (moderate): Compared to subsurface drains, a groundwater extraction well can be installed more cost effectively.

- O&M Costs (low): Maintenance for a groundwater extraction well is low as compared to substance drains. Removal of contaminated perched groundwater is achieved by standard pumping equipment.

5.2.10 Mechanical Removal Process Options

As shown in Figure 5-1, there were five process options considered for mechanical removal:

- Loader/dozer
- Crane with clamshell
- Conveyor system
- Backhoe
- Dragline system

Although each of the process options evaluated could be implemented during remediation of Operable Unit 1, the crane with clamshell was selected as the representative process option. The clamshell was selected because it represented a versatile mechanical removal system that could be used on all waste pits including those currently holding liquids. Other process options such as loader/dozer and backhoe are more suitable for solids only and are less efficient at moving sludges. When mounted on a crane, the clamshell also has significantly more reach than conveyor systems. A dragline system is similar in operation to a clamshell and could also be implemented at the site. A summary of the clamshell evaluation is discussed below:

- Effectiveness (moderate): Crane-mounted clamshells are moderately effective for excavating materials. The primary disadvantage is lower production rates than devices such as draglines.

- Implementability (high): A clamshell could be easily used at Operable Unit 1. The area is open with very few obstructions. Clamshells of all sizes are also readily available and are not considered specialized equipment.

- Capital Costs (moderate): The capital cost for a clamshell is considered moderate. Costs will vary with the number of units obtained, the crane size, and the type of bucket.

- O&M Costs (moderate): Operation and maintenance costs are moderately high and require frequent service during operation.

5.2.11 Hydraulic Removal Process Options

Because of previous screening, the only hydraulic removal method being evaluated is the use of a jetting ring with cutterhead. The method evaluation is described below:

- Effectiveness (high): Hydraulic removal systems can be highly effective although not as productive as some methods of mechanical removal.

- Implementability (high): Hydraulic removal could be readily implemented in the type of material found in Pits 5 and 6 and the Clearwell.

- Capital Costs (moderate): Capital costs for hydraulic removal are moderate.

- O&M Costs (moderate): O&M costs for hydraulic removal are moderate. The system requires numerous pumps, suction, and discharge lines.

5.2.12 Pneumatic Removal Process Options

Previous screening reduced the pneumatic removal process options to use of a vacuum with cutter head assembly. Pneumatic dredges are similar in operation to hydraulic dredges except they use compressed air and hydrostatic pressure to draw sediments to the collection head and through the transport piping. They can also be mounted with cutter heads to assist in operation. The use of a pneumatic removal system would be limited to use on Waste Pits 5 and 6 and the Clearwell. A summary of the pneumatic removal evaluation is as follows:

- Effectiveness (low): The primary limiting factor on the effectiveness of pneumatic removal systems is the limited production rates.
- Implementability (low): Pneumatic removal systems are not in widespread use in the United States and may not be as readily available as other types of systems.
- Capital Costs (moderate): Capital costs for pneumatic removal systems are moderate and require a dredging platform, compressors, pumps, and intake and discharge lines.
- O&M Costs (moderate): O&M costs for pneumatic removal systems are moderate. Production rates are lower; therefore, the operation time and associated operation costs are increased. The pumps and compressor systems also require periodic maintenance.

5.2.13 Waste Stabilization Process Options

Four process options were evaluated as part of the waste stabilization technology. These included:

- Asphalt-based solidification
- Cement-based solidification
- Thermoplastic encapsulation
- Vitrification

Of these four process options, two were retained for evaluation as representative process options: (1) cement-based stabilization and (2) vitrification. These two options were retained because they represented two significantly different processes in their performance, operation, and relative stage of development. Cement stabilization was chosen over asphalt and thermoplastic encapsulation because it is similar in principle but judged as superior in overall performance. Vitrification was retained as a process option because of all the common solidification methods; it offers the waste form with the lowest leachability. Because vitrification is a relatively new process on a large scale, the cement stabilization was retained to balance out the new but promising technology with a more proven and readily available process.

The evaluation of cement stabilization and vitrification is summarized below:

- Effectiveness
  - Cement stabilization (moderate)
  - Vitrification (high)

  Cement-based stabilization is moderately effective in treating wastes. The wastes are mechanically locked within a solidified matrix that reduces the exposed surface area of the waste and thereby the leachate generation. Cement solidification is most suitable for immobilizing metals and is less effective for use in wastes with organics.

  Vitrification is highly effective in stabilizing certain wastes. The vitrification process involves combining the waste with a molten glass at a temperature of 1350°C. The resulting noncrystalline solid has an extremely low leach rate for most wastes.

- Implementability
  - Cement stabilization (moderate)
  - Vitrification (low)

  Cement stabilization is moderately easy to implement. Major advantages include the readily available equipment and materials. Disadvantages are the increase in volume and weight for disposal once the waste is stabilized.

  Vitrification is rated as having low implementability. The primary problem with vitrification is that it is a relatively new technology without readily available equipment. The process also has high energy demand requirements and requires trained personnel that are not readily available.

- Capital Costs
  - Cement stabilization (moderate)
  - Vitrification (high)

  Capital costs for cement stabilization were rated as moderate. The process would require construction of waste handling, mixing, and curing facilities. However, the equipment for cement stabilization is not a new technology and would be readily available.

  Capital costs for vitrification would be high. The process is a new technology and has not been implemented on as large a scale as the FMPC. Therefore, specialized equipment would have to be designed and built.

- O&M Costs
  - Cement stabilization (moderate)
  - Vitrification (high)

  O&M costs are expected to be moderate for cement stabilization. The operation will require additional materials (cement) and maintenance of the mechanical equipment, which must operate in a fairly caustic environment.

  Vitrification O&M costs will be high. The equipment required is new and unproven. The system also requires a relatively extensive off-gas collection and cleaning system

that must be maintained. Materials will include the addition of silicate to promote vitrification.

5.2.14 On-Property Disposal Process Options

As shown in Figure 5-1, there are three process options being considered within the on-property disposal technology:

- Above/belowgrade vault
- Tumulus (EDF)
- Temporary storage

The tumulus was selected as the representative process option because the characteristics of the waste require that a five-meter cover be put over the waste (10CFR61). The five-meter cover rules out any abovegrade vault and imposes extremely tough design problems for belowgrade vaults. Because the remedial action is to be permanent, the temporary storage facility was not chosen as the representative process option.

The tumulus will be carried through as the representative process option because with proper design, it can meet the five-meter criteria and the long-term storage requirements of 10CFR61.

- Effectiveness (high): A properly designed tumulus will dispose of the waste as effectively as a RCRA-design landfill while providing superior isolation qualities from the groundwater regime and isolation of the waste from the surface environment and human contact.

- Implementability (high): The tumulus disposal process option basically consists of mounding over waste that has been placed on a stable structural pad. Once designed, the construction and implementation of the tumulus should occur without delay.

- Capital Costs (high): The aboveground structure will be constructed of reinforced vault-like concrete designed for permanent waste disposal as well as an intrusion barrier made of compacted concrete. These concrete layers will contribute to the high cost. In addition, the high cost will be in part due to the detailed construction of the vegetative layers, drainage layer and the clay layers of the cap. Furthermore, the facility will consist of a RCRA-type closure cap with leachate collection system which will also inflate the cost.

- O&M Costs (moderate): Operation and maintenance costs are expected to be moderate. The costs are primarily associated with mowing, cap inspection, and groundwater monitoring.

5.2.15 Off-Site Disposal Process Options

Figure 5-1 shows two process options being considered within the off-site disposal technology:

- Rail transport
- Truck transport

Truck transport was deleted from further consideration as a process option on the basis of risk. A preliminary risk analysis was performed for the two modes of transportation. This risk analysis took into account the injuries and deaths attributed to each mile of truck or rail transport. The results of this analysis are discussed briefly in Section 4.3.5 and are displayed in Tables 4-1 and 4-2. Truck transportation was calculated to cause more than three times more fatalities and six times more injuries than rail transport. As a result of the preliminary risk assessment described in Section 4.3.5, truck transport was ruled out as a viable off-site disposal option. Therefore, only direct rail transport and rail transport with a truck transfer station near the disposal site will be retained for further consideration.

A summary of the rail transport process option evaluation is discussed below:

- Effectiveness (high): The rail transport process option is an effective option for off-site transportation because of the reduced risk to human life. By transporting waste by rail transport, public exposure is drastically limited as compared to other transportation methods. In addition, rail transportation provides the ability to haul large tonnages of waste at one time, reducing the probability of an accident per ton of waste transported.

- Implementability (moderate): The rail transport process options will be easily implemented from the standpoint that the FMPC can readily accommodate rail transport by use of an existing on-site rail spur. However, the rail transport process option requires a dedicated railway line and is susceptible to route availability.

- Capital Costs (moderate): The rail transport process option is expected to be moderately costly because of the following requirements: upgrading of the existing mainline tracks, the need to build loading and unloading waste handling facilities, and the need to build an unloading rail spur.

- O&M Costs (low): Operation and maintenance costs are expected to be low for the rail transport process option because of the limited need for machinery, equipment, and maintenance items. In addition, historical records indicate that railway components have a relatively long life span and require little maintenance as compared to other transportation systems.

5.2.16 Physical Treatment Process Options

Physical treatment process options retained for evaluation include:

- Waste segregation/separation
- Reverse osmosis
- Selective ion removal

Of these three process options, waste segregation/separation was chosen as the representative process option because it is applicable to a wide range of waste types encountered in the waste pits. Waste segregation/separation processes are applicable to pit wastes, soils surrounding the pits, and liquids, including surface water and groundwater.

Reverse osmosis and ion exchange will still be used in remediation of the site, but their use will be restricted to applications involving treatment of liquids, such as the site-wide water treatment system.

Waste inventory records obtained from the CIS indicate that Waste Pits 1 through 6, the Burn Pit, and the Clearwell contain a wide range of waste with diverse characteristics existing in liquid, solid, and semisolid phases. Some examples of the waste include fly ash, wooden pallets, metal drums, construction rubble, sump liquor, graphite, depleted slag, PCBs, mercury, arsenic, lime sludge, raffinate concentrate, asbestos, filter cakes, and radioactive material such as radium, thorium, and uranium. In addition, contaminated surface water and soils (composed primarily of clay) encapsulate the pit waste and are expected to be part of the waste because they have a high probability of being contaminated with the waste.

Once excavated, all waste will be deposited in a waste processing facility for segregation and separation. The processing facility will be equipped to handle all physical and chemical types of waste identified on site thus far. This is to include all contaminated soils that lie beneath and surround the waste pits because they can be easily remediated in the same fashion as other forms of waste.

The waste materials will undergo a series of segregation/separation processes in which the waste will be transformed into a feed material for treatment. Typical segregation activities may include the following:

- Sludge waste entering the processing facility will be dewatered as needed by being subjected to one or more of the following processes: filter presses, gravity thickeners, rotary vacuum filters, dewatering lagoons, or centrifuge. The wastewater can then be routed to a liquid tank for further segregation/pretreatment. Likewise, the resulting dewatered sludges will then be routed for further segregation/pretreatment or treatment processes.

- Wastewater entering the processing facility will be mechanically screened for sizeable solids. The wastewater will then receive direct treatment or will undergo a separation process whereby the solids will be removed from the waste stream. The solids may

be removed by allowing the influent to pass through a fixed screen, a hydraulic classifier, or a cyclone or a clarification basin. Once removed, the solids will be deposited into a solids hopper for further treatment. The pretreated wastewater can then be treated by one or more technologies such as filtration, activated carbon, biological treatment, air stripping, chemical reduction, reverse osmosis, or ion exchange before being discharged.

- Solid waste, including dewatered sludges, entering the processing facility will pass through a mechanical classifier (essentially a set of vibrating screens) and/or shredders for size gradation or reduction. Wooden pallets, metal drums, or other discernable waste materials may be immediately deposited into a shredder before entering the classifier. Once the contaminated soils and other pit waste enter the classifier, the waste may be separated according to grain size. The separation of solids by grain size allows for the removal of some forms of hazardous waste-contaminated soils and sediments because of the apparent tendency of the contaminants to preferentially adsorb onto fine-grained materials such as clay and organic matter.

Large metallic or concrete waste that may be too massive for the shredders may be temporarily diverted and manually dismantled, crushed, or shredded before being disposed. Disposal of such large bulky materials may require depositing those items directly into a large vault and then filling the vault with grout.

A summary of the waste segregation/separation evaluation is discussed below:

- Effectiveness (moderate): The overall effectiveness of the waste segregation/separation was rated as moderate. The effectiveness is highly dependent on the nature and consistency of the waste being classified and on the type of equipment involved.

- Implementability (moderate): Waste segregation/separation can be readily implemented at Operable Unit 1. Equipment and technology is available from other existing industries capable of processing any of the waste types in the pits. Implementability was rated moderate instead of high. Due to the wide range of waste, the facility will require multiple units capable of handling solids, liquids, and sludges.

- Capital Costs (moderate): Capital costs associated with the waste segregation/separation process is expected to be moderate. A majority of the cost will be attributable to the segregation/separation equipment (dewatering equipment, shredders, screens, mechanical, etc.).

- O&M Costs (moderate): The operation and maintenance costs associated with this process are primarily due to the general maintenance of the segregation/separation equipment.

5.2.17 Chemical Treatment Process Options

The process options considered within this technology are:

- Leaching/extraction
- Neutralization
- Precipitation

These process options are depicted in Figure 5-1.

Leaching/extraction is used to solubilize the metal found in soils and sludges. When the metals are solubilized the solution is then neutralized. Neutralization involves addition of an acid or base to adjust the pH of the solution to a desirable range or level. Chemical precipitation involves addition of an alkaline or base compound to elevate the pH and to convert the metal to insoluble compounds, which settle out of the solution.

Unlike the waste silos, the extraction of metals from the pits wastes is not considered a viable process. The mass of solids resulting from the processing of the silo wastes would be approximately 20 percent of the initial untreated mass. The mass of solids resulting from processing the pit waste would be roughly 62 to 65 percent. The reason for this is the much higher concentrations of calcium, magnesium, and aluminum in the pits, which will leach and precipitate along with the radioactive and hazardous metals (Table 5.1). The wastes in the phosphate form may be more difficult to stabilize than the wastes in the current form. A summary of the chemical process evaluation is discussed below:

- Effectiveness (moderate): Leaching is widely used in the mining industry. However, because treatability has not been performed on the waste in the pits, it is not known if sufficient separation would occur to result in two distinct streams so that one stream could be classified as nonradioactive and nonhazardous.

- Implementability (low): The equipment required for this option will require physical space on the property that might not be available.

- Capital Costs (high): A series of leach tanks, mixers, pumps, precipitators, and solids/liquid separating equipment will be required, along with a structure to house the equipment.

- O&M Costs (high): This option will require a lot of manpower. In addition, large quantities of chemicals will be required.

5.2.18 Thermal Treatment (Thermal Separation)

The thermal treatment process is used to treat soils and sludges that are contaminated by organics. In this process, heat is supplied to the contaminated medium at a temperature sufficient to volatilize the hazardous organics. Temperatures used in this process are not high enough to destroy most organic compounds; they must be destroyed by further treatment of the vapor driven off the solids.

TABLE 5-1

METAL CONCENTRATIONS IN SILOS AND PITS
(Concentrations in ppm)

Metals	Silos 1 and 2 (avg)	Pit 3	Pit 5
Calcium	32,707	53,183 - 178,241	116,000 - 206,144
Magnesium	3,907	21,492 - 51,570	807 - 63,200
Aluminum	-	8,220 - 64,100	6,373 - 15,400
Iron	19,264	10,730 - 26,989	10,979 - 17,900
Uranium	2,128	566	669
Barium	3,949	-	-
Lead	39,268	26 - 613	-

Some highly volatile inorganics, such as mercury, might be partially volatilized, but thermal separation is not a practical metals removal technology. Thermal separation can remove organics from solids and sludges but has no effect on uranium, thorium, and other radioactive compounds. These compounds exist in Waste Pits 1 through 6, the Clearwell, and the Burn Pit.

Drying uses heat to remove bound water from sludges or solids. Calcination is drying at temperatures high enough to remove water of hydration and to decompose carbonates. Drying temperatures are unlikely to be high enough to volatilize any metals. Calcination and drying are weight/volume reduction techniques; they have no effect on the hazards associated with any organics, metals, or radioactive compounds in sludges. Calcination may offer some additional weight/volume reduction over drying, but this advantage will probably be outweighed by the increase in air emissions and cost.

Drying may be a cost-effective pretreatment for many of the high moisture sludges in the waste pits. Drying could be employed before solidification, vitrification, or packaging these wastes. Thus, because of the inefficacy of this technology on many of the constituents located in the pits, this process option will only be considered as a pretreatment for remediation of the waste pits. A summary of the thermal treatment process evaluation is discussed below:

- Effectiveness (medium): Uranium, thorium, and other radioactive compounds are not affected by thermal treatment. Water is effectively removed by drying; however, drying temperatures are not high enough to volatilize metals. Advantages of calcination will likely be outweighed by increases in air emissions and cost.
- Implementability (high): Equipment for this technology is readily available and can be easily installed.
- Capital Costs (moderate): The items required for this technology are drying equipment, conveyor, and dust collectors.
- O&M Costs (moderate): The major cost associated with this technology is its daily energy requirement.

5.2.19 Biological Treatment Process Option

Bioremediation is a technology by which organic contaminants are biodegraded by employing aerobic or anaerobic bacteria. This technology has two configurations: in situ biotreatment and on-site bioreactor treatment.

In situ bioremediation uses microorganisms that are indigenous or cultured bacteria to biodegrade organic compounds in soils. The natural biodegradation process may require enhancement by

introducing nutrients (i.e., nitrogen, phosphorous), oxygen, and other bacterial strains. This biological process is applicable to sediment sludge, soil, and other material contaminated with organic materials.

On-site biodegradation technology involves treatment of contaminated waste, soils, and sludges containing organics in a mobile bioreactor. The environmental conditions created by this technology optimize microbial biodegradation of particular contaminants.

The two configurations of bioremediation technology are suitable for remediation of organics but do not address the uranium contamination found at the site. Thus, biological treatment methods will not be considered as a viable technology for solids and sludge. However, the process will be considered as a pretreatment process option for denitrification of liquid waste including groundwater and surface water. A summary of the biological treatment process evaluation is discussed below:

- Effectiveness (high): Denitrification is a proven bioremedial process that will effectively break down nitrates and nitrites into molecular nitrogen. The denitrification process occurs in an anaerobic environment, requires relatively little nurturing, and has no adverse effects on the environment. Furthermore, the denitrification process has a historic record of being very reliable and requiring little attention for continued effectiveness.

- Implementability (high): The abundant availability of the denitrification process knowledge coupled with the availability of equipment and resources will make the implementation of this process very practical as well as implementable. The denitrification process will require a relatively minimal amount of equipment, making the installation and implementation of this process very simple.

- Capital Costs (low): As previously stated, the denitrification process requires a minimal amount of process equipment as compared to other treatment technologies. The denitrification process is easily installed and implemented compared to other treatment technologies. Therefore, this process option will prove to have relatively low capital cost.

- O&M Costs (low): The primary O&M cost associated with the denitrification process option will be general equipment maintenance and the provision of a carbon source. The maintenance costs associated with this process option have a historical reputation of being relatively low primarily because of the minimal amount of treatment equipment required for implementation and the simplistic nature of the equipment.

6.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

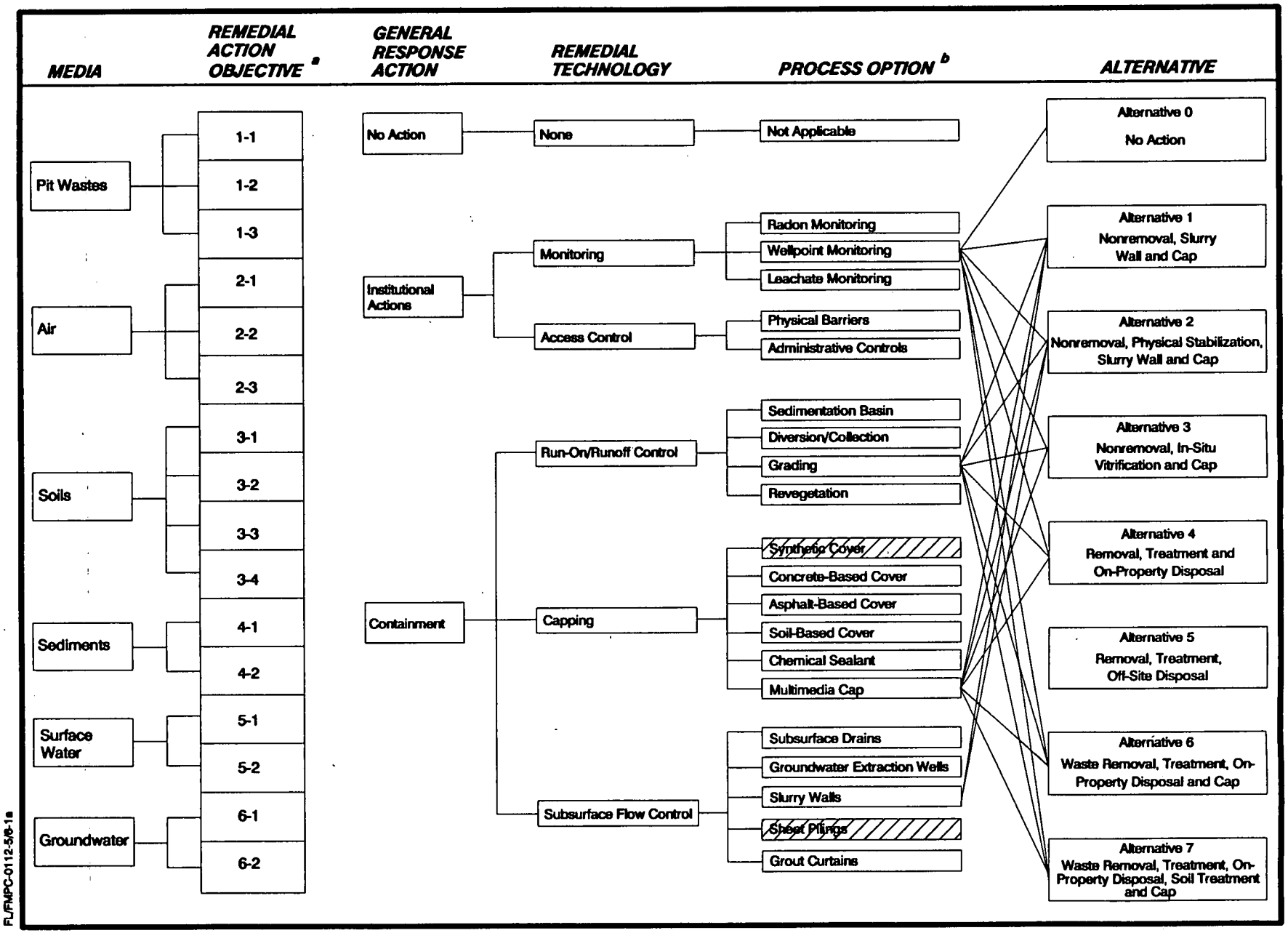
Remedial action alternatives have been assembled by combining the selected process options developed in Sections 4.0 and 5.0 into alternatives representing possible cleanup remedies for Operable Unit 1. The alternatives were developed to address identified problems in Operable Unit 1 with respect to the specified remedial action objectives. Guidance for the development of these alternatives was obtained from the following sources:

- Code of Federal Regulations (CFR), Title 40, Part 300 (NCP)
- Section 121 of the Superfund Amendments and Reauthorization Act of 1986 (SARA)
- U.S. EPA, October 1988, Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA

As recommended by the EPA Guidance Document and the NCP, acceptable engineering practices, as related to site-specific conditions, were considered during remedial action alternative development.

The selected process options discussed in Section 5.0 have been assembled into seven remedial action alternatives for initial screening as shown in Figure 6-1. The process options assembled for each alternative are summarized in Figure 6-2. The remedial actions for sediments, surface soils, and pit waste are combined because the technologies and process options used to formulate the alternatives are applicable to each of these media, and they are best addressed as a unit. The alternatives were formulated by combining the most feasible soil/sediment actions with the most feasible actions for other media such as water and fugitive dust generated during remediation. In some cases, more than one process option was selected to represent a technology type if there were sufficient differences in performance such that one would not adequately represent the other (e.g., stabilization versus vitrification). This process remains flexible for any necessary additions or refinements to these alternatives. The seven alternatives developed for the initial screening process for the Operable Unit 1 remedial action are as follows:

- Alternative 0: No Action
- Alternative 1: Nonremoval, slurry wall, and cap
- Alternative 2: Nonremoval, physical stabilization, slurry wall, and cap
- Alternative 3: Nonremoval, vitrification, and cap
- Alternative 4: Removal, waste treatment, and on-property disposal
- Alternative 5: Removal, waste treatment, and off-site disposal
- Alternative 6: Removal, waste treatment, on-property disposal, and cap
- Alternative 7: Removal, waste treatment, on-property disposal, soil treatment, and cap



FL/FMPC-0112-5/6-1a

FIGURE 6-1. GENERAL ALTERNATIVE DEVELOPMENT PROCESS

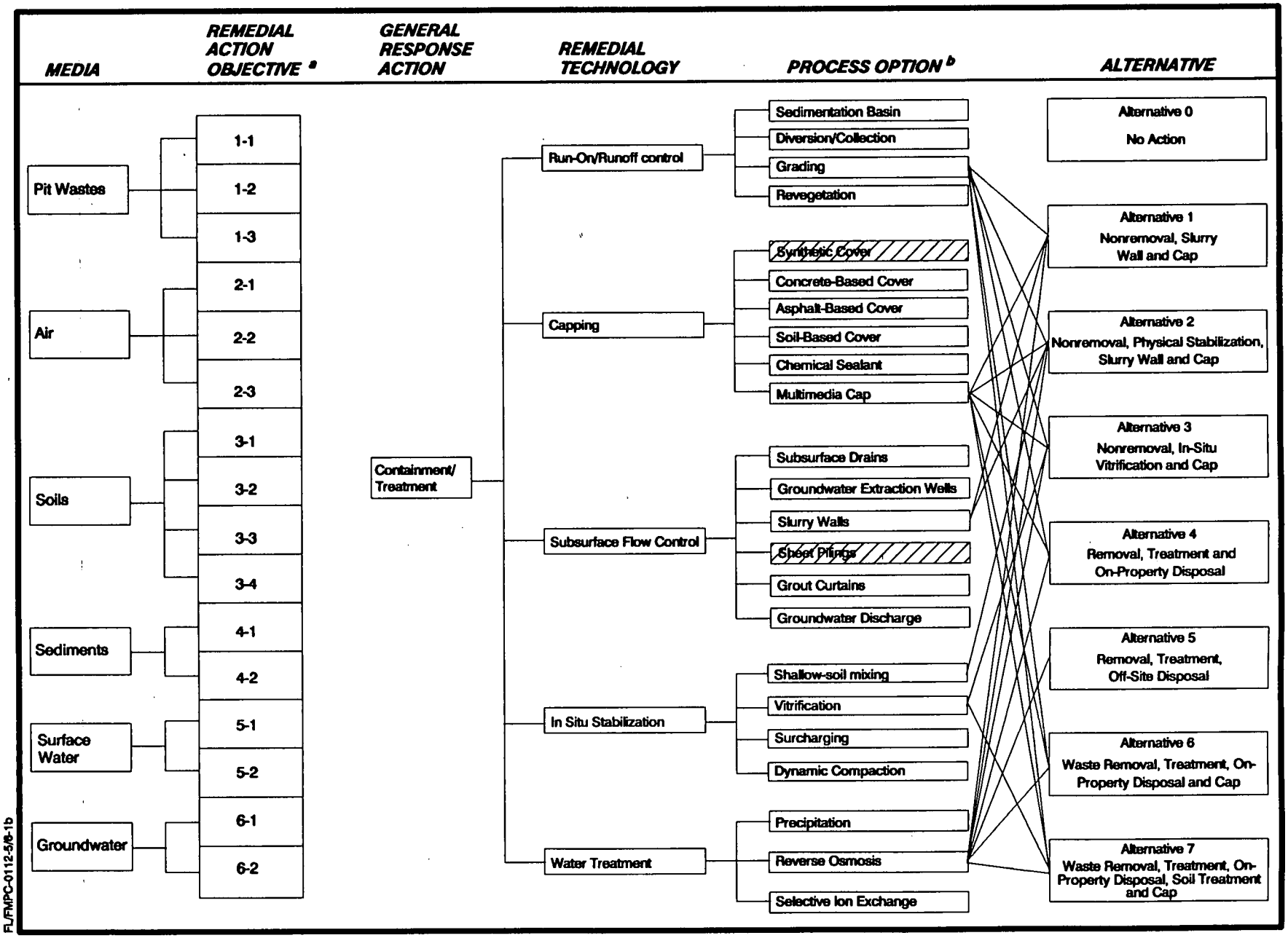


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FIGURE 6-1.
(CONTINUED)

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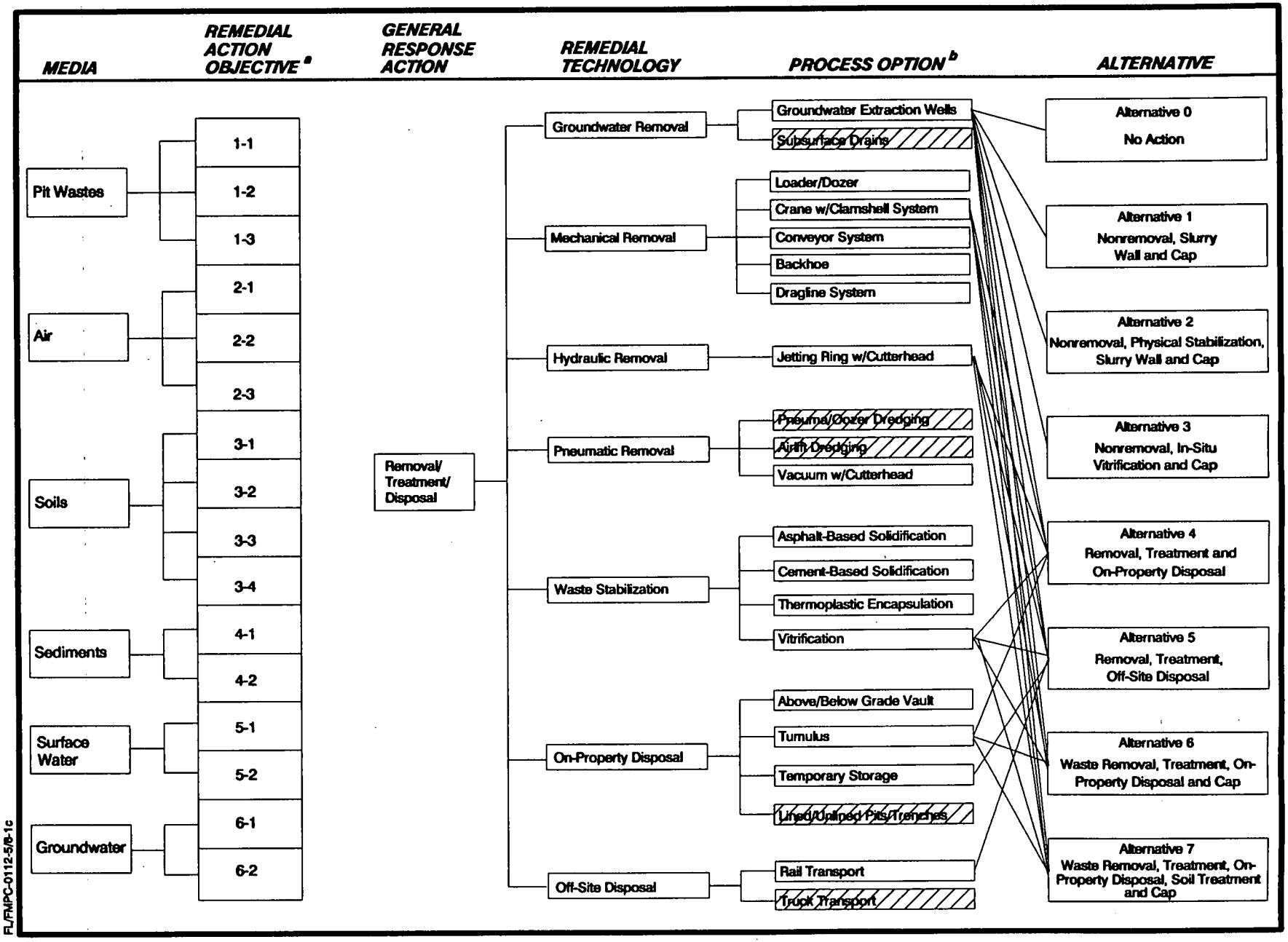

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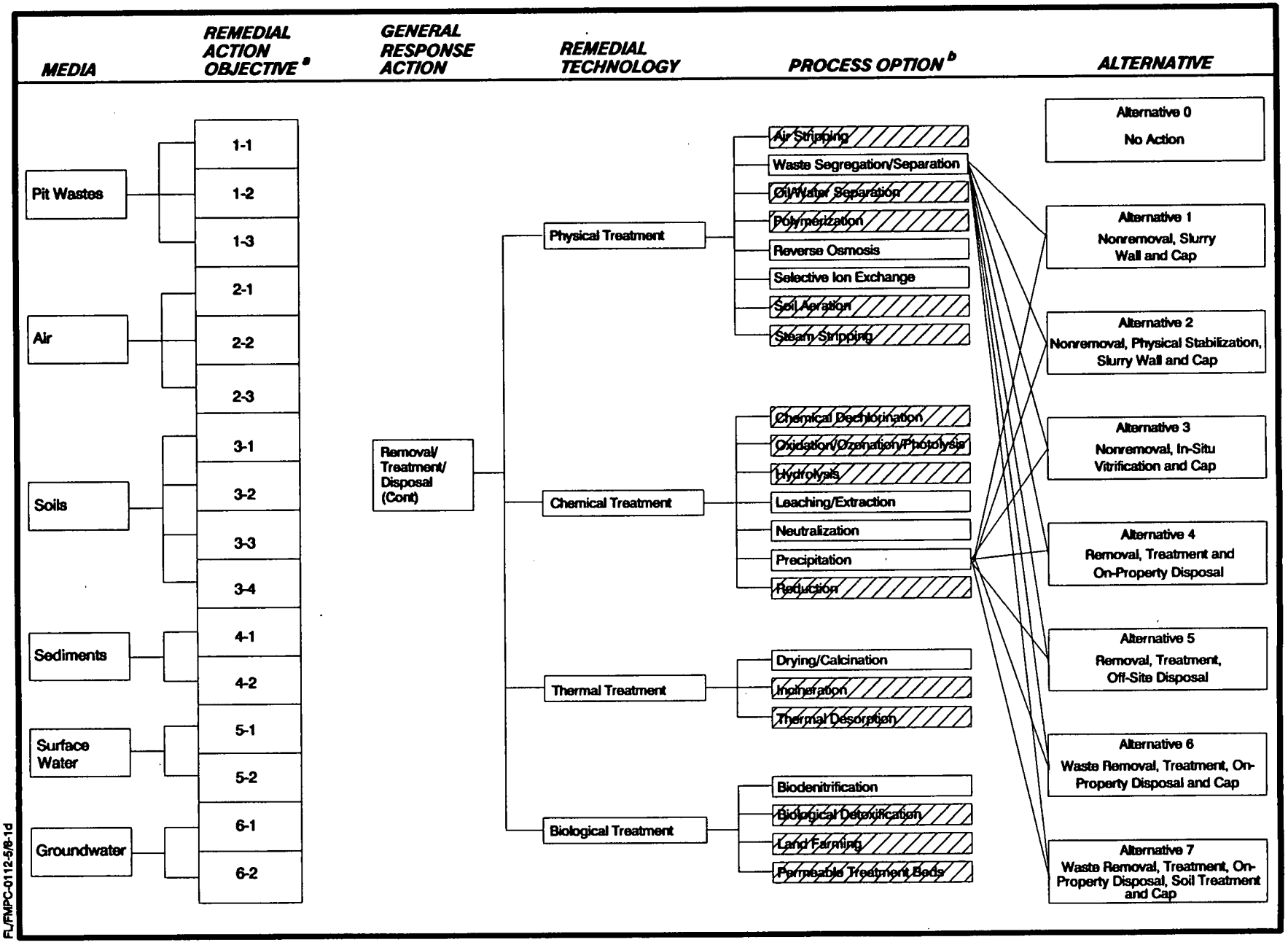
FIGURE 6-1
(CONTINUED)



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[a] See Figure 2-1
[b] Representative process option selected

FIGURE 6-1 (CONTINUED)

ALTERNATIVE / PROCESS OPTION	0 No Action	1 Nonremoval, Slurry Wall and Cap	2 Nonremoval, Physical Stabilization, Slurry Wall and Cap	3 Nonremoval, In-Situ Vitrification and Cap	4 Removal, Treatment and On-Property Disposal	5 Removal, Treatment, Off-Site Disposal	6 Waste Removal, Treatment, On-Property Disposal and Cap	7 Waste Removal, Treatment, On-Property Disposal, Soil Treatment and Cap
Wellpoint Monitoring	X	X	X	X	X		X	X
Grading		X	X	X	X		X	X
Multimedia Cap		X	X	X	X		X	X
Subsurface Drains		X	X					
Slurry Walls		X	X					
Groundwater Extraction		X	X					
Shallow-Soil Mixing			X					X
Vitrification (In Situ)				X				X
Surcharging			X					
Precipitation		X	X	X	X	X	X	X
Reverse Osmosis		X	X	X	X	X	X	X
Selective Ion Exchange		X	X	X	X	X	X	X
Crane w/Clamshell System					X	X	X	X
Jetting Ring w/Cutterhead					X	X	X	X
Cement-Based Solidification					X	X	X	X
Vitrification (Ex Situ)					X	X	X	X
Tumulus					X		X	X
Temporary Storage						X		
Rail Transport						X		
Waste Segregation/Separation		X	X	X	X	X	X	X

FIGURE 6-2. REMEDIAL ACTION ALTERNATIVES AND PROCESS OPTIONS

FL/FMPC-0112-5/6-2

To better quantify specific details better, the following areas were developed for each alternative:

- Remediation time frame and treatment rate
- Size and configuration of on-property extraction and treatment systems and containment structures
- Spatial requirements for constructing treatment containment structures or support areas
- Packaging and transportation requirements for disposal options

The remediation time frame is interdependent on the size and configuration of the alternatives as well as worker protection concerns. Based on best engineering judgment, these four factors were considered in the preliminary design of each alternative. Two or more options were selected for some alternatives that had considerable variation because of size and/or configuration.

A detailed description of each of the alternatives is included in the following sections.

6.1 ALTERNATIVE 0 - NO ACTION

6.1.1 Description

This alternative is the "No-Action" alternative. The pit wastes will remain as they are without the implementation of any removal, treatment, containment, or mitigating technologies. This alternative requires only one well installation, perpetual site maintenance, and monitoring. It provides a baseline for comparison purposes.

6.2 ALTERNATIVE 1 - NONREMOVAL, SLURRY WALL, AND CAP

6.2.1 Description

The first nonremoval alternative for Operable Unit 1 is intended to isolate the waste from the environment and to minimize the generation and release of contaminated leachate to the underlying Great Miami Aquifer. This includes the removal and treatment of any standing water, subsurface flow control measures, construction of a closure cap, and storm water runoff and run-on control measures. The subsurface flow control measures combine a slurry wall, subsurface drains, and a temporary groundwater extraction system.

The following technologies are applicable to this alternative (Figure 6-1):

- Removal and Treatment of Standing Water - Pits 5 and 6 and the Clearwell have standing water requiring treatment by a site-wide water treatment plan, if available.

The treatment plant process systems include clarification, filtration, ion exchange, and reverse osmosis. The treatment plant will also process all contaminated water generated by other aspects of this remedial alternative, including groundwater.

- Subsurface Flow Control - The subsurface flow control technologies will minimize the horizontal groundwater flow through the Operable Unit 1 area. These technologies are shown in Figure 6-1 and consist of the following:

  - A soil or cement/bentonite partial slurry wall placed around the north, east, and south of the Operable Unit 1 area. The slurry wall will be installed through the surficial till layer into the underlying Great Miami Aquifer. The slurry wall will divert the flow from the local water table around the enclosed area.

  - A series of perimeter drains may be placed upgradient from the slurry wall. The drains will intercept and divert uncontaminated till groundwater to prevent contact with waste and contaminated soil by facilitating downgradient movement.

  - Temporary groundwater wells will lower the groundwater table inside the slurry wall area, providing both contaminant (plume) control and reduction of the water available to interact with the in situ waste. These wells will be removed and grouted shut before capping. It is assumed that the withdrawn water is contaminated to some degree and will require treatment before discharge.

- Capping - After completion of the contour grading, a multiple layer closure cap will be installed. The cap will be constructed, as described in Appendix A, utilizing a minimum four-foot-thick low permeability clay layer, a combination two-foot natural aggregate filter blanket/drainage layer, and a two-foot-thick vegetative layer design. However, the cap design will be modified to incorporate a biological intrusion barrier consisting of a five-foot-thick layer of roller-compacted concrete placed between the clay and drainage layers. The intrusion barrier will provide additional long-term waste isolation benefits including:

  - Protection against inadvertent human intrusion into the waste
  - Protection against general biological intrusion through the clay layer
  - Protection against severe wind and rain induced erosion, due to the loss of institutional control, by providing an armored surface over the clay layer

  All cap elements and layers will be contoured to grades that promote drainage while minimizing the effects of storm water erosion and any minor amounts of residual waste pit subsidence. For additional details, see Figure 4-2.

- Flow Realignment - The objective of flow realignment is to permanently redirect flow away from a zone of contamination or to minimize destructive water erosion from damaging a critical natural or engineered feature. As presently configured, Paddys Run is the main drainage channel for the western portion of the site originating just north of the FMPC, flowing to within 150 feet of the west side of Operable Unit 1, and continuing south to the Great Miami River. Construction of the closure cap finished contour grades will require intruding on the present streambed location. Therefore, meeting the stated objectives on a long-term basis will require partial relocation and recontouring of Paddys Run.

- Runoff/Run-on Control - Runoff control features remove storm water from the Operable Unit 1 area, and run-on control features direct storm water away from the closed facility. Runoff/run-on control can be accomplished by using site contour grading, vegetation, diversion and collection ditches, as well as various physical devices including silt traps and sedimentation basins.

6.2.2 System Requirements

This alternative will require:

- Earth-moving, excavation, and compaction equipment
- Temporary groundwater extraction system
- Clay capable of achieving 10^{-7} centimeters per second vertical permeability
- Long-term maintenance and environmental monitoring program
- Partial relocation of Paddys Run
- Water treatment facility and water supply
- Decontamination facilities
- Short- and long-term runoff/run-on control

6.2.3 Size and Configuration

The following is a listing of the approximate sizes and numbers of the various components of the remediated pits.

• Closure cap	approximately 37 acres
• Slurry wall	3500 feet x 60 feet (x 3 feet) = 210,000 square feet
• Subsurface drains	10 each, 3 feet diameter, 40 feet deep

6.2.4 Remediation Time Frame

Remediation will take approximately two years from the initial staging of construction equipment and water treatment to the final capping of the pits and completion of Paddys Run realignment.

6.2.5 Spatial Requirements

The spatial requirements are as follows:

- Staging area for construction material and equipment - 5.0 acres
- Office and field laboratories - 0.5 acre
- Decontamination facilities - 0.5 acre
- Wastewater treatment system - 0.5 acre

6.2.6 Packaging/Transportation Requirements

The only transportation requirement identified is transporting the fill, aggregate, and clay closure components to the site.

6.2.7 Wastes Generated

Minor amounts of contaminated miscellaneous equipment and job control waste will be generated and disposed of under the closure cap.

6.3 ALTERNATIVE 2 - NONREMOVAL, PHYSICAL STABILIZATION, SLURRY WALL, AND CAP

6.3.1 Description

The second nonremoval alternative for Operable Unit 1 is identical to Alternative 1 with the exception that a waste stabilization step has been incorporated. The purpose of this additional process is to promote the densification of the waste in a controlled manner, which will minimize the potential for long-term waste settlement and the release of contaminated waste pit water into the underlying Great Miami Aquifer. The future maintenance of the cap due to waste consolidation (settling) will be correspondingly reduced as previously discussed in Section 4.3.

This nonremoval alternative isolates the wastes from the environment thus minimizing the generation and release of contaminated leachate to the underlying Great Miami Aquifer. This is accomplished by removing and treating any free standing water, in situ waste stabilization, construction of a closure cap, storm water runoff and run-on control measures, as well as subsurface flow control features including slurry walls, subsurface drains, and temporary groundwater wells. Placement of a closure cap will require the partial flow realignment of Paddys Run. The following technologies are presented in the order in which they appear in Figure 6-1.

- Removal and Treatment of Standing Water - Pits 5 and 6 and the Clearwell have standing water requiring treatment by a wastewater treatment facility. The treatment facility process systems include clarification, filtration, ion exchange, and reverse osmosis. The treatment facility will also process all contaminated water generated from other sources associated with remedial efforts, including groundwater. A treatment facility is presently scheduled to be built that will meet the wastewater treatment needs for all operable units.

- Subsurface Flow Control - The subsurface flow control technologies will minimize the horizontal groundwater flow through the Operable Unit 1 area. These technologies are shown in Figure 4-2 and may consist of the following:

  - A soil/bentonite partial slurry wall placed around the north, east, and south of the Operable Unit 1 area. The slurry wall will be installed through the surficial till layer into the underlying Great Miami Aquifer. The slurry wall will divert the flow from the local water table around the enclosed area.

- A series of perimeter drains may be placed upgradient from the slurry wall. The drains will intercept and divert uncontaminated till groundwater to prevent contact with waste and contaminated soil by facilitating downgradient movement.

- Temporary groundwater wells will lower the groundwater table inside the slurry wall area, providing both contaminant (plume) control and reduction of the water available to interact with the in situ waste. These wells will be removed and grouted shut before capping. It is assumed that the withdrawn water is contaminated to some degree and will require treatment before discharge.

- Physical Stabilization - CIS data indicate Pits 5 and 6 and the Clearwell exclusively contain sludges from plant production and/or surface soil sediments, whereas Pits 1 through 4 and the Burn Pit contain actual or assumed quantities of drums, construction rubble, and/or miscellaneous site debris. Pits 1 through 6 have a subsurface moisture content that varies from 20 to 60 percent. Therefore, specific in situ stabilization techniques were developed for various pits within the operable unit area to minimize the potential of long-term waste settlement, future cap maintenance, and release of contaminated waste pit water into the surrounding subsoils.

  - SSM

    Because of the absence of drums and construction rubble, SSM, as described in Section 4.3 and Appendix A, will be the preferred stabilization technology for Pits 5 and 6 and the Clearwell. SSM will reduce the amount of standing water requiring treatment, as well as stabilizing the waste and associated pore water into the grout matrix. The SSM technology will provide structural competence and an end product with little or no contaminant leachability potential.

  - Surcharging (overburdening)

    Pits 1 through 4 and the Burn Pit will each receive a 16- to 20-foot-thick soil overburden as shown in Figure 4-3. Before the surcharge placement, a series of leachate (pore water) collection trenches and sumps will be installed in the surface of Pits 1 through 4 and the Burn Pit. These sumps and trenches will serve to collect any liquids released during the surcharging process. A leachate collection system in the form of wells may also be utilized. All collected leachate will be processed in the remedial water treatment plant.

    After the pit wastes have achieved the required compaction goals, as indicated by laboratory tests and verified by field monitoring, the overburdening soil will be removed to design-specified contour elevations.

- Capping - After completion of the contour grading, a multiple layer closure cap will be installed. The cap will be constructed, as described in Appendix A, utilizing a minimum four-foot-thick low permeability clay layer, a combination two-foot natural aggregate filter blanket/drainage layer, and a two-foot thick vegetative layer design. However, the cap design will be modified to incorporate a biological intrusion barrier consisting of a five-foot-thick layer of roller-compacted concrete placed between the clay and drainage layers. The intrusion barrier will provide additional long-term waste isolation benefits including:

- Protection against inadvertent human intrusion into the waste
- Protection against general biological intrusion through the clay layer
- Protection against severe wind and rain induced erosion, due to the loss of institutional control, by providing an armored surface over the clay layer.

All cap elements and layers will be contoured to grades that promote drainage while minimizing the effects of storm water erosion and any minor amounts of residual waste pit subsidence. For additional details, see Figure 4-2.

- Flow Realignment - The objective of flow realignment is to permanently redirect flow away from a zone of contamination or to minimize destructive water erosion from damaging a critical natural or engineered feature. As presently configured, Paddys Run is the main drainage channel for the western portion of the site originating just north of the FMPC, flowing to within 150 feet of the west side of Operable Unit 1, and continuing south to the Great Miami River. Construction of the closure cap finished contour grades will require intruding on the present streambed location. Therefore, to meet the stated objectives on a long-term basis will require partial relocation and recontouring of Paddys Run.

- Runoff/Run-on Control - Runoff control features remove storm water from the Operable Unit 1 area while run-on control features direct storm water away from the closed facility. Runoff/run-on control can be accomplished by using site contour grading, vegetation, diversion and collection ditches, as well as various physical devices including silt traps and sedimentation basins.

6.3.2 System Requirements

This alternative will require:

- Earth-moving, excavation, and compaction equipment
- Temporary groundwater extraction system
- Clay capable of achieving 10^{-7} centimeters per second vertical permeability
- Long-term maintenance and environmental monitoring program
- Partial relocation of Paddys Run
- Water treatment facility and water supply
- SSM system with air treatment
- Decontamination facilities
- Short- and long-term runoff/run-on control
- Soils for surcharging

6.3.3 Size and Configuration

The following is a listing of the approximate sizes and numbers of the various components of the remediated pits.

• Closure cap	approximately 37 acres
• Slurry wall	3,500 feet x 60 feet (x 3 feet) = 210,000 square feet
• Subsurface drains	10 each, 3 feet diameter, 40 feet deep
• In situ physical stabilization treatment areas	
- SSM	241,000 square feet (Pits 5 and 6 and Clearwell)
- Surcharge	488,000 square feet (Pits 1 through 4 and Burn Pit)

6.3.4 Remediation Time Frame

Remediation will take approximately two years from the initial staging of construction equipment and water treatment to the final capping of pits and completion of Paddys Run realignment.

6.3.5 Spatial Requirements

The spatial requirements are as follows:

- Staging area for construction material and equipment - 5.0 acres
- Office and field laboratories - 0.5 acre
- Decontamination facilities - 0.5 acre
- Wastewater treatment system - 0.5 acre

6.3.6 Packaging/Transportation Requirements

The only transportation requirement identified is transporting the fill, aggregate, and clay closure components to the site.

6.3.7 Wastes Generated

Minor amounts of contaminated miscellaneous equipment and job control waste will be generated and disposed of under the closure cap.

6.4 ALTERNATIVE 3 - NONREMOVAL, IN SITU VITRIFICATION, AND CAP

6.4.1 Description

This alternative is similar to Alternative 2 in that a waste immobilization step has been incorporated into the nonremoval scenario. However, the solidification/stabilization step now specifies vitrification technology rather than the physical stabilization technologies called for under Alternative 2. A second important difference is that the subsurface control measures are not included in this alternative. The reason for this exclusion is that the resultant vitrified mass should preclude the future release of contaminated water from the waste, thus eliminating the need for subsurface flow control. Capping will prevent rain water from coming in contact with the vitrified

mass and immediately surrounding partially vitrified soils, provide run-on and runoff control of surface water, and prevent direct human, animal, and plant contact with the mass.

The following technologies make up the components of this alternative (Figure 6-1):

- Removal and Treatment of Standing Water - Pits 5 and 6 and the Clearwell have standing water requiring treatment by a site-wide treatment plant, if available. The treatment plant process systems include clarification, infiltration, ion exchange, and reverse osmosis. The treatment plant will also process all contaminated water generated by other aspects of this remedial alternative, including groundwater.

- In Situ Vitrification - Vitrification of the waste pits would be accomplished by placing an array of electrodes at predetermined grid points across the pits. Electrical energy would then be applied until a temperature above 1600°C is achieved and the soil is converted to a molten mass. The process would be repeated at adjacent soil blocks until the entire site was treated.

  An off-gas treatment system would be used to collect and treat gases generated by the vitrification process. The off-gases would be collected by a hood and drawn into the treatment system which would contain the following unit processes: (1) quenching, (2) pH controlled scrubbing, (3) dewatering (mist elimination), (4) heating (for dew point control), (5) particulate filtration and (6) activated carbon adsorption.

  Upon cooling, an obsidian-like vitrified monolith results (silicate glass and microcrystalline structure) which possesses excellent structural and environmental properties. The silicate glass is very durable relative to environmental exposure and will hold a wide variety of materials in nonleachable form.

- Capping - After completion of the contour grading, a multiple layer closure cap will be installed. The cap will be constructed, as described in Appendix A, utilizing a minimum four-foot-thick low-permeability clay layer, a combination two-foot natural aggregate filter blanket/drainage layer, and a two-foot-thick vegetative layer design. However, the cap design will be modified to incorporate a biological intrusion barrier consisting of a five-foot-thick layer of roller-compacted concrete placed between the clay and drainage layers. The intrusion barrier will provide additional long-term waste isolation benefits including:

  - Protection against inadvertent human intrusion into the waste
  - Protection against general biological intrusion through the clay layer
  - Protection against severe wind and rain induced erosion, due to the loss of institutional control, by providing an armored surface over the clay layer.

  All cap elements and layers will be contoured to grades that promote drainage while minimizing the effects of storm water erosion and any minor amounts of residual waste pit subsidence. For additional details, see Figure 4-2.

- Flow Realignment - The objective of flow realignment is to permanently redirect flow away from a zone of contamination or to minimize destructive water erosion from damaging a critical natural or engineered feature. As presently configured, Paddys

Run is the main drainage channel for the western portion of the site originating just north of the FMPC, flowing to within 150 feet of the west side of Operable Unit 1, and continuing south to the Great Miami River. Construction of the closure cap finished contour grades will require intruding on the present streambed location. Therefore, to meet the stated objectives on a long-term basis will require partial relocation and recontouring of Paddys Run.

- Runoff/Run-on Control - Runoff control features remove storm water from the Operable Unit 1 area while run-on control features direct storm water away from the closed facility. Runoff/run-on control can be accomplished by using site contour grading, vegetation, diversion and collection ditches, as well as various physical devices including silt traps and sedimentation basins.

6.4.2 System Requirements

This alternative will require:

- Earth-moving, excavation, and compaction equipment
- Clay capable of achieving 10^{-7} centimeters per second vertical permeability
- Long-term maintenance and environmental monitoring program
- Partial relocation of Paddys Run
- Water treatment facility and water supply
- In situ vitrification and off-gas treatment system
- Decontamination facilities
- Short- and long-term runoff/run-on control

6.4.3 Size and Configuration

The following is a listing of the approximate sizes and numbers of the various components of the remediated pits.

- Closure cap - 37 acres
- In situ vitrification treatment area - 17 acres (Pits 1 through 6, Clearwell and Burn Pit)

6.4.4 Remediation Time Frame

Remediation will take approximately two years from the initial staging of construction equipment and water treatment to the final capping of pits and completion of Paddys Run realignment.

6.4.5 Spatial Requirements

The spatial requirements are as follows:

- Staging area for construction material and equipment - 5.0 acres
- Office and field laboratories - 0.5 acre

- Decontamination facilities - 0.5 acre
- Wastewater treatment system - 0.5 acre

6.4.6 Packaging/Transportation Requirements

The only transportation requirement identified is transporting the fill, aggregate, and clay closure components to the site.

6.4.7 Wastes Generated

Minor amounts of contaminated miscellaneous equipment and job control waste will be generated and disposed of under the closure cap.

6.5 ALTERNATIVE 4 - REMOVAL, WASTE TREATMENT, AND ON-PROPERTY DISPOSAL

6.5.1 Description

This alternative is intended to completely remove the pit wastes and dispose of them in an on-property EDF. This process includes the removal and treatment of standing water, waste removal, waste segregation, treatment, and final disposal (see Figure 6-1).

There are two waste removal technology options. Depending on the physical nature of the pit sludges, including water content and the presence of standing surface water, hydraulic dredging and/or mechanical dredging technologies can be employed.

Pits 1 through 4 and the Burn Pit contain actual or assumed quantities of drums, construction rubble, and/or miscellaneous site debris. Therefore, as described in Appendix A, extensive waste segregation activities will require mechanical shredders, crushers, compactors, and balers, as well as a separate facility for drum handling, sampling, and treatment as required.

After segregation, the remaining sludge material will be treated before disposal. Depending on the amount of organics present in the pit sludges, the process options selected for further consideration include drying and/or vitrification and dewatering and stabilization. These process options are described in Appendix A.

Any water not utilized by the waste (sludge) treatment technologies will be processed by the site-wide, centralized wastewater treatment facility. The technologies under review for the water treatment plant include:

- Clarification
- Filtration
- Ion exchange
- Reverse osmosis

If future sampling or treatability studies determine that the organic contaminants are of a type or concentration that could have a detrimental effect on the stabilization process, the process would have to include a step to remove or destroy these organics. After treatment, the resultant waste form will be transferred from a temporary holding area to either a tumulus or series of abovegrade structures, as described in Appendix A. Although both the tumulus and above grade structure provide containment, the tumulus will be retained as the representative process option. The reinforced concrete roof of the abovegrade structure will function as the cap intrusion barrier component.

As with all on-property disposal technologies including in situ stabilization, a properly designed site, regularly scheduled monitoring, and facility maintenance programs will be required throughout some specified postclosure period.

6.5.2 System Requirements

This alternative will require:

- Long-term maintenance and environmental monitoring program
- Waste removal equipment
- Water treatment facility and water supply
- On-property storage facility
- Miscellaneous service utilities
- Process plant facility
- Decontamination facility
- Earth-moving, excavation, and compaction equipment
- Waste segregation facility
- Short- and long-term runoff/run-on control
- Drum handling facility (provided by FMPC in conjunction with general plant activities)

It is assumed that the plant has no existing excess capacity for sludge or wastewater treatment.

6.5.3 Size and Configuration

- Vitrification - 1300 cubic yards of vitrified waste per day, 100,000-square foot treatment facility
- Grout stabilization - 2200 cubic yards of stabilized waste per day, one acre treatment facility

6.5.4 Remediation Time Frame

Remediation will take approximately six years from the initial staging of equipment to final backfilling of the pits using either vitrification or physical stabilization (based on four years of excavation, one year construction/startup, and one year for final closure).

6.5.5 Spatial Requirements

The spatial requirements are as follows:

- Offices and field laboratory - 0.5 acre
- Decontamination facilities - 0.5 acre
- On-property treatment and packaging and process facility - 1.0 acre
- Staging area for supplies and earth-moving equipment - 5.0 acres
- Tumulus or equivalent - 150 acres
- Treated waste transfer station - 2.0 acres
- Wastewater treatment plant - 0.5 acre

6.5.6 Packaging/Transport Requirements

There will be an on-property treatment/packaging facility to prepare the waste for on-property storage, and there will be on-property transportation requirements to move the treated waste to on-property storage.

6.5.7 Wastes Generated

Any equipment that is too contaminated to warrant decontamination will be considered waste and will be sent to an appropriate disposal facility. Wastewater from remedial activities will be treated before release.

6.6 ALTERNATIVE 5 - REMOVAL, WASTE TREATMENT, AND OFF-SITE DISPOSAL

6.6.1 Description

This alternative is the same as Alternative 4 in all ways except the final disposal of the treated wastes is at an approved off-site disposal facility.

The waste removal technologies, sorting technologies, and on-property treatment and packaging technology options are the same as those for Alternative 4.

Any water not used for making concrete will be processed by the wastewater treatment plant constructed specifically for use during Operable Unit 1 remediation or a site-wide treatment plant, if available. The technologies under review for the wastewater treatment plant include:

- Clarification
- Filtration
- Ion exchange
- Reverse osmosis

6.6.2 System Requirements

This alternative will require:

- Waste removal equipment
- Wastewater treatment facility and a water supply
- On-property temporary waste storage and loading facilities
- Earth-moving, excavation, and compaction equipment
- Decontamination facility
- Miscellaneous service utilities
- Construction of a rail spur to the assumed approved off-site waste disposal facility
- Process plant facility
- Waste segregation facility
- Short- and long-term erosion control features
- Drum handling facility (provided by FMPC is conjunction with general plant activities)

It is assumed that the plant has no excess capacity for sludge or wastewater treatment.

6.6.3 Size and Configuration

- Vitrification - 1300 cubic yards per day, 100,000-square-foot production facility
- Grout - 2200 cubic yards per day, one acre production facility

6.6.4 Remediation Time Frame

Remediation will take approximately six years from the initial staging of equipment to final back-filling of pits if either vitrification or physical stabilization is used (based on four years of excavation, one year construction/startup, and one year for final closure).

6.6.5 Spatial Requirements

The spatial requirements are as follows:

- Offices and field laboratory - 0.5 acre
- Decontamination facilities - 0.5 acre
- On-site treatment and packaging facility - 1.0 acre
- On-site short-term storage area - 5.0 acres
- Staging area for supplies and earth-moving equipment - 5.0 acres
- Treated waste transfer station - 2.0 acres

6.6.6 Packaging/Transport Requirements

See Appendix B.

6.6.7 Wastes Generated

Any equipment that is too contaminated to warrant decontamination will be considered waste.

6.7 ALTERNATIVE 6 - WASTE REMOVAL, TREATMENT, ON-PROPERTY DISPOSAL, AND CAP

6.7.1 Description

This alternative, like Alternative 4, addresses the removal and treatment of the waste pit caps (or standing surface water on those pits without caps) and pit waste from each of the waste pits including the Burn Pit and Clearwell. However, Alternative 5 will differ from Alternative 4 in that the contaminated soils that lie beneath and surround the pit waste will remain in place and will be covered by a closure cap. The closure cap has been incorporated into this alternative to evaluate the potential reduction of risks associated with utilization of both pit waste removal and capping technologies.

The following technologies make up the components of this alternative:

- Removal and Treatment of Standing Water - Pits 5 and 6 and the Clearwell have standing water requiring treatment by a wastewater treatment facility. The treatment facility process systems include clarification, filtration, ion exchange, and reverse osmosis. The treatment facility will also process all contaminated water generated from other sources associated with remedial efforts, including groundwater. A treatment facility is presently scheduled to be built that will meet the wastewater treatment needs for all operable units.

- Waste Removal and Segregation - As outlined in Alternative 4, there are two removal technology options. Depending on the physical nature of the pit sludges, including

water content and the presence of standing surface water, hydraulic and/or mechanical dredging technologies can be employed.

Waste segregation activities will be required as a result of an undetermined amount of drums, construction rubble, and/or miscellaneous site debris known to exist in Pits 1 through 4. As described in Appendix A, Page A-33, waste segregation activities will require mechanical shredders, crushers, compactors, and balers, as well as a separate facility for drum handling, sampling, and treatment.

- Waste Treatment - When all waste materials have been segregated, the sludge and contaminated capping materials will be treated before disposal. Depending on the amount of organics present in the waste material, the process options selected for further consideration include drying and/or vitrification, dewatering, and stabilization as described in Appendix A. However, if future sampling and/or treatability studies determine that the organic contaminants could have a detrimental effect on the stabilization process, the process would have to include a pretreatment method to remove or destroy these organics.

  - Waste Treatment by Vitrification - Vitrification is the process of using high temperatures to alter the chemical and physical characteristics of the waste. The toxic organic constituents of the waste will be broken down by anaerobic pyrolysis, which reduces the organics to their constituent elements. The resulting material will have characteristics of obsidian, a naturally-occurring volcanic glass. Upon cooling, an obsidian-like vitrified monolith results (silicate glass and microcrystalline structure) that possesses excellent structural and environmental properties. The silicate glass is very durable with respect to environmental exposure and will hold a wide variety of materials in a nonleachable form.

    An off-gas treatment system would be used to collect and treat gases generated by the vitrification process. The off-gas would be collected by a hood and drawn into the treatment system that would contain the following unit processes: (1) quenching, (2) pH-controlled scrubbing, (3) dewatering (mist elimination), (4) heating (for dewpoint control), (5) particulate filtration, and (6) activated carbon adsorption.

  - Waste Treatment by Stabilization/Solidification - Waste stabilization is the process by which a reduction in the solubility or chemical reactivity of a waste is obtained by changing its chemical or physical state. Waste solidification is the process by which waste is converted into an easily handled solid with minimized volatilization, leaching, or spillage attributes. By combining waste stabilization and solidification, waste can be effectively neutralized and solidified for easy management and disposal.

    Stabilization/solidification of the waste material will be accomplished by subjecting the waste to a pozzolan-portland cement process. This process utilizes portland cement and fly ash or other pozzolan materials to produce a very strong waste/concrete composite. The waste containment is produced by entrapping the waste in the pozzolan concrete matrix. In addition, soluble silicates may be added to accelerate hardening and metal containment.

If future treatability studies determine that the organic contaminants could have detrimental effect on the stabilization process, the process would have to include a pretreatment method to remove or destroy these organics.

- On-Property Disposal - After treatment, the resultant waste will be transferred from a temporary holding area to an EDF as described in Appendix A. The reinforced concrete roof of the abovegrade structure will function as the cap intrusion barrier component.

- Capping - Once removal, segregation, and treatment activities have been completed, the open pits will be leveled and covered with a multiple-layer closure cap. The closure cap will be designed and constructed as described in Appendix A, utilizing a minimum four-foot-thick low permeability clay layer, a combination two-foot-thick natural aggregate filter blanket/drainage layer, and a two-foot-thick vegetative layer design. The cap design will also incorporate a biological intrusion barrier consisting of a five-foot-thick layer of roller-compacted concrete placed between the clay and drainage layers. The intrusion barrier will provide additional long-term isolation for the contaminated soils remaining in place.

  All cap components and layers will be contoured to grades that promote drainage while minimizing the effects of storm water erosion.

- Runoff/Run-on Control - Runoff control features remove storm water from the operable unit area, and run-on control features direct storm water away from the closed facility. Runoff/run-on control can be accomplished by using site contour grading, vegetation, diversion and collection ditches, as well as various physical devices including silt traps and sedimentation basins.

- Flow Realignment - The objective of flow realignment is to permanently redirect flow away from a zone of contamination or to minimize destructive water erosion from damaging a critical natural or engineered feature. As presently configured, Paddys Run is the main drainage channel for the western portion of the site originating just north of the FMPC, flowing to within 150 feet of the west side of Operable Unit 1, and continuing south to the Great Miami River. Construction of the closure cap's finished contour grades will require intrusion on the present streambed location. Therefore, to meet the stated objectives on a long-term basis will require a partial relocation and recontouring of Paddys Run.

If selected, this alternative will reduce the amount of contamination left in place as well as mitigate the health risks associated with waste removal and treatment without capping. The most prominent advantages of this alternative are the immediate reduction in radioactivity and the diminished potential for contaminated leachate to be released to the underlying Great Miami Aquifer.

6.7.2 System Requirements

This alternative will require:

- Earth-moving, excavation, and compaction equipment

- Short- and long-term runoff/run-on control
- Waste removal equipment
- Decontamination facility
- Waste segregation facility
- Drum handling facility
- Water treatment facility and water supply
- On-property storage facility
- Miscellaneous service utilities
- Process plant facility
- Clay capable of achieving 10^{-7} centimeters per second vertical permeability
- Temporary groundwater extraction system
- Partial relocation of Paddys Run
- Long-term maintenance and environmental monitoring program

A wastewater treatment facility is presently scheduled for construction that will meet the wastewater treatment needs of all operable units.

6.7.3 Size and Configuration

- Vitrification - 1300 cubic yards of vitrified waste per day; 100,000-square-foot treatment facility

- Grout stabilization - 2200 cubic yards of stabilized waste per day; one-acre treatment facility

- Closure cap - approximately 37 acres

6.7.4 Remediation Time Frame

Remediation will take approximately six years from the initial staging of construction and waste treatment to the final capping of the waste pits and realignment of Paddys Run.

6.7.5 Spatial Requirements

The spatial requirements are as follows:

- Offices and field laboratory - 0.5 acre
- Decontamination facilities - 0.5 acre
- On-site treatment, packaging and process facility - 1.0 acre
- Staging area for supplies and earth-moving equipment - 5.0 acres
- Disposal facility - 150 acres
- Treated waste transfer station - 2.0 acres
- Waste water treatment plant - 0.5 acre

6.7.6 Packaging/Transport Requirements

There will be an on-property treatment/packaging facility to prepare the waste for on-property storage. In addition, on-property transportation will be required to move the treated waste to on-property storage. The only other transportation requirements identified are those associated with transporting fill and closure cap materials to the site.

6.7.7 Waste Generated

Minor amounts of contaminated equipment and job control waste will be generated and disposed of under the closure cap. Wastewater from remedial activities will be treated before release.

6.8 ALTERNATIVE 7 - WASTE REMOVAL, TREATMENT, ON-PROPERTY DISPOSAL, SOIL TREATMENT, AND CAP

6.8.1 Description

This alternative differs from Alternative 6 by introducing treatment of the soil underlying the waste material located in Waste Pits 1 through 6, the Burn Pit, and the Clearwell. Therefore, in addition to the excavation of pit waste, the treatment of the waste, and infiltration cap installation, two technologies are considered for the soil treatment: vitrification and solidification. These technologies are also applicable to the excavated waste material.

The following technologies make up the components of this alternative:

- Removal and Treatment of Standing Water - Pits 5 and 6 and the Clearwell have standing water requiring a wastewater treatment plant for use during the operational unit remediation. The treatment plant process systems include clarification, infiltration, ion exchange, and reverse osmosis. The treatment plant will also process all contaminated water generated by other aspects of this remedial alternative, including groundwater. The plant could be built for use during the remediation efforts or excess capacity from the site-wide water treatment plant could be utilized.

- Removal and Treatment of Pit Waste

  - Vitrification - This technology treats hazardous waste by using high temperatures to alter the chemical and physical characteristics of the waste. The toxic organic constituents located in the pits will be broken down by anaerobic pyrolysis, which reduces the organics to their constituent elements. The resulting material will show characteristics of obsidian, which is a naturally-occurring volcanic glass. Characteristics of this vitrified material include resistance to chemical degradation and reduced leaching of inorganic materials such as heavy metals.

A gravity-fed conveyor will be used for solid waste treatment in conveying the solid waste to the reactor. The contaminated feed stream will be subject to a nominal temperature of 1650°C (+/- 40°C). Various unit processes will be required to collect the off-gases and particulates drawn into the treatment system: (1) quenching, (2) pH-controlled scrubbing, (3) dewatering (mist elimination), (4) heating (for dew point control), (5) particulate filtration, and (6) activated carbon adsorption.

- Stabilization/Solidification (Cement Stabilization) - This is a technology that limits the mobility and solubility of hazardous constituents through the production of a solid block of interstitially held waste material; the block is often referred to as a monolith. This technology will be performed in tanks or containers. Depending on waste characteristics in the pits, specific binding reagents would be required. Because of the radioactive constituents present in the waste pits, cement stabilization (as described in Appendix A) will be the preferred technology.

  Before stabilization, it may be necessary to pretreat the sludge to adjust the pH and to insolubilize the heavy metals thereby reducing their mobility. The result of this treatment will be a block of soil or a continuous stabilized mass of high strength and low permeability material that resists leaching. The pits containing large amounts of inorganic constituents will find this technology useful.

  In considering this technology, a number of critical parameters are to be considered: (1) choice of stabilizing agent and other additives, (2) waste-to-additive ratio, and (3) mixing conditions. If future sampling or treatability studies determine that the organic contaminants could have a detrimental effect on the stabilization process, the process would have to include a method to remove or destroy these organics. Nitrates and sulfates can also interfere in cement stabilization.

- Treatment of Soils Under the Pits

  - In Situ Vitrification - Following excavation of the contaminated constituents, this technology will be used on the remaining soils in the pits. Vitrification of the waste would be accomplished by placing an array of electrodes at predetermined grid points across the pits. Electrical energy would then be applied until a temperature above 1600°C is achieved and the soil is converted to a molten mass. The process would be repeated at adjacent soil blocks until the entire site was treated.

    An off-gas treatment system would be used to collect and treat gases generated by the vitrification process. The off-gases would be collected by a hood and drawn into the treatment system that would contain the following unit processes: (1) quenching, (2) pH-controlled scrubbing, (3) dewatering (mist elimination), (4) heating (for dewpoint control), (5) particulate filtration, and (6) activated carbon absorption.

    Upon cooling, an obsidian-like vitrified monolith results (silicate glass and microcrystalline structure) that possesses excellent structural and environmental properties. The silicate glass is very durable relative to environmental exposure and will hold a wide variety of materials in nonleachable form.

- SSM - Because of the absence of drums and construction rubble, SSM, as described in Section 4.3 and Appendix A, will reduce the amount of standing water requiring treatment, as well as stabilizing the waste and associated pore water into the grout matrix. The SSM technology will provide structural competence and an end product with little or no potential of contaminant leachability.

- Capping - When the excavation of the waste in the pits is completed, the remaining soil is treated followed by installation of a multilayer cap. Backfill will be used to establish a horizontal gradient needed to install the cap. The cap will be constructed as described in Appendix A, utilizing a minimum four-foot-thick low permeability clay layer, a combination two-foot-thick natural aggregate filter blanket/drainage layer, and a two-foot-thick vegetative layer design. However, the cap design will be modified to incorporate a biological intrusion barrier consisting of a five-foot-thick layer of roller-compacted concrete placed between the clay and drainage layers. The intrusion barrier will provide additional long-term waste isolation benefits, including protection against inadvertent human intrusion into the waste, protection against general biological intrusion through the clay layer, and protection against severe wind-induced erosion, due to the loss of instutional control, by providing an armored surface over the clay layer.

  All cap elements and layers will be contoured to grades that promote drainage while minimizing the effects of storm water erosion and any minor amounts of residual waste pit subsidence.

- Flow Realignment - For a discussion of this process, refer to Alternative 3 under this category.

- Runoff/Run-on Control - For a synopsis of this control feature, refer to Alternative 3 under this category.

After treatment, the resultant waste form will be transferred from a temporary holding area to an EDF, as described in Appendix A. The reinforced concrete roof of the above-grade structure will function as the cap intrusion barrier component.

As with all on-property disposal technologies, including in situ stabilization, a properly designed site, regularly scheduled monitoring, and facility maintenance programs will be required throughout some specified postclosure period.

6.8.2 System Requirements

This alternative will require:

- Earth-moving, excavation, and compaction equipment
- Long-term maintenance and environmental monitoring program
- Water treatment facility and water supply
- Decontamination facility

- In situ vitrification and off-gas treatment system
- Solidification/stabilization system
- Waste segregation facility
- Waste removal equipment
- Short- and long-term runoff/run-on control
- Solidification/stabilization system
- Drum handling facility (provided by FMPC in conjunction with general plant activities)

6.8.3 Size and Configuration

Listed below are approximate sizes and numbers of the various components of the remediated pits:

- Vitrification - 1300 cubic yards of vitrified waste per day; 100,000-square-foot treatment facility
- In situ vitrification treatment area - 17 acres (Pits 1 through 6, Burn Pit, Clearwell)
- Closure cap - approximately 37 acres

6.8.4 Remediation Time Frame

Remediation will take approximately ten years from the initial staging of equipment to final backfilling of the pits if either vitrification or stabilization is used. This is based on one year construction/startup, four years of excavation and treatment, four years for soil treatment, and one year for final closure.

6.8.5 Spatial Requirements

The spatial requirements are as follows:

- Offices and field laboratory - 0.5 acre
- Decontamination facilities - 0.5 acre
- Treatment, packaging, and process facility - 1.0 acre
- Staging area for supplies and earth moving equipment - 5.0 acres
- Tumulus or equivalent - 150 acres
- Treated waste transfer station - 2.0 acres
- Wastewater treatment plant - 0.5 acre

6.8.6 Packaging/Transport Requirements

There will be an on-property treatment/packaging facility to prepare the waste for on-property storage, and there will be on-property transportation requirements to move the treated waste to on-property storage.

6.8.7 Wastes Generated

Any equipment that is too contaminated to warrant decontamination will be considered waste and will be sent to an appropriate disposal facility. Wastewater from remedial activities will be treated before release.

7.0 INITIAL SCREENING OF ALTERNATIVES

7.1 SCREENING CRITERIA

7.1.1 Alternative Evaluation Process

The refined alternatives are evaluated against three broad criteria: effectiveness (short and long term), implementability, and cost. Because this evaluation should reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives are evaluated more generally in this phase than they will be during the subsequent detailed analysis task. Per the methodology of OSWER Directive 9355.3-01 (CERCLA Guidance Document), at least one "no-action," "in situ," and "remove/treat" alternative will be carried forward to the detailed analysis of alternatives phase. The no-action alternative is retained as a baseline against which the other alternatives are compared. The detailed analysis will subject the remaining alternatives to nine specific criteria and their individual factors rather than the three general criteria used in the alternative screening process. The relationship between the screening criteria and the nine detailed analysis evaluation criteria is illustrated in Figure 7-1. During the initial screening of alternatives only the three broad criteria are used for evaluation. However, per CERCLA guidance, preliminary consideration is given to the two threshold and five primary balancing factors.

Per the CERCLA Guidance Document, only similar alternatives are compared in the evaluation and screening process. The in situ alternatives (1, 2, and 3) will be compared as a general class of action and the waste removal alternatives (4, 5, 6, and 7) will be compared as another general class. The rating scale used for this evaluation process assigns each alternative a score from 1 to 5, with 5 rated as highly favorable and 1 rated as unfavorable.

7.1.2 Effectiveness Evaluation

A key aspect of the screening evaluation is the effectiveness of an alternative in protecting human health and the environment. In addition to determining the effectiveness of the alternative in meeting the remedial action objectives, each alternative will be evaluated for its effectiveness in achieving reductions in toxicity, mobility, and volume. The short- and long-term effectiveness were evaluated, with the short term referring to the active remediation (construction) period and the long term referring to the postremediation period.

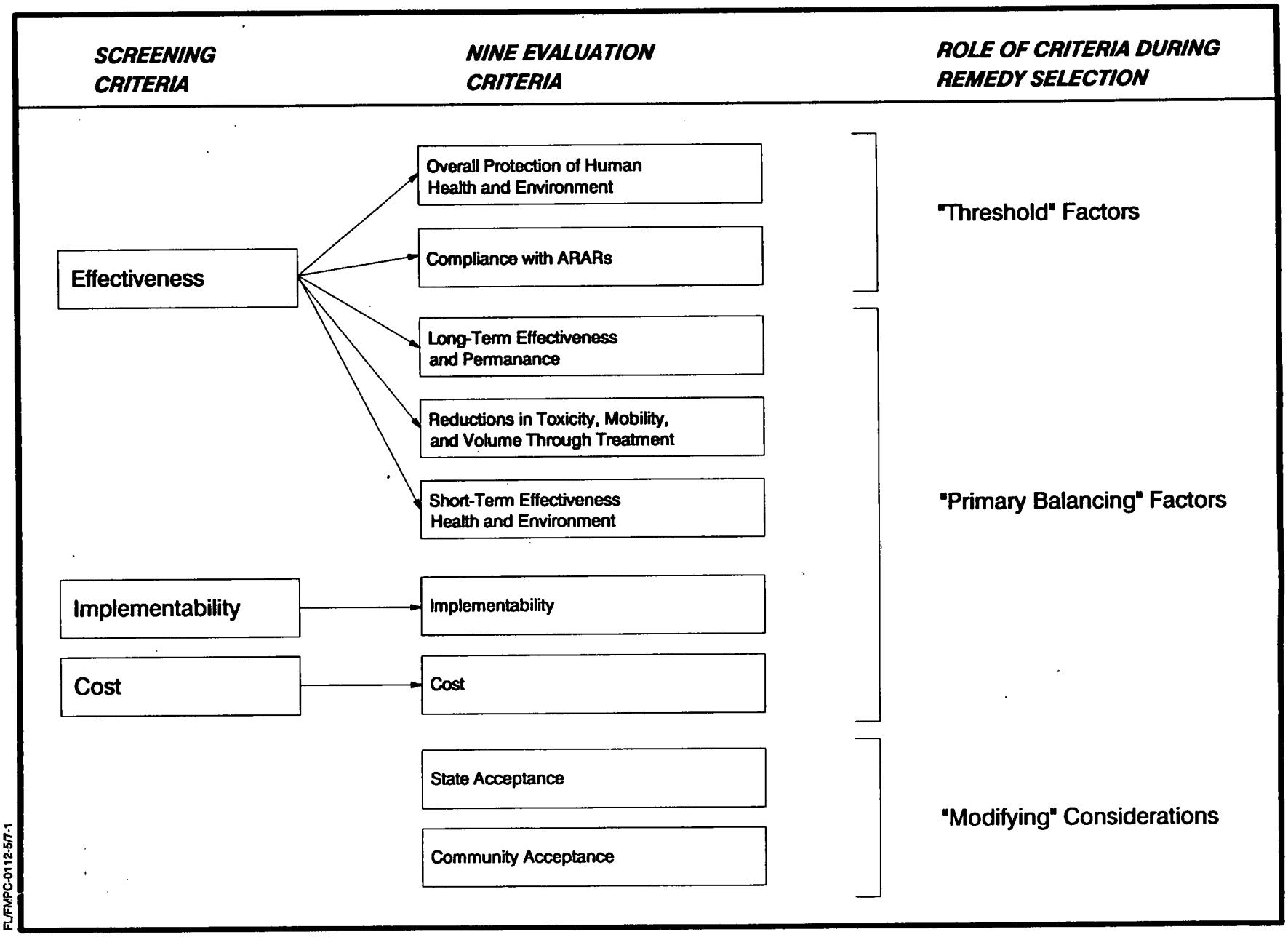

FIGURE 7-1. RELATIONSHIP OF SCREENING CRITERIA TO THE NINE EVALUATION CRITERIA

7.1.3 Implementability and Reliability Evaluation

Implementability is a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative. It provides a means of evaluating the ability of an alternative to be adapted to site-specific conditions.

The technical feasibility evaluation considered the following:

- Construction
- Operation
- Regulatory requirements
- Maintenance
- Monitoring
- Material/equipment replacement
- Ongoing treatment and/or monitoring
- Discharge/emission/disposal

The technical reliability of each alternative was also evaluated to determine the likelihood that technical problems associated with implementation could lead to schedule delays.

The administrative feasibility evaluation considered the following:

- Permitting and licensing approval
- Availability of on-site/off-site treatment, storage, and disposal services
- Availability of equipment
- Availability of design, operating, and support personnel

7.1.4 Cost Evaluation

Cost evaluations were prepared for each alternative to allow a relative comparison between similar alternatives. This analysis identifies alternatives that cost substantially more than a similar alternative. The cost evaluation was based on a variety of cost-estimating data such as cost curves, generic unit costs, vendor information, conventional cost-estimating guides, commercial remedial costs, and previous similar estimates as modified by site-specific information.

7.1.5 Innovative Technologies

Technologies are classified as innovative if they are fully developed but lack sufficient cost or performance data for routine use at Superfund sites. These technologies were carried through the screening phase if there was reason to believe that they offered significant advantages in performance or implementability. The nature of innovative technologies is such that a relatively complete performance and cost evaluation is not possible at this time because of insufficient data.

Those technologies considered for detailed analysis and considered as "innovative," per EPA's Guide to Treatment Technologies for Hazardous Wastes at Superfund Sites, are as follows:

- In Situ and Ex Situ Vitrification - Vitrification is the process of using high temperatures to alter the chemical and physical characteristics of the waste. Both in situ and ex situ vitrification are being considered for remediation efforts and are hereby being carried forward for detailed analysis.

- Reverse Osmosis - Reverse osmosis involves diffusion of water through a semipermeable membrane with applied pressure. It is a separation process that can retain particles (including dissolved species) as small as 1 to 10 Angstroms. Reverse osmosis is being considered for the site-wide wastewater treatment facility and is hereby carried forward for detailed analysis.

7.1.6 Compliance With ARARs

CERCLA Section 121 requires that remedial actions attain a level or standard of control that is applicable or relevant and appropriate to any hazardous substances, pollutants, or contaminants that will remain on site. Three classifications of ARARs are considered: 1) contaminant specific, 2) location specific, and 3) action specific. Contaminant-specific ARARs address the acceptable amount or concentration of a specific pollutant that may be found in or discharged to soil, water, and air. Location-specific ARARs are based on the specific setting and nature of the site, and action-specific ARARs relate to technology or activity-based requirements or limitations on the specific response actions taken with respect to the type of wastes. Thus, a determination of the potential ARARs for proposed actions at a site are based on factors specific to that site and the individual action. A comprehensive list of potential ARARs can be found in Appendix B.

7.2 ALTERNATIVE 0 - NO ACTION

7.2.1 Effectiveness

7.2.1.1 Protection of Human Health

The short- and long-term level of human health protection provided by this alternative is extremely low. Without some sort of remedial action, continued contaminant migration is certain to occur. Therefore, this alternative rates a 1 in both categories.

7.2.1.2 Protection of Environment

The short- and long-term effectiveness in this category rate the same as for the protection of human health.

7.2.1.3 Reduction in Toxicity, Mobility, and Volume

This alternative rates a 1 in this category because there is no reduction in toxicity, mobility, or volume.

7.2.2 Implementability

7.2.2.1 Constructability

This alternative rates a 5 in this category because of the minor amount of construction required.

7.2.2.2 Reliability

This alternative rates a 1 in this category because existing conditions cannot be relied on to prevent future releases from the unit.

7.2.2.3 Maintenance/Operation

Perpetual maintenance and monitoring will be required to ensure the unremediated site surface soils and pit berms remain functional. It is expected that maintenance will be extensive because of general and stream erosion on the west perimeter of the Operable Unit 1 area caused by precipitation at Paddys Run; therefore this alternative rates a 1.

7.2.2.4 Special Engineering and Equipment

This alternative requires no special engineering, equipment, or technical expertise and is rated a 5 in this category.

7.2.3 Cost

Excluding any future potential remediation expense, the cost for this alternative is lower than any of the specified remedial actions. The cost associated with long-term monitoring is estimated to be $9 million.

7.2.4 Screening Summary

This alternative provides neither short- nor long-term protection for human health and the environment nor a reduction in contaminant toxicity, mobility, and volume. This, coupled with the unlikelihood of agency approval, provides an overall alternative ranking of 17.

7.3 ALTERNATIVE 1 - NONREMOVAL, SLURRY WALL, AND CAP

7.3.1 Effectiveness

7.3.1.1 Protection of Human Health

This alternative was given ratings of 3 for short term and 2 for long term for the protection of human health. Although this is a nonremoval action and requires minimal handling risks, the benefits of not handling the material were offset by the risks associated with constructing a cap over moist unstabilized waste. There are also long-term risks associated with potential discharges to the perched groundwater. As the waste consolidates under the cap loads, pore water will be squeezed out of the waste/soil matrix into the surrounding pits, soils, and into the perched groundwater. Waste consolidation may be experienced for years after the completion of cap construction. This may lead to the long-term introduction of contaminated pore water in the till groundwater. However, dewatering prior to compaction and leachate collection should mitigate the chances of spreading contaminated water and leachate into the perched groundwater.

7.3.1.2 Protection of Environment

The short- and long-term effectiveness of this alternative to protect the environment rates a below-average score of 2. The rationale for this rating is similar to that for human health. Although the cap and slurry wall offer improvement over existing conditions, the concern over leaving unstabilized waste containing high moisture content offsets these benefits. There is also a high probability for cap subsidence and failure as the unstabilized waste consolidates.

7.3.1.3 Reduction in Toxicity, Mobility, and Volume

Alternative 1 was given a rating of 2 for its ability to reduce the toxicity, mobility, and volume of waste. The construction of a slurry wall and cap over unstabilized and untreated waste will reduce the mobility of contaminants but will do nothing to decrease the toxicity or volume of the waste.

7.3.2 Implementability

7.3.2.1 Constructability

This alternative was rated average (3) for constructability. The equipment and technology required for installation of the cap and slurry wall are available and proven. There may be some difficulty

in constructing the cap over unstabilized waste but they are primarily long-term performance problems.

7.3.2.2 Reliability

Alternative 1 was given a below average (2) rating for reliability. As previously discussed, there are concerns about the structural integrity of the cap if placed over unconsolidated waste.

Although the Clearwell and Pits 5 and 6 will require removal and treatment of the standing waters, the CIS data indicate that most pit wastes are extremely wet and compressible. As the closure cap is placed, the induced load will initiate waste compression (consolidation). Dependent on factors such as total cap weight, time to construct, water content of the waste, and porosity of the surrounding pit soils, the cap may experience considerable settlement for years after completion. This extended settlement period will require considerable cap maintenance and possible reconstruction efforts.

7.3.2.3 Maintenance/Operation

Implementation of this alternative will require long-term postclosure monitoring and maintenance. The long-term maintenance will include mowing and care of the vegetative cover of the cap to prevent erosion and the natural vegetative succession to species whose roots could intrude into the cap. Monitoring will include groundwater and radon sampling. The cost of this postclosure monitoring and maintenance is included in the cost estimate for the alternative.

This alternative was given a rating of 2 due to the reliability problems discussed in Section 7.3.2.2. If cap subsidence and failure occur due to waste consolidation the maintenance and operation costs will increase significantly.

7.3.2.4 Special Engineering and Equipment

This alternative was rated above average (4) for the types of equipment required during construction.

7.3.3 Cost

The cost of this alternative was rated low because it is a nonremoval alternative and no waste stabilization processes are being implemented. Total costs were estimated to be $166 million of which $100 million are capital costs and $66 million are O&M costs.

7.3.4 Screening Summary

As shown in Table 7-1, this alternative was given a total score of 22 and a low cost. The primary factors in this alternative receiving a low score were the concerns over not stabilizing the waste in the pits. Subsidence of the waste and the resultant cap failure and release of leachate to the groundwater impacted almost all of the rating criteria.

7.4 ALTERNATIVE 2 - NONREMOVAL, PHYSICAL STABILIZATION, SLURRY WALL, AND CAP

7.4.1 Effectiveness

7.4.1.1 Protection of Human Health

This alternative offers the best short-term effectiveness of all the alternatives and rates a 4 because it is a waste nonremoval alternative; therefore there are minimal waste handling risks. With dedicated maintenance and monitoring, the long-term effectiveness can be maintained. However, this alternative rates a 3 in this category because it is uncertain to exactly what extent the containment techniques used will prevent contaminant migration over the long term.

7.4.1.2 Protection of Environment

The short- and long-term effectiveness in this category is average (3) because the positive environmental impact of reducing emissions from the waste pits is outweighed by the realignment of Paddys Run.

7.4.1.3 Reduction in Toxicity, Mobility, and Volume

This alternative rates a 3 in this category because, even though the pit wastes have been reduced in volume and are relatively immobile because of compaction and the impermeable cap, the wastes have not been treated except for SSM in Pits 5 and 6 and the Clearwell.

7.4.2 Implementability

7.4.2.1 Constructability

This alternative rates a 4 in this category because the technology is available, proven, and easiest to implement.

TABLE 7-1.
ALTERNATIVE RANKINGS

Alternative Number		0	1	2	3	4	5	6	7
Short-Term Human Health		1	3	4	3	3	2	3	3
Short-Term Environmental Protection		1	2	3	3	3	2	3	3
Long-Term Human Health		1	2	3	3	4	5	3	4
Long-Term Environmental Protection		1	2	3	3	4	5	3	4
Reduction in Mobility, Toxicity, and Volume		1	2	3	4	4	5	3	4
Contructability		5	3	4	2	3	3	3	3
Reliability		1	2	4	2	3	3	3	3
Maintenance		1	2	3	2	4	5	3	3
Special Engineering & Equipment		5	4	4	2	3	3	3	3
Summation		17	22	31	24	31	33	27	30
Relative Cost (Millions of Dollars)	Capital	$ 0	$ 100	$ 139	$ 500	$ 1500	$ 2000	$ 1353	$ 1592
	Long-Term O&M	$ 9	$ 66	$ 66	$ 66	$ 20	$ 0	$ 86	$ 86

RATING SCALE

1 = Unfavorable
2 = Below Average
3 = Average
4 = Above Average
5 = Highly Favorable

ALTERNATIVE DESCRIPTIONS

Alternative 0 - No Action
Alternative 1 - Nonremoval, Slurry Wall, and Cap
Alternative 2 - Nonremoval, Physical Stabilization, Slurry Wall, and Cap
Alternative 3 - Nonremoval, Vitrification, and Cap
Alternative 4 - Removal, Sludge Treatment, and On-Property Disposal
Alternative 5 - Removal, Sludge Treatment, and Off-Property Disposal
Alternative 6 - Waste Removal, Treatment, On-Property Disposal and Cap
Alternative 7 - Waste Removal, Treatment, On-Property Disposal, Soil Treatment and Cap

7.4.2.2 Reliability

This alternative rates a 4 in this category because of its relatively simple application and low probability of scheduling and operational delays.

7.4.2.3 Maintenance/Operation

Following the implementation of the remedial action, perpetual maintenance and monitoring will be required to ensure that the remedial action objectives continue to be met. The long-term maintenance will include mowing and care of the vegetative cover of the cap to prevent erosion and the natural vegetative succession to species whose roots could intrude into the cap. Monitoring will include groundwater and radon sampling. The cost of this postclosure monitoring and maintenance is included in the cost estimate for the alternative. This alternative rates a 3 in this category.

7.4.2.4 Special Engineering and Equipment

This alternative requires no special engineering, equipment, or technical expertise (except for SSM); therefore it is rated 4 in this category.

7.4.3 Cost

The cost of the nonremoval, physical stabilization, slurry wall, and capping alternative is low. Total costs are approximately $205 million of which $139 million are capital and $66 million are O&M costs.

7.4.4 Screening Summary

The advantages of this alternative are the relatively simple and inexpensive implementation and the effective short-term protection of human health and the environment. The SSM technology will solidify/stabilize the wastes in Pits 5 and 6 and the Clearwell. This alternative meets the remedial action objectives of preventing ingestion or contact with the wastes, preventing the release of airborne contamination and radon gas from the wastes, and mitigating migration to surface or groundwater.

The disadvantage of this alternative is that surcharging does not reduce the waste toxicity of any pits to which it can be applied. Similarly, an additional disadvantage of surcharging is that the compaction of the waste materials may cause drums containing liquids to rupture and result in additional contaminant migration.

The waste pits vary in age of operation from 31 to 38 years for Waste Pit 1, 26 to 33 years for Waste Pit 2, and 4 to 30 years for Waste Pit 4. Due to length of burial time in Waste Pits 1 and 2, it is unlikely that the subject drums are structurally intact. Drums buried in Waste Pit 4 greater than 10 years are also suspect. As part of the pit surcharging alternative, an extraction system would be put in place to capture all liquids released during consolidation of the soils. The liquids would be collected and treated in the site-wide wastewater treatment facility.

Because this is a containment and compaction technology, it ranks below other technologies as a remedial treatment that permanently and significantly reduces the volume or toxicity of hazardous substances, pollutants, and contaminants. However, capping does significantly reduce the mobility of these contaminants by effectively minimizing the infiltration of rain water through the pit wastes. The requirement for future remediation is a possibility. This alternative receives an overall ranking of 31.

7.5 ALTERNATIVE 3 - NONREMOVAL, IN SITU VITRIFICATION, AND CAP

7.5.1 Effectiveness

7.5.1.1 Protection of Human Health

Alternative 3 was rated as average (3) for its short-term and long-term effectiveness in protecting human health. Theoretically, vitrification should rate much higher for its protection of human health. However, there are concerns about the vitrification process being able to reach the 30- to 40-foot depths required for complete vitrification of Pits 3 through 6.

7.5.1.2 Protection of the Environment

This alternative was rated as average (3) for its short-term and long-term ability to protect the environment. In situ vitrification is still considered an unproven state of the art technology when applied at the depths required for Pits 3 through 6. The possibility of having unvitrified material in the pit bottoms is the reason for the lower rating.

7.5.1.3 Reduction in Toxicity, Mobility, and Volume

Theoretically, if complete vitrification of waste occurs there will be a significant decrease in toxicity, mobility, and volume. This alternative was therefore rated above average (4) based strictly

on its theoretical ability to work. If the vitrification process did not reach the full depth of the waste in the pits, the potential for contamination of the groundwater would remain.

7.5.2 Implementability

7.5.2.1 Constructability

Assuming the in situ vitrification process was technologically implementable, verification of the completeness of melt could easily present significant problems caused by the following:

- Pits containing scrap metal, drums, or rebar could prevent proper installation of electrodes and cause problems such as electrical shorts.
- Electromechanical system breakdowns may provide only a partial melt. If this occurs, vitrification may have to be reinitiated in a cooled semivitrified material. This would require re-establishing a new electrical conductance path (joule heat trench) into a partially or fully vitrified material. The process repairs may include drilling and/or air-hammer in a contained area, thus greatly increasing the exposure risks to workers.
- Final QA/QC verification for completeness of melt may require extensive and costly drilling into the solidified melt matrix.
- The vitrification process requires a large and efficiently vented off-gas collection system. In the event of vent system failure, the superheated gases would be released to the environment and workers would be exposed to various radiochemical and chemical contaminants.

For these reasons, Alternative 3 was rated below average (2) for constructability.

7.5.2.2 Reliability

Reliability for this alternative was rated below average (2) for the same reasons discussed under constructability.

7.5.2.3 Maintenance/Operation

Maintenance/operation for this alternative was rated below average (2) for the same reasons discussed under constructability.

7.5.2.4 Special Engineering and Equipment

Alternative 3 was rated below average (2) for special engineering equipment requirements. Vitrification is still considered an innovative technology and requires specialized equipment.

7.5.3 Cost

Vitrification was rated as average (3) for cost. Although lower in cost than some removal options, vitrification requires specialized equipment and an off-gas treatment system that results in higher cost than other in situ treatment alternatives. Total costs are approximately $566 million of which $500 million is capital and $66 million is O&M costs.

7.5.4 Screening Summary

In situ vitrification is an unverified technology option and is difficult to verify in field practice. Electromechanical and venting subsystem breakdowns may create both worker and environmental exposure risks that could far exceed physical stabilization risks. Therefore, in situ vitrification was given an overall rating of 24.

7.6 ALTERNATIVE 4 - REMOVAL, WASTE TREATMENT, AND ON-PROPERTY DISPOSAL

7.6.1 Effectiveness

7.6.1.1 Protection of Human Health

The short-term effectiveness of this alternative rates a 3 because this removal action involves the risk of a waste-handling accident during removal, treatment, packaging, and transportation for on-property disposal.

The long-term effectiveness of this alternative rates a 4 because although the wastes will be treated and stored in an EDF, they will be stored over a vulnerable aquifer near a major population area.

7.6.1.2 Protection of the Environment

The short-term effectiveness of this alternative rates a 3 because this removal action involves the risk of a waste-handling accident during removal, treatment, packaging, and transportation for on-property disposal.

The long-term effectiveness of this alternative rates a 4 because although the wastes will be treated and stored in an EDF, they will be stored over a vulnerable aquifer near a major population center.

7.6.1.3 Reduction in Toxicity, Mobility, and Volume

This alternative rates a 4 in this category because the wastes are physically stabilized or vitrified and placed in an EDF. However, perpetual maintenance and monitoring will be required to maintain the disposal facility.

If vitrification is used, there may be a 20 to 40 percent reduction in waste volume, and if physical stabilization is used there may be a 30 to 40 percent increase in waste volume. All percentages are preliminary estimates.

7.6.2 Implementability

7.6.2.1 Constructability

This alternative rates a 3 in this category. Although the removal methods, stabilization methods, and on-property disposal facility being considered are based on available and proven technology, the waste segregation facility subsystems (i.e., conveyor feeds and crusher/shredders) may present design and startup problems.

7.6.2.2 Reliability

This alternative rates a 3 because of its greater complexity. There is a greater probability of schedule and operational delays. Due to waste variabilities, vitrification and grout mixtures may require extensive adjustments.

7.6.2.3 Maintenance/Operation

Following implementation of the remedial action, perpetual maintenance and monitoring will be required to ensure that the objectives of the remedial actions are met. The long-term maintenance will include mowing and care of the vegetative cover over the EDF to prevent erosion and the natural vegetative succession to species whose roots could intrude into the cap. Monitoring will include groundwater and radon sampling. This alternative, better than Alternative 2, rates a 4. Less maintenance will be required to maintain the remedial action objectives for an EDF than for an in situ waste containment design. The cost of postclosure monitoring and maintenance for 30 years following closure is included in the estimate for the alternative.

7.6.2.4 Special Engineering and Equipment

This alternative rates a 3 in this category because of the relatively unique removal, segregation, and processing equipment required.

7.6.3 Cost

The total cost of this alternative is approximately $1.24 to $1.80 billion, of which $1.22 to $1.78 billion is capital cost and $20 million is long-term operating costs.

7.6.4 Screening Summary

The advantages of this alternative are its effective waste treatment and above-average, long-term effectiveness at moderate cost. Its primary disadvantages are its moderate short-term effectiveness caused by risks associated with waste treatment and the reduced implementability caused by the relative complexity of the waste treatment processes. This alternative receives an overall ranking of 31.

7.7 ALTERNATIVE 5 - REMOVAL, WASTE TREATMENT, AND OFF-SITE DISPOSAL

7.7.1 Effectiveness

7.7.1.1 Protection of Human Health

The short-term effectiveness of this alternative rates a 2 in this category because this waste removal action involves the risk of a handling accident during removal, treatment, packaging, and transportation for off-site disposal.

The long-term effectiveness of this alternative rates a 5 because after treatment and appropriate packaging, the waste would be shipped to an approved off-site waste disposal facility for permanent disposal.

7.7.1.2 Protection of the Environment

The short- and long-term effectiveness of this alternative rates the same as for protection of human health.

7.7.1.3 Reduction in Toxicity, Mobility, and Volume

This alternative rates a 5 as the waste is removed from the site.

7.7.2 Implementability

7.7.2.1 Constructability

This alternative is identical to Alternative 4 in this category.

7.7.2.2 Reliability

This alternative is identical to Alternative 4 in this category.

7.7.2.3 Maintenance/Operation

This alternative will require no perpetual maintenance or monitoring because the waste will not be stored on property. This alternative rates a 5 in this category.

7.7.2.4 Special Engineering and Equipment

This alternative is identical to Alternative 4 in this category.

7.7.3 Cost

The cost of this alternative is high, mostly for transportation. Total costs are estimated at $1.82 to $2.25 billion, all of which is capital cost because no waste is left on property.

7.7.4 Screening Summary

The primary advantages of this alternative are its excellent long-term effectiveness and nonexistent FMPC maintenance and operational costs. The primary disadvantages are the high cost and below-average, short-term effectiveness caused by waste transportation risks. This alternative receives an overall ranking of 33.

7.8 ALTERNATIVE 6 - WASTE REMOVAL, TREATMENT, ON-PROPERTY DISPOSAL, AND CAP

7.8.1 Effectiveness

7.8.1.1 Protection of Human Health

The short-term effectiveness of this alternative rates a 3 in this category because this waste removal action involves the risk of a handling accident during removal, treatment, packaging, and transportation for on-property disposal.

The long-term effectiveness of this alternative rates a 3 because the wastes will be treated before storage over a vulnerable aquifer near a major population area.

7.8.1.2 Protection of the Environment

The short-term effectiveness of this alternative rates a 3 because this removal action involves the risk of a waste-handling accident during removal, treatment, packaging, and transportation for on-property disposal.

The long-term effectiveness of this alternative rates a 3 because the wastes will be treated before storage over a vulnerable aquifer near a major population area.

7.8.1.3 Reduction in Toxicity, Mobility, and Volume

This alternative rates a 3 because the wastes are physically stabilized and/or vitrified and placed in an EDF. In addition, the contaminated soils remaining in place will be capped to further reduce the mobility of the contamination. However, perpetual maintenance and monitoring will be required to maintain the disposal facility.

Vitrification may cause a 20 to 40 percent reduction in waste volume, and physical stabilization may result in a 30 to 40 percent increase in waste volume. All percentages are preliminary estimates.

7.8.2 Implementability

7.8.2.1 Constructability

This alternative rates a 3 in this category. Although the removal methods, stabilization methods, and on-property disposal facility being considered are based on available and proven technology, the waste segregation facility subsystems (i.e., conveyor feeds and crusher/shredders) may present design and startup problems.

7.8.2.2 Reliability

This alternative rates a 3 because of its great complexity. There is a greater probability of schedule and operational delays due to waste variabilities and the time required for vitrification and grout mixing.

7.8.2.3 Maintenance/Operation

Perpetual maintenance and monitoring will be required to ensure that the remedial action objectives continue to be met. The long-term maintenance will include mowing and care of the vegetative cover of the cap to prevent erosion and the natural vegetative succession to species whose roots could intrude into the cap. Monitoring will include groundwater and radon sampling. The cost of this postclosure monitoring and maintenance is included in the cost estimate for the alternative. This alternative rates a 3 in this category.

7.8.2.4 Special Engineering and Equipment

This alternative rates a 3 in this category because of the relatively unique removal, segregation, and processing equipment required. In addition, because vitrification is still considered an innovative technology, specialized equipment will be required.

7.8.3 Cost

This alternative prescribes waste treatment by vitrification and stabilization as well as waste storage in an on-property EDF. The contaminated soils around and below the pits are to remain in place and are to be covered by a closure cap. As previously acknowledged, waste treatment by vitrification and stabilization will be moderately costly because of the specialized equipment and off-gas treatment system required for these technologies. Coupled with the building of an on-property storage facility and a closure cap, the cost for this alternative is higher than the cost of Alternatives 1 through 4. The costs are estimated to be $1.44 billion, of which $1.35 billion is capital cost and $86 million is long term O&M.

7.8.4 Screening Summary

The advantages of this alternative are its effective waste treatment and long-term effectiveness. Likewise, the primary disadvantages of this alternative are its moderate short-term effectiveness caused by risks associated with waste treatment and the reduced implementability caused by the relative complexity of the waste treatment processes. The cost of this alternative, as previously mentioned, is expected to be slightly higher than most of the other alternatives. This alternative receives an overall ranking of 27.

7.9 ALTERNATIVE 7 - WASTE REMOVAL, TREATMENT, ON-PROPERTY DISPOSAL, SOIL TREATMENT AND CAP

7.9.1 Effectiveness

7.9.1.1 Protection of Human Health

The short-term effectiveness of this alternative rates a 3 because this removal action involves the risk of a waste-handling accident during removal, treatment, packing, and transportation for on-property disposal. Vitrification of the waste could theoretically increase the previously mentioned rating because of its protection of human health.

The long-term effectiveness of this alternative rates a 4 because the wastes will be treated before storage.

7.9.1.2 Protection of the Environment

Because of the potential of a waste-handling accident during the removal, treatment, packaging, and transporation for on-property disposal, the short-term effectiveness of this alternative rates a 3.

Because the waste will be treated before storage, the long-term effectiveness of this alternative rates a 4.

7.9.1.3 Reduction in Toxicity, Mobility, and Volume

The treatment technologies used in this alternative will contain the hazardous material in a monolith or in a vitreous mass that will be stored in an EDF thus permitting a rating of 4 for this alternative. However, perpetual maintenance and monitoring will be required to maintain the disposal facility.

The use of vitrification in this alternative may reduce the volume of the treated material by 20 to 40 percent. The use of the stabilization/solidification technology may increase the waste volume by 30 to 40 percent. All percentages are considered preliminary estimates.

7.9.2 Implementability

7.9.2.1 Constructability

This alternative rates a 3 in this category. Although the removal methods, stabilization methods, and on-property disposal facility being considered are based on available and proven technology, the waste segregation facility subsystems (i.e., conveyor feeds and crusher/shredders) may present design and startup problems.

7.9.2.2 Reliability

Because of the greater complexity of this alternative, this catagory is given a rating of 3. There is a greater probability of schedule and operational delays. Extensive adjustments may be required because of the variabilities within the waste that will affect the vitrification and solidification technologies.

7.9.2.3 Maintenance/Operation

This alternative is identical to Alternative 4 in this category.

7.9.2.4 Special Engineering and Equipment

This alternative rates a 3 in this category because of the relative unique removal, segregation, and processing equipment required.

7.9.3 Cost

Vitrification was rated as medium for cost. Although lower in cost than some removal options, vitrification requires specialized equipment and an off-gas treatment system that results in higher costs than other in situ treatment alternatives. The total cost for this alternative is $1.68 billion of which $1.60 billion is capital and $86 million for long-term O&M.

7.9.4 Screening Summary

The SSM technology will solidify/stabilize the wastes in Pits 5 and 6 and the Clearwell. This alternative meets the RAOs of preventing ingestion or contact with the wastes, preventing the release of airborne contamination and radon gas from the wastes, and mitigating migration to surface and groundwater.

In situ vitrification is an unverified technology option and is difficult to verify in field practice. Electromechanical and venting subsystem breakdowns may create both worker and environmental exposure risks that could far exceed physical stabilization risks.

The capping in this alternative will significantly reduce the mobility of the contaminants by effectively minimizing the infiltration of rain water through the pit wastes. This alternative recieves an overall ranking of 30.

7.10 ALTERNATIVE RANKING

Based on the results of the alternative evaluation just conducted, a ranking of the alternatives was performed. It is important to note that the evaluation criteria were applied equally to all of the alternatives; therefore, the alternative rankings are not weighed. The results of this ranking are shown in Table 7-1.

8.0 ALTERNATIVES RETAINED FOR DETAILED ANALYSIS

8.1 PRESENTATION OF ALTERNATIVES RECOMMENDED FOR DETAILED ANALYSIS

In Section 7.0, the alternatives were formally ranked according to their ability to meet the general screening criteria. The results of that ranking show that the five screened alternatives achieved relatively similar scores. Because of the relatively close scores of the alternatives in this ranking process, the alternatives listed below are recommended for further development and refinement in Task 13, Detailed Analysis of Alternatives:

- Alternative 2 Nonremoval - Physical Stabilization, Slurry Wall, and Cap
- Alternative 4 Removal - Waste Treatment and On-Property Disposal
- Alternative 5 Removal - Waste Treatment and Off-Site Disposal
- Alternative 6 Removal - Waste Treatment, On-Property Disposal, and Cap
- Alternative 7 Removal - Waste Treatment, On-Property Disposal, Soil Treatment, and Cap

Alternative 0 (No Action) will also be included in the detailed analysis of alternatives as a baseline alternative. In Section 4.0 the following alternatives were removed from further consideration because of concerns about technology implementability and reliability:

- Alternative 1 Nonremoval - Slurry Wall and Cap
- Alternative 3 Nonremoval - In Situ Vitrification and Cap

See Figure 8-1 for the Operable Unit 1 postscreening response actions.

8.2 DETAILED ANALYSIS OF ALTERNATIVES (TASK 13) PREVIEW

The detailed analysis of alternatives follows the development and screening of alternatives and precedes the selection of a preferred remedial action (denoted Task 14). The screened alternatives will be refined to provide greater detail and accuracy based on the results of additional analysis, treatability studies, and site characterization. During the detailed analysis, each alternative will be assessed against the criteria below:

- Overall protection of human health and environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction in toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

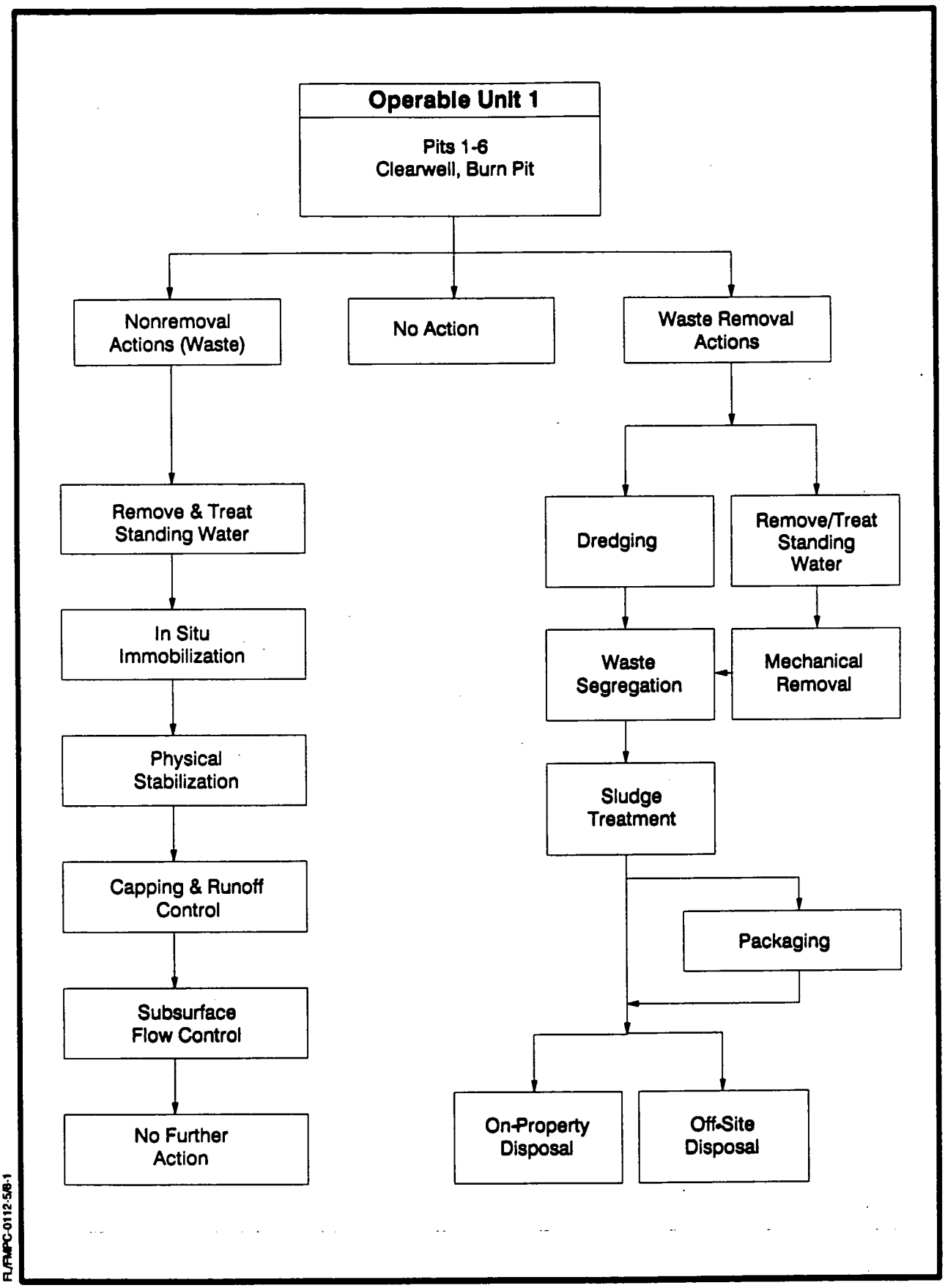

FIGURE 8-1. SCREENED RESPONSE ACTIONS FLOW CHART

This approach to analyzing alternatives is designed to provide decision makers with sufficient information to adequately compare the alternatives, select an operable unit remedy, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD).

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APPENDIX A

DESCRIPTION OF TECHNOLOGIES AND PROCESS OPTIONS

A.1.0 DESCRIPTION OF TECHNOLOGIES AND PROCESS OPTIONS

A.1 INTRODUCTION

The following description of potentially applicable technologies and process options is presented in alphabetical order.

A.1.1 Capping (Infiltration Capping)

The capping specified for this alternative is a multiple-layer design that minimizes the vertical infiltration of storm water through the Operable Unit 1 area. Because of extended service life requirements, no synthetic materials such as flexible membrane liners (FML) or geotextiles may be incorporated into the design except to facilitate construction.

Before cap construction, clean fill soils will be placed and contoured to provide long-term cap support and to minimize any potential future settlement problems. The multiple-layer cap design will consist of the following elements:

- Clay layer

  A four-foot minimum thickness, compacted clay layer with a verified 1×10^{-7} cm/s permeability will be placed over the fill soils. Because FMLs are excluded from the design, the proposed clay layer is 24 inches thicker than that specified under Title 40 of the Code of Federal Regulations (CFR) 264. This additional thickness will provide greater long-term resistance to stress-induced cracking and potential vegetative root attack, thereby minimizing the possibility of water migration through the clay layer. Caps must also meet the requirements set forth in 40CFR61 Subpart Q, and 40CFR192 for control of radon through the clay layer. The cap must be constructed with enough erosion resistance to provide reasonable assurance of containment of radioactive waste and radon for 1000 years.

- Drainage layer

  A two-foot-thick drainage layer with a 1×10^{-3} cm/s minimum permeability will be placed over the clay and consist of two 1-foot-thick layers. The upper layer will be a graded natural aggregate filter protecting the lower drainage layer from clogging. Although more costly to procure and install than the typical Resource Conservation and Recovery Act (RCRA) geotextile filter fabric, the all-natural drainage layer will alleviate concerns over long-term material durability, as well as improving the overall drainage layer performance including:

  - Reducing the hydraulic driving forces acting on the clay layer by more timely removal of water percolating through the vegetative cover

  - Balancing the moisture content of vegetative and clay layers against seasonal extremes, including drought

- Providing an intrusion barrier to protect the clay layer against deep-rooted plants and burrowing animals

- Vegetative layer

  The two-foot-thick vegetative layer placed over the drainage layer shall be composed of common clean soils with the upper three-inch thickness capable of supporting a hardy, persistent growth, shallow-rooted (zero root density at 12 inches deep) grass crop.

  The vegetative layer protects the clay layer against environmental abrasion including desiccation, freeze/thaw damage, erosion, and hydraulic-induced-stresses caused by standing or ponding water. The vegetation on the surface should be maintained to preclude old field succession.

All cap layers will be contoured to grades that promote drainage while minimizing the effects of waste subsidence and storm water erosion. In addition, based on the extremely long half-lives of various radionuclides present in the waste, 10CFR40 Appendix A will be used in determining cap thickness.

Present non-RCRA regulatory criteria, such as 10CFR61.7(b)(5), and engineering practices require designs that minimize both maintenance and storm water infiltration, as well as providing structural longevity for intrusion barrier purposes in excess of 500 years.

A.1.2 Clarification

Clarification is also known as sedimentation and involves the separation of suspended solids from a liquid by gravity. It has no effect on the dissolved solids.

Clarification can either be used as a pretreatment technique to remove suspended organic or inorganic contaminants before downstream processing or as a final polishing step to produce a high quality effluent suitable for direct discharge. Solids separation is usually enhanced by flocculation. Clarification can be performed in large tanks or pits (preferably with a sloped bottom) or in package equipment supplied by vendors.

Clarification will not reduce the hazards associated with the solids, but it will reduce their volume. The sludge and wastewater produced by clarification will probably have to be treated further. No adverse environmental effects would be expected from this process. Clarification is a common process that can be included in the wastewater treatment system. In fact, some clarification of the wastewater in pits and lagoons has probably already occurred.

A.1.3 Dynamic Compaction

Dynamic compaction involves dropping 5- to 40-ton weights from heights of 20 to 100 feet, resulting in compaction of surface and subsurface soils. A large-capacity crane repeatedly lifts and releases the weight at one location before moving on to the next location.

This technology has been proven very effective in treating all types of soils, even at 60-foot depths, and has been shown to be extremely cost-effective. The technique will generate various depth craters dependent on the subsurface conditions. To minimize the potential of contaminate release into the surface environment, a thick soil blanket (approximately four or five feet) is placed over the treatment area. The following support activities would be required before the start of any compaction effort:

- Carry out studies to confirm the technology's abilities
- Remove and treat free-standing water
- Evaluate and implement groundwater control measures

Groundwater control measures will be implemented during soil compaction activities. The groundwater control measures will include dewatering prior to compaction and leachate collection during compaction. The dewatering will be accomplished by a variety of means including well points and/or interceptor trenches. In addition to the dewatering measures it should be noted that intergranular pore pressure in the soil below the compaction zone lends to redirect free liquids to the surface of the compacted material and not downward into the aquifer.

After treatment, the soil blanket will be contoured and a RCRA-type cap constructed. Groundwater control measures will be installed to make each dynamically compacted area an environmentally secure and permanent waste disposal unit.

A.1.4 Filtration

Filtration is a method for separating solids from a liquid. The stream to be filtered passes through a media that allows the liquid to pass through while trapping the solids.

Filtration is commonly used in water treatment plants for solids removal. It can be performed in pressure filters, vacuum filters, gravity filters, bag filters, or cartridge filters. Pressure filtration is typically used for dewatering sludges and reducing transportation and disposal costs. The feed to

the pressure filter may have to be conditioned and thickened with inorganic chemicals. Bag and cartridge filters are typically used to provide additional treatment to effluent water before final discharge. Filtration typically produces filter cakes that contain 20 to 50 percent solids.

Filtration usually provides a better separation of solids from water compared to clarification. Filtration will not reduce the hazard associated with the insoluble wastewater constituents, but it will reduce their volume. The filter cake can be treated with the other sludges. The wastewater may have to be treated further.

There are no environmental concerns associated with filtration except the disposal of any hazardous sludge generated. Filtration is a commonly used unit operation and can be cost-effective.

Filtration is a solids/liquid separation operation that may be used as part of the waste treatment process. Filtration is unlikely to be a cost-effective volume reduction technique for the semisolid sludges, but it may be used to remove low levels of solids from wastewater or to reduce the volume of sludges produced by clarification processes.

A.1.5 Flocculation

Flocculation is the coagulation of small colloidal suspended solids into larger particles to allow relatively easier separation from the wastewater.

Flocculation is primarily a physical process and will help remove only the suspended solids and will not affect the dissolved solids. Typically, chemicals such as alum, ferric chloride, and high molecular weight polymeric compounds are added to help agglomerate the particles. More than one flocculent is normally used for removing inorganics in conjunction with neutralization/precipitation and clarification/filtration. Typically, laboratory-scale bench settling tests are required to select type and dosage of flocculent.

Flocculation could be a part of a system to remove the suspended solids from wastewater. Flocculation will not reduce the hazard associated with the solids, but it will facilitate their subsequent treatment and disposal. The wastewater may have to be treated further before discharge. The sludge could be processed with the other sludges for disposal. Significant adverse environmental impacts should not result from this process if the flocculent is properly handled and stored. Flocculation costs are usually relatively low. However, depending on the type and/or dosage of flocculent used, the costs can be high.

A.1.6 Hydraulic Removal/Dredging

Hydraulic removal/dredging uses properly selected and designed pumps, with material dislodging mechanisms, drivers, suction and discharge line, all included in a site-specific, self-contained package.

Hydraulic removal/dredging is generally limited to excavating slurries containing 10 to 20 percent solids by weight. It offers flexibility in pumping the slurry/sediment a considerable distance (several thousand feet) to a designated treatment/storage area.

By combining the capabilities of plain suction, cutterhead, and portable dredges, a site-specific pretested hybrid unit can be ordered to pump a slurry with a larger percentage of solids. Similar units have been built in the past and have a dredging depth capacity of 10 to 50 feet.

This dredging method cannot be used for the removal of 55-gallon drums or other similar, nonsludge wastes. Therefore, mechanical removal methods would be employed to complete waste removal by excavation. Hydraulic dredging is appropriate for Pits 5 and 6 and the Clearwell because of the standing water. Its use on other pits would require the addition of large quantities of water after the cover material has been mechanically removed.

A.1.7 Ion Exchange

Ion exchange is a process in which certain dissolved ions are removed from water by exchanging them with other (counter) ions held by an insoluble solid (resin). Ion exchange resins are typically polymer beads that have been modified by the addition of chemical groups which attract various ionic species. The resins can be regenerated for reuse with a strong solution of the exchangeable counter ion. Resin types range from general purpose demineralization resins that remove nearly all salts to selective chelating resins that have high affinities for specific ions.

Ion exchange is used extensively for water and wastewater treatment. It is used also for treatment of a variety of industrial wastes to allow for the recovery of materials or by-products. Additionally, ion exchange has been used in waste treatment for removal and recovery of radioactive materials from contaminated streams. It is usually used to remove low levels of ionic species (generally between 100 and 500 ppm) and is not cost-effective at higher concentrations. Treatment of water with ion exchange can achieve very low effluent concentrations of contaminants.

Ion exchange may be used as a final treatment to remove trace metals and radionuclides from dilute wastewater. The resins may be used once and disposed of or they may be regenerated, which will produce a concentrated waste stream for treatment and disposal; the concentrated regenerate may be treated with the sludge. Ion exchange is an easily implemented, reliable, commercial technology. Treatment cost is moderately expensive and will depend on the type of resin employed and the quantity of the various ionic species removed from the wastewater.

A.1.8 Mechanical Removal

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

  Backhoes have limited lateral and vertical reaches that can be improved by using an extended reach and depth machine. They are capable of excavating almost any type of material.

  Material transport and support equipment are required for a successful operation.

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

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

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

  Crawler-mounted loaders can be good excavators and used to carry material as far as 300 feet. Medium-sized crawler-loaders typically have maximum bucket capacities of 5 to 6 cubic yards. Rubber-tire-mounted loaders for high production operations on

stable surfaces have bucket capacities up to 20 cubic yards. Usually front-end loaders are used in combination with excavation equipment like backhoes.

- Dragline - A dragline is similar to a clamshell and is also a crane-operated device that would be crawler-mounted for this application. The primary difference is that a dragline bucket is loaded by being pulled across the material, whereas the clamshell is dropped into the material and hoisted vertically. A dragline can be used to excavate many types of materials.

  The dragline has a longer reach than a clamshell and better horizontal control. It has a greater potential of hoisting material and may require a specially designed bucket.

A.1.9 On-Property Disposal Facility

An on-site tumulus or aboveground waste disposal facility could be constructed for the disposal of the waste material. The proposed tumulus disposal concept basically consists of mounding over waste that has been placed on a stable structural pad. The aboveground structure is a reinforced vault-like concrete structure designed for permanent waste disposal. Both the tumulus and the aboveground structure will accept only dry waste placed in noncorrosive containers and/or highly stabilized/solidified waste forms. The following design(s) are being considered:

- Tumulus Design (Figure A-1)

  - RCRA-type closure cap with leachate collection/detection systems (LC/DS) and roller-compacted concrete intrusion barrier

  - Cap thickness, including fill cover over the waste forms, will be based on the five-meter criterion per 10CFR61.

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

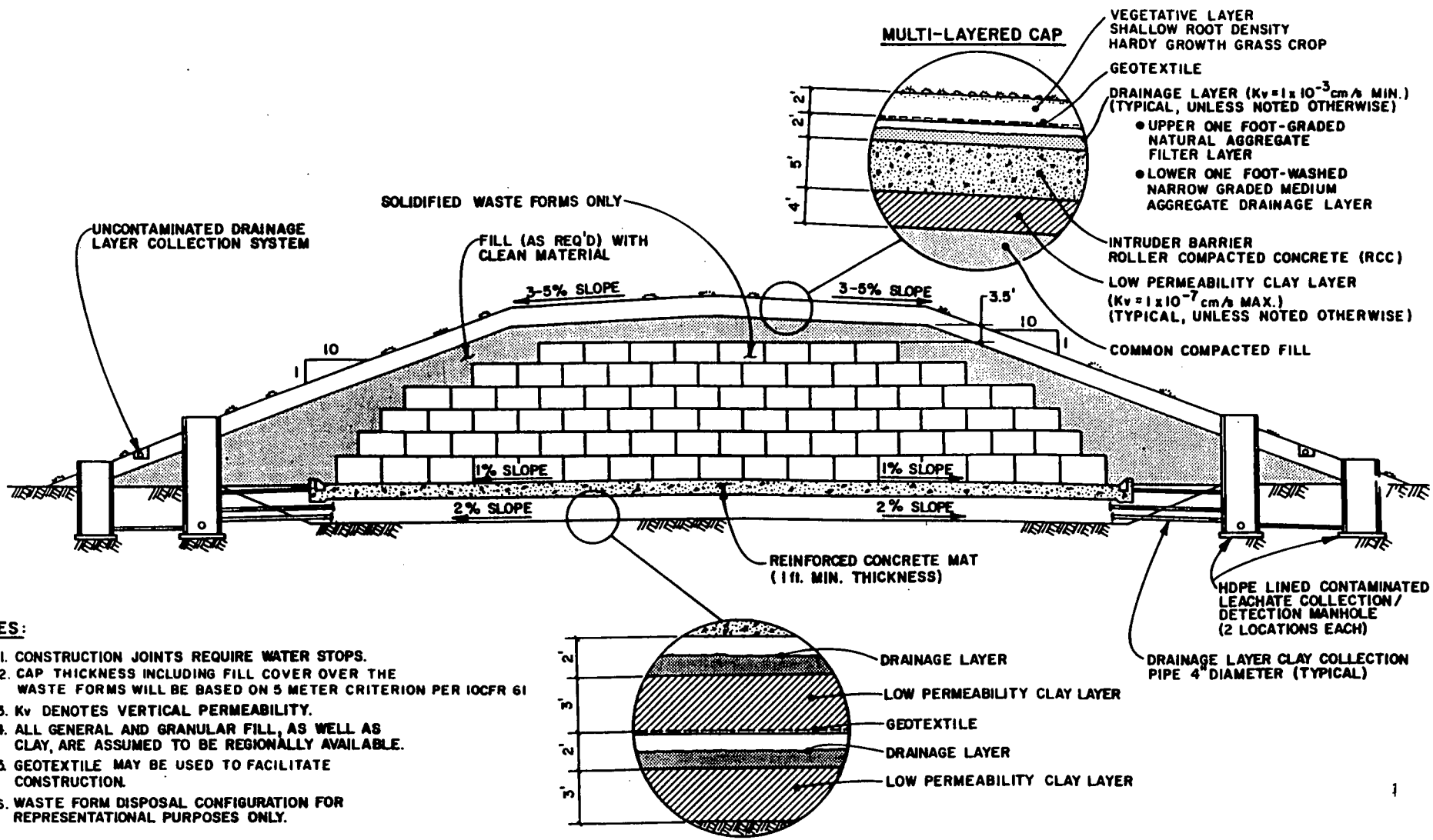
- Aboveground Structure

  - Designs 1A and 1B - The vault is constructed directly on grade (Figure A-2)

    (a) Design 1A with a liner system including LC/DS
    (b) Design 1B is without the secondary leachate collection system or the high density polyethylene (HDPE) liner (only a primary leachate collection system).
    (c) A RCRA-type cap can be placed over the closed structure

  - Designs 2A and 2B - The vault is constructed with the structural support slab placed six feet over grade using an extended height reinforced concrete foundation (Figure A-3).

    (a) Design 2A with a liner system including LC/DS
    (b) Design 2B is without the secondary leachate collection system or the HDPE liner (only a primary leachate collection system)
    (c) A RCRA-type cap can be placed over the closed structure



NOTES:

1. CONSTRUCTION JOINTS REQUIRE WATER STOPS.
2. CAP THICKNESS INCLUDING FILL COVER OVER THE WASTE FORMS WILL BE BASED ON 5 METER CRITERION PER 10CFR 61
3. Kv DENOTES VERTICAL PERMEABILITY.
4. ALL GENERAL AND GRANULAR FILL, AS WELL AS CLAY, ARE ASSUMED TO BE REGIONALLY AVAILABLE.
5. GEOTEXTILE MAY BE USED TO FACILITATE CONSTRUCTION.
6. WASTE FORM DISPOSAL CONFIGURATION FOR REPRESENTATIONAL PURPOSES ONLY.

NOT TO SCALE

FIGURE A-1. TUMULUS SECTION

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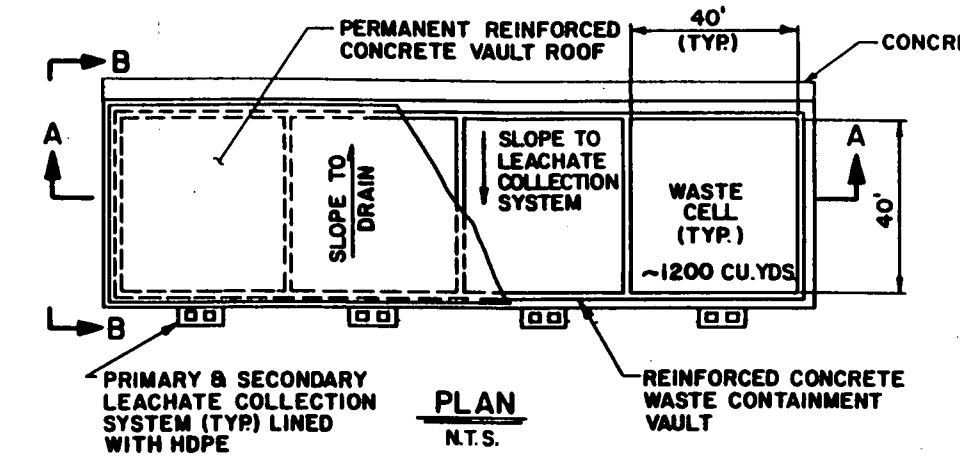
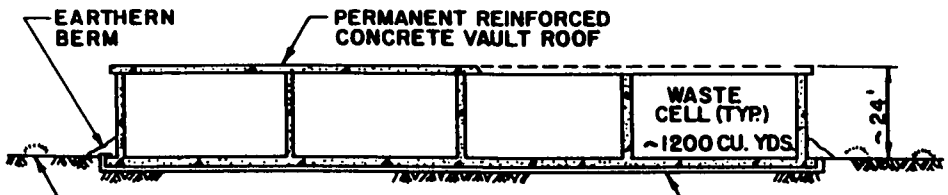
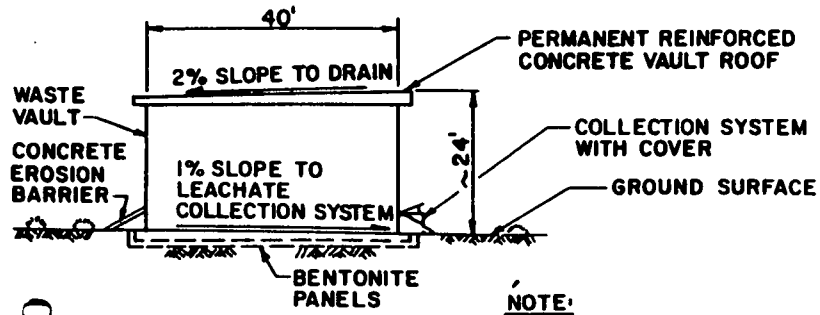
(10-3-90) UIT12



PLAN
N.T.S.

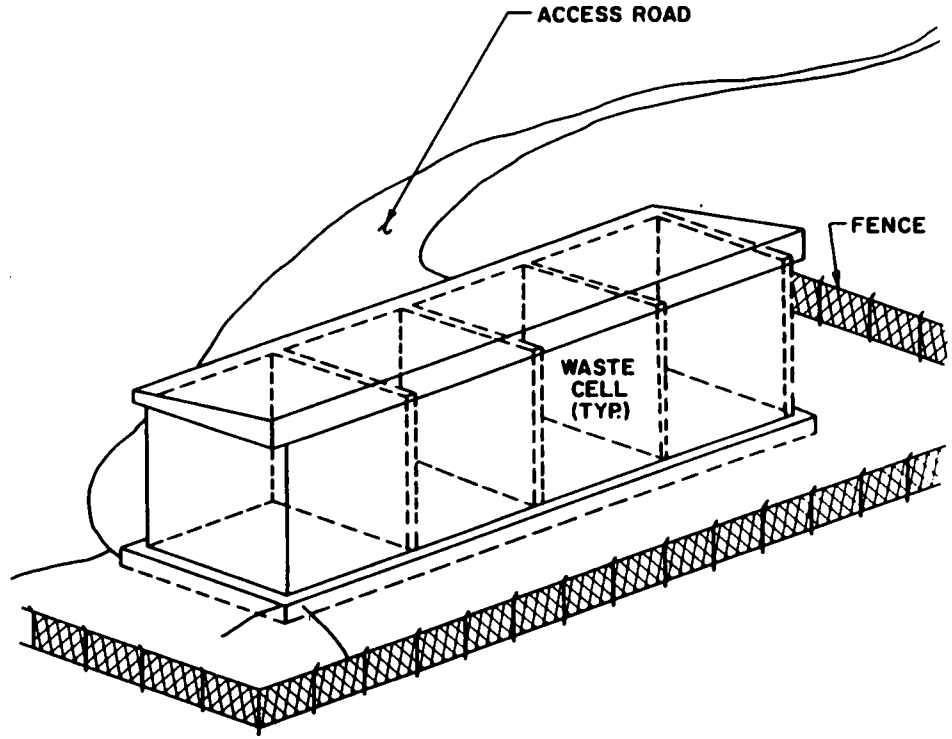


SECTION A-A
N.T.S.



SECTION B-B
N.T.S.

NOTE:
ELEVATION VIEW ENLARGED TO SHOW ROOF SLOPE



NOTES:

1. DURING WASTE PLACEMENT OPERATION, USE A TEMPORARY STEEL COVER WITH TIE DOWNS FOR ENVIRONMENTAL & VECTOR CONTROL.
2. DOUBLE LINERS WITH LCDS NOT SHOWN.
3. THIS DESIGN WITH SLIGHT MODIFICATION CAN RECEIVE WASTE USING FORKLIFT, CONVEYOR OR "WASTE CRETE" PUMPED DIRECTLY INTO THE CELLS.
4. ALL EXPOSED EXTERIOR SURFACES TO RECEIVE WATERPROOF COATING.

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FIGURE A-2. GREATER CONFINEMENT DISPOSAL VAULT FACILITY (GCD)

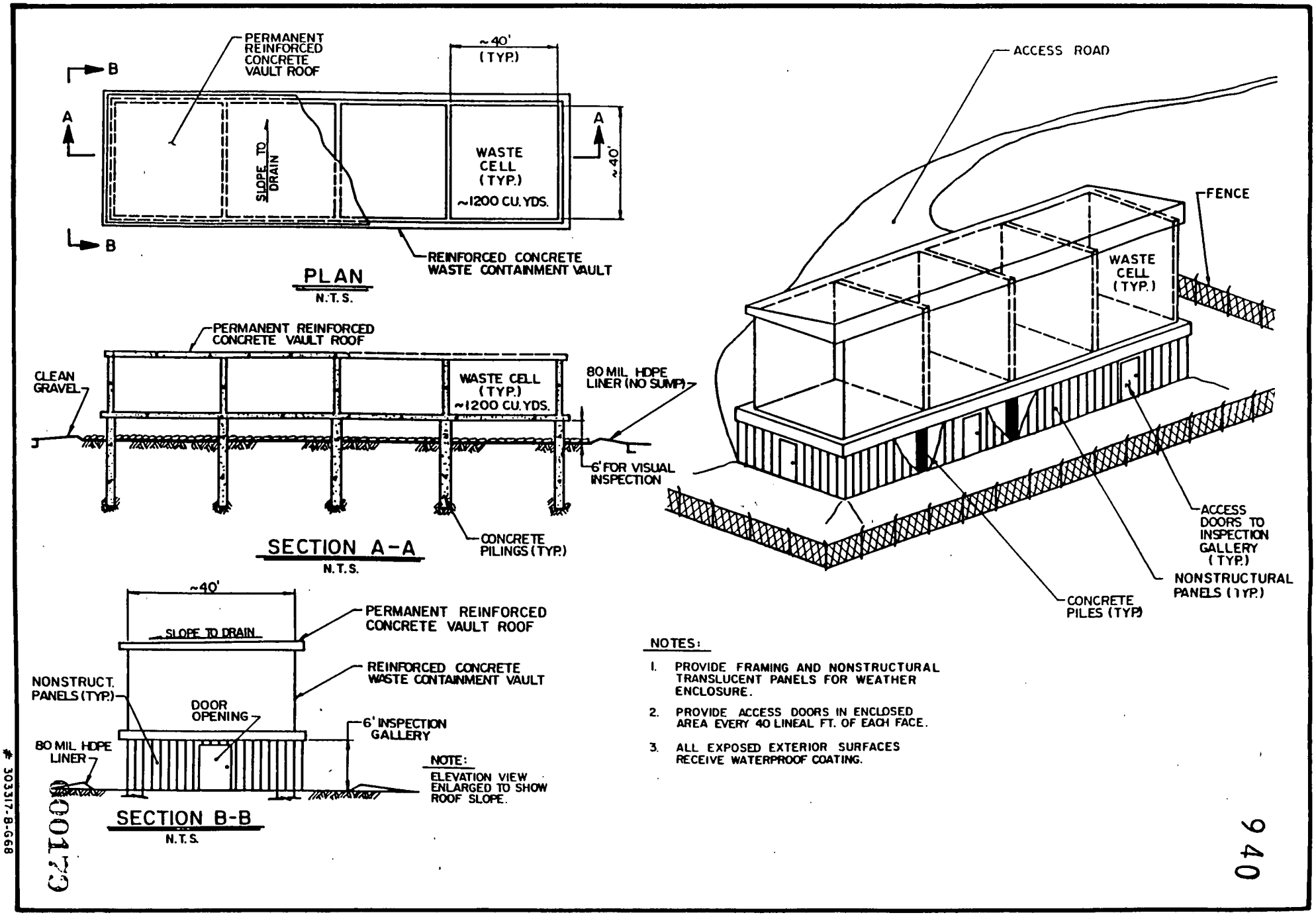

FIGURE A-3. GCD WITH STRUCTURAL SLAB AND VAULT PLACED ABOVE GRADE

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(5-23-90) U1 T12
0001173

As a condition of placement, no untreated (wet, raw) waste or free liquids will be accepted for disposal in any on-property disposal facility. After treatment the resulting waste form may be placed in bulk and/or containerized as follows:

- Dry (having a moisture content less than 15 percent by dry weight basis) placed in a noncorrosive, structurally adequate container
- Pumpable, self-leveling, setable grout/waste mix; this grout/waste mix will be termed "waste crete"

As with all on-property disposal technologies, a properly designed site, as well as regularly scheduled monitoring and facility maintenance programs will be required in perpetuity.

A.1.10 Packaging/Transportation

Shipment of wastes off site must meet the U.S. Department of Transportation's (DOT) stringent packaging requirements for radioactive materials. DOT in 49CFR provides a number of general categories under which radioactive material may be shipped. Within the possible shipping designations allowed in the DOT regulations, there are four which apply to the waste pits (with certain restrictions):

- Limited quantities
- Low specific activity (LSA) material
- Type A package quantities
- Type B package quantities

Under each of these categories, the Operable Unit 1 residues will be specified as "normal form" because they have not been tested to meet the requirements of 49CFR173.469.

A.1.10.1 Limited Quantities

The term "limited quantities" of radioactive material is a designation for shipping the least restricted articles and the smallest quantities of radioactive material. Generally, items such as radioactive watches, clocks, and smoke detectors are shipped under this category. Although the waste pit residues could be made to conform to the restrictions of this classification, it would not be practical. This classification places a restriction on the activity level allowed in each shipping container and because of the assumed concentrations of thorium-230 found in the wastes, it would require an inordinate number of packages to ship the wastes. The logistics of taking inventory and accounting for this number of packages alone renders this shipping classification unsuitable for the shipping of the pit wastes.

A.1.10.2 Low Specific Activity

The advantage to shipping radioactive material as low specific activity (LSA) is to gain exemptions from using specification packaging (i.e., Type A, Type B, etc.). Whereas the other packaging and shipping classifications place a limit on the curie content of a package, the LSA classification places a limit on the specific activity of the contents of each package.

Pit waste will have to meet the restrictions of 49CFR173.403(n)(4) which states: "Material in which the radioactivity is essentially uniformly distributed and in which the average concentration of the contents do not exceed:

(i) 0.0001 millicurie per gram of radionuclides for which the A_2 quantity is not more than 0.05 curie
(ii) 0.005 millicurie per gram of radionuclides for which the A_2 quantity is more than 0.05 curie, but not more than 1 curie
(iii) 0.3 millicurie per gram of radionuclides for which the A_2 quantity is more than 1 curie."

Note: "A_2" is the maximum activity of radioactive material, other than special form or low specific activity radioactive material, permitted in a Type A package.

In order to apply this definition it must be noted that 49CFR173.433(b)(3) states that "In the case of a mixture of different radionuclides, where the identity and activity of each radionuclide is known, the permissible activity of each radionuclide R_1, R_2, ...R_n must be such that $F_1 + F_2 + ... + F_n$ is not greater than unity, when:

$$F_1 = \frac{\text{Total activity of } R_1}{A_i(R_1)}$$

$$F_2 = \frac{\text{Total activity of } R_2}{A_i(R_2)}$$

$$F_n = \frac{\text{Total activity of } R_n}{A_i(R_n)}$$

where $A_i(R_1, R_2,...R_n)$ is the value of A_1 or A_2 as appropriate for nuclide R_1, R_2,...R_n."

Note: "A_1" is the maximum activity of special form radioactive material permitted in a Type A package.

What all of the foregoing means for Operable Unit 1 is that the radionuclides in the decay chain present in the pits will have to be divided into three categories: those with an A_2 value equal to or less than 0.05 curies, those with an A_2 value greater than 0.05 but not more than 1 curie, and those with an A_2 value greater than 1 curie. Then, using the above formula, the maximum activity concentrations may be calculated to determine packaging requirements.

A.1.10.3 Type A Quantities

The pit residues can be shipped in Type A packaging that requires the activity level in each package not to exceed the A_2 value for the radionuclide of concern. 49CFR173.412 lists the design and performance specifications for Type A packaging. Type A packages are designed to more stringent requirements than LSA packages and are typically used for the packaging of materials with greater levels of radioactivity. Type A containers are generally more expensive than LSA containers.

Because of the activity levels of the pit residues and the package activity level restrictions for Type A packages the wastes would require an inordinate number of packages. As in the Limited Quantities discussion, the logistics for storing and accounting for a large quantity of packages would be prohibitive.

A.1.10.4 Type B Quantities

Type B packaging is required for all wastes that exceed Type A packaging requirements. 10CFR71.51 lists the design and performance requirements for Type B packages. Type B packaging is constructed to much higher standards than either Type A or LSA packaging and is therefore much more expensive.

Generally, shipments of Type B quantities are made in a primary disposable container that is placed in a Type B overpack for transportation purposes only. The main advantages to Type B shipments are the use of larger packaging and reduction of risk during shipment because of the higher grade packaging. The main disadvantages are cost, increased number of truck trips, and use of Type B overpacks.

A.1.1.1 Precipitation

Precipitation is the removal of metals and other components from wastewater by chemical addition and adjustment of pH to a point where the various species exhibit minimum solubilities.

The most commonly used precipitation technique is pH adjustment with alkaline materials (e.g., caustic soda, soda ash, and lime) or sulfides. The insoluble compounds that precipitate can be removed from the wastewater by flocculation, clarification, and filtration. Coagulants such as alum, ferrous sulfate, or ferric chloride are also used to facilitate metals removal. Precipitation typically produces an effluent with 0.1 to 1.0 parts per million (ppm) metals, and the watewater may require additional treatment to meet discharge criteria. Problems are encountered when ammonia levels are high or chelating and when complexing agents are present in the wastewater.

Most of the metals are concentrated in the sludge, and the wastewater is relatively low in heavy metals such as zinc, uranium, and thorium. Additional lime or caustic soda treatment is unlikely to be effective. Sulfide precipitation may be more effective but still not adequate to meet stringent discharge requirements. Sulfide precipitation can have some potential environmental problems. A sulfide reagent coming into contact with an acidic waste stream can result in the evolution of toxic hydrogen sulfide fumes. Another potential problem for processes discharging to enclosed sewers if the danger associated with residual levels of sulfide in the wastewater. In addition, all precipitation processes generate a solid sludge, which may be hazardous and must be disposed of properly. Precipitation is a proven commercial technology, and the costs for this technique are low. However, bench-scale tests would be necessary to confirm this option.

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A.1.12 Reverse Osmosis

Reverse osmosis (RO) involves diffusion of water through a semipermeable membrane with applied pressure. It is a separation process that can retain particles (including dissolved species) as small as 1 to 10 Angstroms.

Historically, RO has been associated with removal of salts and inorganic compounds from brackish water. Unlike water, salts and other contaminants cannot pass through the semipermeable membrane and are concentrated. The degree of concentration depends on the pressures on the membrane. Membranes can foul, thus reducing treatment rate. This situation happens if the solubility limit of any of the salt species in wastewater is exceeded; chemical reagents known as sequestrants can be added to reduce this effect.

RO might be used to concentrate the salts in the wastewater. Calcium sulfate fouling can be a problem in treating most of the Feed Materials Production Center (FMPC) wastewaters. RO will not reduce the hazards associated with the salts but will facilitate their subsequent treatment and disposal. Adverse environmental effects should not result from this process. RO can be implemented with commercially available process equipment; costs are moderate compared to other wastewater treatment processes.

A.1.13 Shallow Soil Mixing

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

Characterization Investigation Study (CIS) data indicated Pits 5 and 6 and the Clearwell exclusively contain sludges from plant production and/or site surface soil sediments, whereas Pits 1 through 4 and the Burn Pit contain large quantities of drums, construction rubble, and miscellaneous site debris. Therefore, SSM, as a stabilization technology, will be applicable only to Pits 5 and 6 and the Clearwell.

The SSM system has the advantages of a negative head pressure, treatment of any off-gases and/or dust, waste treatment by stabilization chemicals that can be correctly proportioned during mixing operations, and operable to mixing depths of 30 feet or more. Therefore, SSM shall be retained as a viable technology for in situ waste stabilization in Pits 5 and 6 and the Clearwell.

A.1.14 Sludge Treatment Options (Sludge Processing By In Situ Vitrification)

Most of the sludges to be treated are composed of lime and soils, with contamination by radioactive and nonradioactive metals as well as some organics. The materials in some of the pits and ponds do not have sufficient load-bearing capacity to support the equipment that is to be used during in situ treatment. The first step for in situ treatment, therefore, is to prepare an adequate surface over which equipment may be moved. This is done using various surface stabilization methods that include vibratory settling, sand or cement addition, and compaction.

In situ vitrification involves adding sand to sludges, placing electrodes into the pit, and then electrically heating the sand/sludge mixture to form a glass-like monolith. This glass has low leachability and will not allow the migration of contaminants from the pit. A hood is placed over the pit during this process to collect off-gas generated by the heating.

Off-gas generated during in situ vitrification is treated by an air pollution control device such as a scrubber. The scrubber will generate a contaminated wastewater stream that must be treated before discharge. Treatment of this water will be done using one of the water treatment strategies described in other process options. Wastewater treatment could be done using a portable unit to remediate a single sludge pit. It could also be done at a centralized facility designed to handle a wide variety of wastewaters from remedial actions at various locations around the facility.

The vitrified wastes can be left in place. They will be highly resistant to leaching and have the best long-term stability of any waste form. The vitrified waste can be capped with clay or soil for aesthetic purposes.

A.1.15 Sludge Treatment Options (Sludge Removal, Drying, and/or Vitrification)

Sludges will be removed from the sites using one of the techniques described in the "sludge removal" technologies and will be delivered to a sludge treatment facility. For sludges containing low levels of organics, the necessary treatment should prevent leachate formation and/or contaminant migration at the disposal site. This will be accomplished by sludge drying or vitrification. Some sludges may be disposed after sludge drying alone, whereas others may require further treatment by vitrification.

The sludge-drying process includes dewatering in a filter press or centrifuge. Wastewater from this process will be discharged to one of the wastewater treatment systems installed at the facility. Dewatered sludge will then be dried further using a thermal dryer. This unit uses heat to evaporate water until the sludge is in a dry solid form. Sludges containing organics must be processed with off-gas collection and treatment systems.

If vitrification is necessary, the dried sludge could be placed in typical glass melting equipment or a reactor with sand and fluxing agents and heated with electrodes. The sludge is melted and contaminants bound into a glass-like substance that prevents leaching out of the material. The vitrification process generates off-gas that requires treatment by a unit such as a scrubber. The scrubber will generate a wastewater stream that will be sent to a wastewater treatment system. Alternatively, the waste could be placed in an engineered mound and vitrified using in situ techniques.

A.1.16 Sludge Treatment Options (Solids/Liquid Separation, Stabilization, and/or Drying)

Organic-free sludges may be treated by several treatment scenarios involving solid/liquid separation, drying, and stabilization. Solid/liquid separation will be done when it is cost-effective to remove liquid from the sludge before further treatment. Some sludges may be sent directly to stabilization if their water content is similar to that needed in the stabilization mixture. Solid/liquid separation will be done before sludge drying, unless the sludge to be treated does not contain enough water to allow it to be effective.

Sludge-drying involves heating the sludge to evaporate water and forming a powder out of the sludge. Dried sludge can be sent to stabilization or directly to disposal. Potential fugitive dust emissions must be controlled during this process.

Stabilization is accomplished by adding fly ash, cement, asphalt, or other stabilizing materials to the sludge. Stabilized wastes will then be sent to disposal.

A.1.17 Sludge Treatment Options For Organic Contamination (Solid/Liquid Separation, Thermal Desorption, and Stabilization)

Sludges containing organics require treatment in systems that control fugitive emissions of organics as well as provide treatment for metals. This will be done by first using solid/liquid separation, removing organics and residual water in a thermal desorber, and then stabilizing the dried sludge, if needed. Solid/liquid separation may be done on a filter press or centrifuge and generates a wastewater stream for treatment.

Thermal desorption uses an indirectly fired kiln or other equipment to heat the sludges to a temperature that drives off organics and water. The vapor from the desorber requires treatment in a unit such as a fume incinerator. Off-gas from the incinerator may require further treatment using a scrubber system for particulate and chloride removal depending on the organics present. Scrubber blowdown water is then sent to a wastewater treatment unit.

Dry sludge from the thermal desorber may be disposed of directly or may require stabilization before disposal. Stabilization involves the addition of fly ash, concrete, asphalt, etc., to form an agglomerate that will prevent leaching of the solid. Potential fugitive dust emissions must be controlled during this process.

A.1.18 Soil-Benzonite Slurry Walls (Vertical Containment Barrier)

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

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

For slurry walls to be effective it is necessary to use them in conjunction with a suitable cap. The slurry wall should extend to the least permeable underlying layer and go to a predetermined design depth below the bottom of the waste. A detailed predesign investigation characterizing the

subsurface conditions and materials is required. Permeabilities of the subsurface layer (to which the slurry wall extends) and the soil-bentonite wall itself are critical elements in the design. The issue of waste/wall compatibility should be addressed early in the design by permeability testing of the proposed backfill mixture with actual site leachate or groundwater. Based on the investigation results, suitable design and support activities can be recommended.

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

A.1.19 Solidification and Stabilization of Radioactive Materials

Radioactive waste forms are defined as Class A, Class B, and Class C per 10CFR61.55. Solidification process applies to Class A. Stabilization process is applicable to Class A, B, and C. Solidified Class A waste products are free-standing monoliths and have no more than 0.50 percent of the waste volume as free liquids. Stabilized Class B and C wastes must meet American Society for Testing and Materials (ASTM) standards for compressive strength, exposure to radiation fields, biodegradation, and leaching as stated in the U.S. Nuclear Regulatory Commission (NRC) Technical Position on Waste Form.

Although there is a difference between solidification and stabilization, this discussion will treat them the same. Solidification may be necessary for preparation for disposal to reduce liquid volumes to acceptable levels and to provide structural integrity to prevent slumping, subsidence, and collapse or other failure when disposed. A number of different solidification agents are available including portland cement, limestone, fly ash, gypsum, absorbents, resins, and polymers. Laboratory testing will be required to determine the proper solidification formula.

A.1.20 Surcharging (Overburdening)

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

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

If drains are installed, they will provide a pathway for contaminated pore water to the fill surface. Pore water would then be collected and treated, which could potentially expose workers to contamination.

If the drains are not used, the surcharge would force the contaminated pore water into the surrounding soil and confining basin subsoils leading to a possible slight rise in monitored contaminants for a short period of time. In either case, the surcharge would produce an adequately compacted waste/soil matrix for closure-cap-bearing purposes.

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

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

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

A.1.21 Groundwater Control

This technology, consisting of ejector wells, wellpoints, and suction wells, has been used for dewatering lagoons in large-scale operations where the volume of sludge or sediment would require an inordinately large number of mechanical dewatering units such as filters and centrifuges.

This technology's essential features are:

- Wellpoints - An array of wellpoint screens, three to five feet apart, are placed into the waste and joined to a common header pipe leading to a vacuum pump. Wellpoints typically have 1.5- to 3.5-inch-diameter well screens and are capable of up to 35 gallons per minute in granular soils.

- Suction Wells - May be defined as large wellpoints up to eight inches in diameter with capacity greater than 35 gpm in granular soil.

- Ejector Wells - May be either single-pipe or two-pipe component systems with the single-pipe ejector wells most commonly used. For technology utilization purposes, the evaluation will be limited to the single-pipe system. The ejector pump system consists of a water tank, pump, required valves, and piping. In the single-pipe model, supply water flows downward between the well casing and the inner ejector return pipe, and a packer assembly separates the supply water from the groundwater so that different pressures are developed. Return pipe flow is a mixture of supply water and groundwater that recharges the system water tank. Excess tank water is removed for treatment, while the balance of the water is recycled for groundwater withdrawal.

A.1.22 Vertical Drains

This technology provides pore water pressure relief to facilitate the natural consolidation process in fine-grained soils. Sand drains are vertical columns filled with sand extending through the soil treatment zone. They are placed on a closely spaced pattern. Wick drains are strips of material that are pushed into the full depth of the soil treatment zone. They are also placed on a closely spaced pattern. Each wick is composed of a grooved or studded flat core sandwiched by a single-ply filter fabric on either side. In the last 10 years, wick drains have become the technology of choice in lieu of sand drains. Therefore, only wick drains will be assessed.

Special installation equipment inserts the wick to the desired depth. The wick provides a pathway for contaminated water to reach the surface for collection and treatment.

The drains can be used more effectively if incorporated into other settlement technologies.

Wick drains are inexpensive to install and have been used on projects in all parts of the world.

Because of the method of installation and collection of free pore water, there may be a potential of environmental and worker contamination. Before the start of any full-scale stabilization efforts, the following support activities would be required:

- Carry out studies to confirm the technology's abilities
- Remove and treat free-standing water

- Install a protective soil layer over any exposed waste to provide a safe working platform for equipment and personnel
- Evaluate and implement groundwater control measures

After treatment, wick drains can be left in place. A RCRA-type cap will be constructed in conjunction with groundwater control measures to provide an environmentally secure and permanent disposal unit.

A.1.23 Vitrification

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

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

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

For in situ vitrification the contaminated waste is not excavated but is vitrified in place. The energy required to heat and melt the waste is supplied by applying electric current to electrodes buried in the waste. Because the molten waste is conductive, it is heated by its own resistance (joule heating). For this process to be cost-effective, the depth of contamination must be at least six feet. Large sites can be treated by successive vitrification of adjacent blocks or zones. Another modified in situ approach that may have a wider application is placing the contaminated waste from a site in a pit or an aboveground mound and then vitrifying it. This allows mixing with other wastes and addition of sand or soil to improve the melting characteristics.

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

A.1.24 Waste Segregation (Waste Pits, Clearwell, Burn Pit)

Waste segregation is a process that separates and isolates the different components making up a waste stream. Waste segregation as applied at FMPC will be accomplished by using the differences in physical characteristics within the waste streams.

Waste segregation would be used on Operable Unit 1 to separate the metallic material, wood, and other debris from the other wastes in each pit. Review of the CIS data indicates drums and other metal materials were buried in the pits. Wood pallets and other debris are also reported to have been buried in the pits. Magnetic surveys were taken to identify metallic objects in the pit areas. This step was taken so test borings could take place without disturbing the metals. Wood fragments were encountered in some of the test borings indicating wood materials had been buried. Technologies for waste segregation include magnetic, eddy current separating, manual sorting, and screening/sizing:

- Magnetic

  This method would further identify areas of ferrous materials within the pits. As cover material is removed, visual inspection could be made to determine the type of material present and the best method for handling and sorting. When removing cover materials, care will be taken to avoid puncturing drums or other containers. Recovered drums or containers will be isolated and sampled to determine RCRA constituents and radioactivity.

- Eddy Current Separator

  This method uses eddy currents to force nonferrous metals from a feed stream. The advantages of this methodology are:

  - High separation capacity
  - Not affected by ferrous metals in the feedstream
  - Low energy requirements
  - Increases in efficiency as metallic size increases

- Manual Sorting

  This method involves the "hands-on" separation of the different physical types of waste material. As metals or other types of debris different from the majority waste

forms are encountered it would be evaluated and removed by the safest method. Special cleaning and decontamination procedures will be necessary for large debris before its disposal.

- Screening/Sizing

  This method involves the physical separation of materials by a series of screens sized to retain particles of a desired size range while allowing smaller particles and liquid to pass through the screen surface. This method will separate materials by size only. The screen can be either moving or fixed. The more widely used moving screens can be vibrating, revolving, or gyrating; with vibrating being the most common and most efficient. Fixed screens are usually inclined and used for separating larger materials.

A.1.25 Waste Disposal Off Site

After treatment, the FMPC waste can be transported to an approved waste disposal facility for permanent disposal. As a condition of disposal, no untreated wet, raw waste, or free liquids will be accepted for transport. Bulk and/or containerized wastes may be transported as follows:

- Dry (having a moisture content less than 15 percent by dry waste weight)
- Pumpable, self-leveling, setable grout/waste mix; this grout/waste mix will be termed "waste-crete"

An additional requirement may be that the waste be characterized as either mixed or low-level radioactive waste. If identified as mixed waste, it will only be accepted in a solidified form. Waste transport may be provided by truck or railroad. While radioactive waste from FMPC is currently shipped to a western site, the availability and limitations of other approved waste sites must be considered in the period of time when waste will actually be available for shipment.

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

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

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

Truck transport can provide portal-to-portal service with the road system available between FMPC and the approved waste site. Dependent on whether the waste is containerized, bulk/dry cake, or

solidified, the number of run trips (each 30 tons one way) could range from 1500 to 5000. The main disadvantage of truck transport is the near-FMPC public roadways. These two-lane rural roads are heavily traveled with considerable uncontrolled cross traffic and regional access/egress commuter traffic.

Rail transport with the existing system can provide an estimated shipment rate of 90 tons of waste per car with 100 cars per train. The number of haul runs could range from 350 to 550.

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

4.1.26 Vacuum Extraction

Vacuum extraction is typically an in situ process for the extrication of volatile organics compounds from a defined contaminated area. This technology extracts the contaminant through an extraction well by using a vacuum pump or blower to create an air flow through the soil, volatilizing the volatile contaminants from the soil into the air stream and then passes the contaminated stream through a vapor/liquid separator. The off gasses from the separator undergoes activated carbon treatment, which produces a clarified gas now releasable to the atmosphere.

It is important in applying this technology to consider the following: the volatility of the contaminants, the porosity and permeability of the soil or other medium that is to support this technology, the soil's moisture content, the required cleanup level, and other chemical and physical properties of the volatiles and soil, respectively.

The essential features of this technology are:

- Extraction wells
- Monitoring wells
- Manifold piping
- Vapor/liquid separator
- Vacuum pump
- Emission control device (i.e. activated carbon canister)

Some advantages of this technology are:

- This technology is effective in treating soils containing nearly any chemical of a volatile nature.
- The technology can be performed in situ or ex situ.
- The technology is cost-effective where contamination is in vadose zone.
- The technology operates well in all weather conditions.

APPENDIX B

B.1.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The development of applicable or relevant and appropriate requirements (ARARs) is in a transitional phase and this appendix represents an early stage of that development. The appendix is intended to provide a global overview of these requirements which have been submitted to U.S. Environmental Protection Agency (EPA) in greater detail in a separate transmittal.

In keeping with the requirements of the Section 120 Consent Agreement, this document has been prepared in such a manner as to avoid making ARAR determinations.

B.1 INTRODUCTION

The U.S. Department of Energy (DOE) must generally comply with all provisions of federal environmental statutes and regulations, as well as all applicable state and local requirements. In performing the Remedial Investigation/Feasibility Study (RI/FS) and subsequent remedial actions for Operable Unit 1 within the Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act of 1986/National Oil and Hazardous Substances Pollution Contingency Plan (CERCLA/SARA/NCP) framework, the Feed Materials Production Center (FMPC) is required to comply with all applicable or relevant and appropriate requirements. The purpose of this appendix is to list potential applicable or relevant and appropriate requirements (ARARs) and/or their sources.

Applicable requirements are those federal and state regulatory requirements that directly and fully address or regulate the hazardous substance, pollutant, contaminant, action being taken, or other circumstance at a CERCLA site. Examples of federal statutes specifically cited in CERCLA from which requirements may apply include the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Marine Protection Research and Sanctuaries Act (MPRSA). Relevant and appropriate requirements are those federal and state human health and environmental regulatory requirements that address problems or situations sufficiently similar to those encountered at CERCLA sites and are appropriate to the circumstances of release or threatened release, so that their uses are well suited to the particular site. In such cases, application of these requirements would be relevant and appropriate although not mandated by law. Relevant and appropriate requirements are intended to carry the same weight as applicable requirements.

B.2 POTENTIAL ARARs FOR OPERABLE UNIT 1

In accordance with current U.S. Environmental Protection Agency (EPA) guidance, ARARs are to be progressively developed and applied on a site-specific basis as the RI/FS proceeds. The initial step in the process entails the listing of all potential ARARs for the remedial action process at the subject site. A comprehensive listing of potential ARARs for all of the operable units for the FMPC was completed as part of the Feasibility Study Work Plan. The potential ARARs for the FMPC were categorized into the following EPA-recommended classifications:

- Chemical-Specific ARARs - Usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values for each chemical of concern. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the environment.

- Location-Specific ARARs - Restrictions placed on the concentration of a chemical or the conduct of activities solely because they occur in special locations.

- Action-Specific ARARs - Usually technology- or activity-based requirements or limitations on actions taken with respect to waste management and site cleanup.

A brief discussion of each of the primary federal and state of Ohio ARARs, along with pertinent agency-issued criteria, advisories, and guidance is given below. A summary listing of potential ARARs is found in Table B-1.

Federal ARARs

Federal ARARs and other criteria, advisories, or guidelines from specific laws include the following:

- Safe Drinking Water Act (42USC300f, et. seq. and 40CFR141 to 149) - Establishes Maximum Contaminant Levels (MCLs) which are enforceable standards for chemicals in public drinking water supplies. They not only consider health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. The EPA has recently proposed MCL goals (MCLGs) for several organic and inorganic compounds in drinking water. MCLGs are nonenforceable guidelines that do not consider the technical feasibility of contaminant removal. The SDWA also authorizes the following programs:

  - The Underground Injection Control (UIC) Program
  - The Sole-Source Aquifer Program
  - The Wellhead Protection Program

- Toxic Substances Control Act (15USC2601, et. seq. and 40CFR702 to 799) - Regulates the use and disposal of polychlorinated biphenyls (PCBs) and asbestos.

- Resource Conservation and Recovery Act/Solid Waste (40CFR240-257) - Establishes the criteria and standards for identification, management, and disposal of solid waste.

- Resource Conservation and Recovery Act (42USC6901, et. seq. as amended and 40CFR260 to 279) - Establishes the criteria and standards for identification, management, and disposal of hazardous waste.

- Federal Water Pollution Control Act, As amended by the Clean Water Act (33USC-1251, et. seq. and 40CFR104 to 140) - Governs point-source discharges through the National Pollutant Discharge Elimination System (NPDES), dredge and fill activities which may degrade or disturb wetlands or other aquatic habitats, and oil or hazardous substance spills to waters of the United States.

- Ambient Water Quality Criteria - Criteria for 64 chemicals were established in 1980, pursuant to Section 304(a)(1) of the CWA. AWQC are available for the protection of human health from exposure to chemicals in drinking water, from ingestion of aquatic biota, and for the protection of fresh-water and salt-water aquatic life.

- Regulation of Activities Affecting Waters of the U.S. (33CFR320 to 329) - U.S. Army Corps of Engineers (COE) regulations that are applicable to wetlands and navigable waters.

- Endangered Species Act of 1978 (16USC1531, et. seq.) - Provides for consideration of the impacts of remedial actions on endangered and threatened species.

- Fish and Wildlife Coordination Act (16USC661, et. seq. and 40CFR6.302) - Provides for consideration of the impacts on wetlands and protected habitats.

- Fish and Wildlife Improvement Act of 1978 (16USC742a) - Provides for consideration of the impacts on wetlands and protected habitats.

- Clean Air Act (42USC4701, et. seq. and 40CFR50, 40CFR61, Subparts H and Q)) - Through the National Ambient Air Quality Standards (NAAQS) it identifies primary and secondary standards for six "criteria" pollutants, and through the National Emission Standards for Radionuclides Emissions from DOE facilities, it provides annual exposure limits from air emissions from DOE facilities.

- EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192) - Applies to the control of residual radioactive material at designated processing or repository sites under Section 108 of the Uranium Mill Tailings Radiation Control Act of 1978 and to restoration of such sites following any use of subsurface minerals under Section 104(h) of the above-referenced act.

- NRC Regulations for Standards for Protection against Radiation (10CFR20) - Establishes standards for protection against radiation hazards arising out of activities under licenses issued by the U.S. Nuclear Regulatory Commission (NRC) and issued pursuant to the Atomic Energy Act (AEA) of 1954, as amended, and the Energy Reorganization Act of 1974.

- NRC Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material

From Ores Processed Primarily for Their Source Material Content (10CFR40, Appendix A) - Establishes technical and long-term site surveillance criteria relating to siting, operation, decontamination, decommissioning, and reclamation of mills and tailings or waste systems and sites at which such mills and systems are located.

- The Atomic Energy Act of 1954 (42USC2011, as amended) - Authorizes the conduct of atomic energy activities.

- Licensing Requirements for Land Disposal of Radioactive Waste (10CFR61) - Establishes procedures and criteria for the land disposal of radioactive wastes.

State of Ohio ARARs

State of Ohio ARARs and other criteria, advisories, or guidance include the authority of the Ohio Environmental Protection Agency (OEPA) to manage federal environmental programs. OEPA shares several responsibilities with other Ohio agencies including the Department of Health (ODH), the Department of Natural Resources (ODNR), and the Public Utilities Commission:

- Ohio Water Pollution Control Act (ORC Chapter 6111) -OEPA has the authority to administer all of the federally mandated water discharge programs, including the NPDES programs for all source categories (OAC3745-33-01 through 3745-33-05), and an effective pretreatment program (OAC3745-3). ORC 6111 also prohibits pollution of waters of the state.

- Solid and Hazardous Waste Disposal Law (OAC Chapter 3734) - OEPA has developed extensive solid and hazardous waste regulations (OAC3745 Chapters 27-70). These programs are administered by the Solid and Hazardous Waste Division of OEPA.

- Water Quality Standards (OAC3745-1) - Ohio has developed water quality standards applicable to state surface water (OAC3745-1-04), an antidegradation policy, (OAC3745-1-05) and has designated water use criteria for both acute and chronic effects on aquatic organisms and for all major surface water bodies (OAC3745-1-07 to 32).

- Drinking Water Rules - The rules for public drinking water are set forth by OAC3745-81-01 to 55, and includes MCLs. OAC3745-82 sets secondary contaminant standards.

- Water Well Installation - For new wells and borings, including those intended for human consumption, well installation is regulated under OAC3745-9 by OEPA and ODNR.

- The Underground Injection Well Control Program - Approvals for injection wells are required from the ODNR and OEPA. The requirements for permits to inject fluids via wells are set forth in OAC3745-34.

- Water System - Authority to establish and enforce rules regarding private water systems is granted to the ODH under OAC3701. ODH governs plan approvals, procedures, construction, and abandonment for private water systems (OAC3701-38). Community and public water supply systems are governed and approved by the OEPA under OAC3745-83 to 95.

- Radiation Standards - Standards for protection and handling of equipment and materials associated with ionizing radiation are governed by rules set by ODH under OAC3701-38.

- Air Pollution Control (ORC3704, OAC3745-15, OAC3745-17) - Establishes the authority of OEPA to regulate and control air pollution within the state under ORC 3704.03. Requires person responsible for any air contaminant source to install, employ, maintain, and operate such emissions, ambient air quality, meteorological, or other monitoring devices or methods as director prescribes. Requires the sampling of emissions at such locations, intervals and in a manner which the director prescribes. Requires the maintenance of records and filing of periodic reports with the director on the location, size, and height of emissions outlets, as well as the rate, duration, and composition of emissions.

- Control of Asbestos Emissions (OAC3745-20-05) - Specifies the standards which must be met regarding the handling and disposal of asbestos.

B.3 GUIDANCE TO BE CONSIDERED

Because ARARs may not exist or may not be sufficient to protect human health and the environment at a CERCLA site, it is necessary to evaluate nonlegally binding or promulgated criteria, advisories, guidance, or policies for protective cleanup levels when determining cleanup requirements or designing a remedy. EPA and support agencies may, as appropriate, identify other advisories, criteria, or guidance to be considered for a particular remediation activity. This to be considered (TBC) category consists of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that are not ARARs.

The application of the ARARs to Operable Unit 1 at the FMPC is complicated by the fact that the DOE and radionuclides (particularly uranium) have been exempted from some environmental regulations. From a radiological standpoint, the DOE has been primarily self-regulating for environmental activities, and has established its own policies for environmental monitoring, waste disposal, and limits of exposure to employees and the public. EPA regulations regarding the handling and disposal of wastes containing radionuclides are under programs set up by the Uranium Mill Tailings Act and the NRC. It should also be noted that DOE orders are not promulgated requirements but fall under the category of TBCs.

A brief discussion of each of the primary federal TBCs presently being considered follows:

FEDERAL TBCs

- Health Effects Assessments - Presents toxicity data for specific chemicals for use in public health assessments. Also considered applicable are cancer slope factors (CSFs) and referenced doses provided in the Human Health Evaluation Manual (EPA 1989).

- Groundwater Protection Strategy - Documents EPA policy to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater:

  - Class 1 - Special Groundwaters: Waters that are highly vulnerable to contamination and are either irreplaceable or ecologically vital sources of drinking water.

  - Class 2 - Current and Potential Sources of Drinking Water and Waters Having other Beneficial Uses: Waters that are currently used or that are potentially available for use.

  - Class 3 - Groundwater not a Potential Source of Drinking Water and of Limited Beneficial Use: Class 3 groundwater units are further subdivided into the following two subclasses:

    a. Subclass 3A includes groundwater units that are highly to intermediately interconnected to adjacent groundwater units of a higher class and/or surface waters. They may, as a result, be contributing to the degradation of the adjacent waters. They may be managed at a similar level as Class 2 groundwaters, depending upon the potential for producing adverse effects on the quality of adjacent waters.

    b. Subclass 3B is restricted to groundwater units characterized by a low degree of interconnection to adjacent surface waters or other groundwater units of a higher class within the Classification Review Area. These groundwaters are naturally isolated from sources of drinking water in such a way that there is little potential for producing adverse effects on quality. They have low resource value outside of mining or waste disposal.

- DOE Order for CERCLA Program (5400.4) (Draft) - Provides direction for DOE to implement a CERCLA program.

- DOE Order for Radiation Protection of the Public and the Environment (5400.5) (February 8, 1990) - Establishes standards and requirements with respect to protection of the public and the environment against radiation.

- DOE Order for Hazardous and Radioactive Mixed Waste Management (5480.2) (December 13, 1982) - Establishes hazardous waste management procedures for facilities operated under authority of the AEA of 1954, as amended.

- DOE Order for Environmental Protection, Safety, and Health Protection Information Reporting Requirements (5484.1) (February 24, 1981) - Establishes the requirements and procedures for reporting and investigating matters of environmental protection, safety, and health protection significant to DOE operations.

- DOE Order for Quality Assurance (5700.6B) (September 23, 1986) - Establishes DOE's quality assurance program.

- DOE Order for Radioactive Waste Management (5820.2A) (September 26, 1988) - Establishes policies and guidelines for the management of radioactive waste and contaminated facilities.

- DOE Plan for Implementing EPA Standards for UMTRA Sites (UMTRA-DOE/AL-163) (January 1984) - Presents guidance for implementing EPA standards on uranium mill tailing remedial action sites.

- DOE Technical Approach Document - Revision II (UMTRA-DOE/AL-050425.0002) (December 1989) - Presents the technical approach for remediation of uranium mill tailings remedial action sites.

- DOE Remedial Action Planning and Disposal Cell Design (UMTRA-DOE/AL 400503) (January 1989) - Presents guidance for complying with the proposed 40CFR192 for planning and disposal cell design for uranium mill tailings remedial action sites.

- DOE Project Surveillance and Maintenance Plan (UMTRA-DOE/AL 350124) - Presents guidance for surveillance and maintenance of uranium mill tailings remedial action sites.

- Executive Order 11988 - Presents requirements for federal agencies to protect floodplains.

- Executive Order 11990 - Presents requirements for federal agencies to protect wetlands.

- National Primary Drinking Water Standards (40CFR141.50 and 141.51) - Provides proposed MCLs and MCLGs. Proposed MCLs may provide guidance for cleanup remedial actions. There appears to be no precedent for using MCLGs to develop cleanup criteria for the national CERCLA program.

- NRC Regulatory Guide for Termination of Operating Licenses for Nuclear Reactors (NRC Regulatory Guide 1.86) (June 1974) - Establishes acceptable surface radioactivity contamination levels for releases of equipment and facilities for unrestricted use.

A summary listing of TBCs is found in Table B-1.

B.4 SUMMARY

The establishment of final federal and state ARARs and TBCs for uranium and other constituents found in the operable unit for the evaluation of remedial action alternatives for Operable Unit 1 at the FMPC will be a progressive, multi-step process involving interactive discussions among DOE, EPA, and OEPA. The critical application of the final ARARs will be performed during the

detailed analysis of alternatives. The ARARs, in conjunction with the baseline risk assessment, will assist in the determination of the cleanup levels required to adequately protect public health and the environment at the FMPC.

TABLE B-1.
SUMMARY LIST OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND GUIDANCE TO BE CONSIDERED

Chemical-Specific ARARs

Requirement	Description
Resource Conservation and Recovery Act (RCRA), (40CFR260-272)	Sets standards applicable to hazardous waste treatment, storage, and disposal
RCRA/Solid Waste (40CFR240-257)	Sets standards applicable to solid waste treatment, storage, and disposal
Safe Drinking Water Act (40CFR141-149)	
a. Maximum contaminant levels (MCLs)	Remedial actions may provide cleanup to the MCLs considered pursuant to SARA Section 121(d)(2)(A)(ii)
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	Establishes doses, levels, and concentrations for restricted and unrestricted areas (10CFR20.101-105)
EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192)	Establishes cleanup limits for uranium and thorium mill tailings in soil and groundwater
Clean Air Act (42USC7401, et. seq.)	
a. National Ambient Air Quality Standards (NAAQS) for six criteria pollutants (40CFR50)	Identifies primary and secondary standards for six "criteria pollutants" (i.e., lead, particulates)
b. National Emission Standards for Radionuclides Emissions from DOE Facilities (40CFR61 Subpart H and Q)	Provides annual limits of 10 mrem/yr (whole body) for air emissions from DOE facilities
Ohio Regulations	Escape, releases, emissions to open air
a. Air Pollution	Prevention of air pollution nuisance
OAC3745-17-02	Nondegradation policy
OAC3745-20-05	Asbestos emissions

TABLE B-1.
(Continued)

Chemical-Specific ARARs	
Requirement	Description
b. Water Pollution OAC3745-81	Drinking water rules, sets MCLs for chemicals and gross alpha, beta, and radium-226 and radium-228
OAC3745-1	Water Quality standards, 3745-01-4(D) sets the criterion applicable to all waters, 3745-01-05 sets forth the antidegradation policy for state waters, 3745-01-07 presents specific surface water quality criteria for both acute and chronic effects on aquatic organisms, 3745-01-21 describes use designations for the Great Miami River, 3745-1-32 sets standards for radioactive materials in receiving waters of the Ohio River
c. Radiation Protection OAC3701-38	Ohio Radiation Protection Standards, OAC3701-38, provide limits for protection and handling of equipment and materials associated with ionizing radiation

TABLE B-1.
(Continued)

Location-Specific ARARs	
Requirement	Description
Ohio Location Standards (OAC3745-54-18)	Governs the location of hazardous waste treatment, storage, or disposal with respect to floodplains
Fish and Wildlife Coordination Act (40CFR6.302)	Provides for coordination of the impacts on wetlands and protected habitats
RCRA/Solid Waste (40CFR240-257)	Sets standards applicable to solid waste treatment, storage, and disposal
RCRA (40CFR250-272)	Sets standards applicable to hazardous waste treatment, storage, and disposal

TABLE B-1.
(Continued)

Action-Specific ARARs	
Requirements	Description
Regulations of activities affecting waters of the U.S. (33CFR320 to 329)	COE regulations apply to dredge and fill materials discharges to U.S. waters.
Resource Conservation and Recovery Act (RCRA) (40CFR260-272)	Sets standards applicable to hazardous waste treatment, storage, and disposal
RCRA/Solid Waste (40CFR240-257)	Sets standards applicable to solid waste treatment, storage, and disposal
Clean Water Act Ambient Water Quality Criteria (40CFR104-140)	Alternatives include discharge to surface waters
NRC Licensing Requirements for Land Disposal of Radioactive Waste (10CFR61)	Provides requirements for siting, design, operation, closure, and control after closure for radioactive waste disposal facilities
NRC Regulations for Licensing of Source Material (10CFR40)	Provides criteria for siting, decontamination, decommissioning, and disposition of uranium tailings and wastes (Appendix A)
EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40CFR192)	Provides standards for control of residual radioactive materials from inactive uranium processing sites
Air Pollution Nuisances Prohibited (OAC3745-15-07)	Prohibits air emissions that could be constituted as a public nuisance
Abandonment of Test Holes and Wells (OAC3745-9-10)	Regulates installation of borings and wells
Effluent Discharge Requirements (OAC3745-31 and 33)	Sets requirements for wastewater treatment facilities
Solid Waste Treatment Facility (OAC3745-27)	Sets requirements for solid non-hazardous waste treatment and disposal facility design
Post-Closure Care (OAC3745-66)	Sets requirements for on-property waste disposal facilities post-closure requirements
Container Storage (OAC3745-55)	Provides container storage requirements

TABLE B-1.
(Continued)

Action-Specific ARARs	
Requirements	Description
Ohio Water Well Standards (OAC3745-9-10)	Provides requirements for abandonment of test holes and wells
Air Pollution (OAC3745-17-08) (OAC3704.03(E))	Prohibits air emissions control of fugitive dust Control of odors and air pollution nuisances

TABLE B-1.
(Continued)

TBCs	
Requirements	Description
Executive Order 11988 Floodplain Management	Provides considerations for management of floodplain areas
Executive Order 11990 Protection Of the Wetlands	Provides considerations for protection of wetlands
Radioactive Waste Management (DOE Order 5820.2A)	Sets requirements for management of radioactive wastes at DOE facilities
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	Sets requirements for protection of the public and the environment from radioactive materials at DOE facilities
CERCLA Program (DOE Order 5400.4) (Draft)	Provides direction for DOE to implement a CERCLA program
Hazardous and Radioactive Mixed Waste Management (DOE Order 5480.2) (December 13, 1982)	Establishes hazardous waste management procedures for facilities operated under authority of the Atomic Energy Act of 1954, as amended
Plan for Implementing EPA Standards for UMTRA Sites (UMTRA-DOE/AL-163)	Presents guidance for implementing EPA standards on uranium mill tailings remedial action sites
Technical Approach Document (UMTRA-DOE/AL 050425)	Presents the technical approach used by DOE for remediation of uranium mill tailings remedial action sites
Remedial Action Planning and Disposal Cell Design (UMTRA-DOE/AL 400503)	Presents guidance for complying with 40CFR192 for planning and disposal cell design for uranium mill tailings remedial action sites
Project Surveillance and Maintenance Plan (UMTRA-DOE/AL 350124)	Presents guidance for surveillance and maintenance of uranium mill tailings remedial action sites.

TABLE B-1.
(Continued)

TBCs	
Requirements	Description
Safe Drinking Water Act [40CFR141-149; Section 1412(b)] a. Proposed maximum contaminant levels (PMCLs) b. Maximum contaminant level goals (MCLGs)	Presents guidance for groundwater cleanup
Residual Radioactive Material as Surface Contamination (USNRC Regulatory Guide 1.86)	Provides surface contamination guidelines for release of equipment and building components for unrestricted use
Chemical Reference Dose Guidance (USEPA Health Effects Assessment Summary Tables (HEAST)).	Provides chemical dose guidance intended to be protective of human health
Chemicals in Drinking Water (40CFR141.50 - 141.51) (OAC3745-81-11)	Sets maximum contaminant level goals (MCLGs) for potential chemicals of concern in community water systems.

APPENDIX C

WASTE PITS, BURN PIT, AND CLEARWELL CHARACTERISTICS

TABLE C-1.

OPERABLE UNIT 1 - WASTE PIT 1 CHARACTERISTICS

Item No.	Description	Quantities and Units	References[a] and/or Comments
1.	Area	82,693 ft^2 (1.9 acres)	Reference 1, 5
2.	Contents: Neutralized waste filter cakes, scrap graphite, brick scrap, sump liquor and cakes, 55-gallon drums, depleted slag, and fly ash	33,676 yd^3	Wastes deposited in Pit 1 are termed "dry" solid wastes - Reference 2
3.	Surface water	None	Pit has been covered - Reference 2
4.	Geotechnical data:		Reference 3
	Dry density	109.4 lb/ft^3	
	Specific gravity	2.62	
	Moisture content[b]	20.0 percent	
5.	Material consistency: The pit was termed "dry." However, sump liquor was deposited and surface infiltration has influenced the consistency. The geological description of the borings indicates materials classified as silts and clays, with varying grain size and moisture contents. Solid, semisolid, and grease-like materials were observed.		Reference 4
6.	Radioactive material concentrations		Reference 1
	Radium-226	12 to 60.2 pCi/g	
	Uranium-238	360 to 6,980 pCi/g	
	Uranium-235	16 to 151 pCi/g	
	Thorium-230	122 to 1,980 pCi/g	
	Thorium-232	1.8 to 17 pCi/g	
	Technetium-99	1 to 15 pCi/g	

TABLE C-1.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
7.	Radioactive material quantities		Reference 2
	Uranium-238	52,000 kg	
	Uranium-235	370 kg	
	Total curies	108 Ci	
8.	Volatile inorganics		Reference 1
	Arsenic	14.46 to 15.2 mg/kg	
	Mercury	0.26 to 0.36 mg/kg	
9.	Organics		Reference 1
	PCBs (Aroclors 1248, 1254, and 1260)	720 to 10,000 g/kg	
	4,4-DDT	1,600 µg/kg	
10.	HSL semivolatiles		Reference 1
	Chrysene	510 µg/kg	
	Phenanthrene	770 to 2,300 µg/kg	
11.	HSL inorganics		Reference 1
	Aluminum	1,703 to 20,223 mg/kg	
	Calcium	4,756 to 192,498 mg/kg	
	Magnesium	7,614 to 36,957 mg/kg	
	Iron	1,833 to 19,688 mg/kg	
12.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity.
13.	Listed hazardous materials	Maximum concentrations	Reference 1
	Chloroform (U044)	210 ppb	
	Chrysene (U050)	510 ppb	

[a]References are listed in Table C-8
[b]By percent of dry weight

TABLE C-2.

OPERABLE UNIT 1 - WASTE PIT 2 CHARACTERISTICS

Item No.	Description	Quantities and Units	References[a] and/or Comments
1.	Area	44,896 ft^2 (1.03 acres)	Reference 1, 5
2.	Contents: Neutralized waste filter cakes, scrap graphite, brick scrap, sump liquor and cakes, slag, fly ash, 55-gallon drums, and construction rubble	18,478 yd^3	Wastes deposited in Pit 2 are termed "dry" solid wastes - Reference 2
3.	Surface water	None	Pit has been covered - Reference 2
4.	Geotechnical data:		Reference 3
	Dry density	86.3 lb/ft^3	
	Specific gravity	2.59	
	Moisture content[b]	20.3 percent	
5.	Material consistency: The pit was termed "dry." However, sump liquor was deposited and surface infiltration has influenced the consistency. The geological description of the borings indicates coarse sand-sized materials, clay- and silt-sized material of semisolid consistency, and various clay-like materials becoming wet between 7 and 10 feet. Chunks of concrete up to 1 inch in size were encountered.		Reference 4
6.	Radioactive material concentrations		Reference 1
	Radium-226	12.2 to 412 pCi/g	
	Uranium-238	53 to 17,900 pCi/g	

TABLE C-2.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
	Radioactive material concentrations (Continued)		Reference 1
	Uranium-235	1 to 8,780 pCi/g	
	Thorium-230	1.2 to 3,980 pCi/g	
	Thorium-232	0.1 to 88 pCi/g	
	Technetium-99	1.0 to 618 pCi/g	
7.	Radioactive material quantities		Reference 2
	Uranium-235	2,550 kg	
	Uranium-238	1,206,000 kg	
	Thorium-230	404 kg	
	Total curies	15 Ci	
8.	Volatile inorganics		Reference 1
	Arsenic	2.75 to 10.06 mg/kg	
	Mercury	0.22 to 0.70 mg/kg	
9.	Organics		Reference 1
	PCBs (Aroclors 1248, 1254, and 1260)	321 to 1,800 µg/kg	
	4,4-DDT	580 to 1,400 µg/kg	
	Vinyl chloride (volatile)	670 µg/kg	
10.	HSL semivolatiles		Reference 1
	Chrysene	920 to 180,000 µg/kg	
	Fluoranthene	590 to 460,000 µg/kg	
	Phenanthrene	1,700 to 370,000 µg/kg	
	Pyrene	1,600 to 310,000 µg/kg	
	2-Methylnaphthalene	7,000 to 7,000 µg/kg	
	4-Chlorophenyl-phenylether	62,000 to 62,000 µg/kg	
	Acenaphthene	43,000 to 43,000 µg/kg	
	Anthracene	120,000 to 120,000 µg/kg	

TABLE C-2.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
	HSL semivolatiles (continued)		
	Benzo(a)anthracene	860 to 130,000 µg/kg	
	Benzo(b)fluoranthene	760 to 110,000 µg/kg	
	Benzo(g,h,i)perylene	42,000 to 42,000 µg/kg	
	Benzo(k)fluoranthene	600 to 120,000 µg/kg	
11.	HSL inorganics		Reference 1
	Aluminum	7,242 to 22,422 mg/kg	
	Magnesium	8,885 to 26,677 mg/kg	
	Iron	13,265 to 24,038 mg/kg	
	Calcium	34,414 to 80,154 mg/kg	
12.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity
13.	Listed hazardous materials	Maximum concentrations	Reference 1
	Benzo(a)pyrene (U022)	140,000 ppb	
	Chrysene (U050)	180,000 ppb	
	Fluoranthene (U120)	460,000 ppb	
	Pyrene (U137)	46,000 ppb	
	Naphthalene (U165)	16,000 ppb	
	Vinyl chloride (U043)	670 ppb	
	Fluorine (P056)	62,000 ppb	

[a]References are listed in Table C-8
[b]By percent of dry weight

TABLE C-3.

OPERABLE UNIT 1 - WASTE PIT 3 CHARACTERISTICS

Item No.	Description	Quantities and Units	References[a] and/or Comments
1.	Area	241,373 ft^2 (5.54 acres)	Reference 1, 5
2.	Contents: Lime neutralized raffinate, raffinate concentrate, slag leach residues, filter cakes, fly ash, lime sludge, and wooden pallets	237,053 yd^3	Wastes deposited in Pit 3 are termed "wet" solid wastes - Reference 2
3.	Surface water	None	Pit has been covered - Reference 2
4.	Geotechnical data:		Reference 3
	Dry density	88.3 lb/ft^3	
	Specific gravity	2.54	
	Moisture content[b]	30.1 percent	
5.	Material consistency: The upper strata is a coarse-grained material underlain by very soft, moist to wet, semisolid material. Wood fragments were encountered.		Reference 4
6.	Radioactive material concentrations		Reference 1
	Radium-226	3.1 to 369 pCi/g	
	Uranium-235	2.5 to 21 pCi/g	
	Uranium-238	134 to 1,380 pCi/g	
	Thorium-230	15 to 21,900 pCi/g	
	Thorium-232	1.0 - 121 pCi/g	
	Technetium-99	1.0 to 1,110.0 pCi/g	

TABLE C-3.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
7.	Radioactive material quantities		Reference 2
	Uranium-235	1,771 kg	
	Uranium-238	129,000 kg	
	Thorium-230	400 kg	
	Total curies	553 Ci	
8.	Volatile inorganics		Reference 1
	Arsenic	15.41 to 3,049.06 mg/kg	
	Mercury	0.45 to 4.01 mg/kg	
9.	Organics		The concentration level for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
10.	HSL semivolatiles		The concentration level for all HSL semivolatiles analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
11.	HSL inorganics		Reference 1
	Aluminum	8,220 to 64,100 mg/kg	
	Magnesium	21,492 to 51,570 mg/kg	
	Iron	10,730 to 26,919 mg/kg	
	Calcium	53,183 to 178,241 mg/kg	
	Arsenic	15 to 3,049 mg/kg	
	Vanadium	50 to 9,696 mg/kg	
	Lead	26 to 613 mg/kg	

TABLE C-3.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
12.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity.
13.	Listed hazardous materials		The concentration level for all listed hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

[a]References are listed in Table C-8
[b]By percent of dry weight

TABLE C-4.

OPERABLE UNIT 1 - WASTE PIT 4 CHARACTERISTICS

Item No.	Description	Quantities and Units	References[a] and/or Comments
1.	Area	83,799 ft^2 (1.92 acres)	Reference 1, 5
2.	Contents: Process residues, filter cakes, slurries, raffinates, depleted graphite, barium chloride, thorium metal, noncombustible trash, asbestos, construction rubble, and scrap drums.	53,706 yd^3	Wastes deposited in Pit 4 are termed "dry" solid wastes - Reference 2
3.	Surface water	None	Pit has been covered - Reference 2
4.	Geotechnical data:		Reference 3
	Dry density	120.6 lb/ft^3	
	Specific gravity	3.33	
	Moisture content[b]	22.4 percent	
5.	Material consistency: Silt and sand-sized material with layers of clay-sized material below 10 feet. The material was saturated below 9 feet.		Reference 4
6.	Radioactive material concentrations		Reference 1
	Radium-226	5 to 20 pCi/g	
	Uranium-235	35 to 426 pCi/g	
	Uranium-238	509 to 15,800 pCi/g	
	Thorium-230	2.2 to 566 pCi/g	
	Thorium-232	0.3 to 21 pCi/g	
	Technetium-99	6.8 to 225 pCi/g	

TABLE C-4.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
7.	Radioactive material quantities		Reference 2
	Uranium-235	5,529 kg	
	Uranium-238	3,048,087 kg	
	Thorium-230	61,800 kg	
	Total curies	233 Ci	
8.	Volatile inorganics		Reference 1
	Arsenic	4.63 mg/kg	
	Mercury	0.18 to 0.63 mg/kg	
9.	Organics		Reference 1
	PCBs (Aroclors 1242, 1248, and 1254)	99 to 1,034 µg/kg	
	Pesticide (ethyl and methyl parathion)	82 to 2,100 µg/kg	
10.	HSL semivolatiles		Reference 1
	Chrysene	760 µg/kg	
	Fluoranthene	1,000 to 2,200 µg/kg	
	Phenanthrene	1,000 to 2,100 µg/kg	
	Pyrene	670 to 1,400 µg/kg	
	Anthracene	510 to 510 µg/kg	
	Benzo(a)anthracene	750 to 750 µg/kg	
	Benzo(b)fluoranthene	510 to 510 µg/kg	
	Benzo(k)fluoranthene	560 to 560 µg/kg	
	Malathion	670 to 670 µg/kg	
11.	HSL inorganics		Reference 1
	Barium	444 to 6,668 mg/kg	
	Aluminum	3,646 to 10,326 mg/kg	
	Iron	3,046 to 16,128 mg/kg	
	Calcium	14,253 to 61,253 mg/kg	
	Magnesium	11,424 to 24,251 mg/kg	
	Fluoride	47,812 to 124,576 mg/kg	

TABLE C-4.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
12.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity.
13.	Listed hazardous materials	Maximum concentrations	Reference 1
	Chrysene (U050)	760 ppb	
	Chloroform (U044)	1,300 ppb	
	Fluoranthene (U120)	2,200 ppb	
	Trichloroethene (U228)	300 ppb	
	Benzo(a)pyrene (U022)	550 ppb	
	Pyrene (U137)	1,400 ppb	

[a]References are listed in Table C-8
[b]By percent of dry weight

TABLE C-5.

OPERABLE UNIT 1 - WASTE PIT 5 CHARACTERISTICS

Item No.	Description	Quantities and Units	References[a] and/or Comments
1.	Area	161,103 ft^2 (3.7 acres)	Reference 1, 5
2.	Contents: Solids from neutralized raffinate, slag leach slurry, sump slurry, and lime sludge	98,841 yd^3	Wastes deposited in Pit 5 are termed "wet" solid wastes - Reference 2
3.	Surface water	748,060 gallons	Approximate quantity, volume directly related to precipitation and evaporation - Reference 1
4.	Geotechnical data:		Reference 3
	Dry density	62.5 lb/ft^3	
	Specific gravity	2.43	
	Moisture content[b]	59.8 percent	
5.	Material consistency: This pit is still open with up to 3 feet of standing surface water over a portion of the pit. The upper 4 feet of the pit consists of watery material with some sand-sized grains. The remaining 25 feet consists of a wet, semisolid material with very little cohesion.		Reference 4

TABLE C-5.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
6.	Radioactive material concentrations		Reference 1
	Radium-226	235 to 999 pCi/g	
	Uranium-235	14 to 79 pCi/g	
	Uranium-238	387 to 1,230 pCi/g	
	Thorium-230	3,080 to 20,200 pCi/g	
	Thorium-232	21 to 90 pCi/g	
	Technetium-99	423 to 2,990 pCi/g	
7.	Radioactive material quantities		Reference 2
	Uranium-235	420 kg	
	Uranium-238	50,309 kg	
	Thorium-230	17,000 kg	
	Total curies	327 Ci	
8.	Volatile inorganics		Reference 1
	Arsenic	139 to 2,800 mg/kg	
	Mercury	1.9 to 6.2 mg/kg	
9.	Organics		Reference 1
	PCBs (Aroclor 1254)	750 ppb	
10.	HSL semivolatiles		The concentration level for HSL semivolatiles analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

TABLE C-5.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
11.	HSL inorganics		Reference 1
	Aluminum	6,373 to 15,400 mg/kg	
	Calcium	116,000 to 206,144 mg/kg	
	Iron	10,979 to 17,900 mg/kg	
	Magnesium	807 to 63,200 mg/kg	
	Arsenic	139 to 2,800 mg/kg	
	Mercury	0.4 to 1.8 mg/kg	
	Vanadium	792 to 5,380 mg/kg	
12.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity.
13.	Listed hazardous materials		The concentration level for all listed hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

[a]References are listed in Table C-8
[b]By percent of dry weight

TABLE C-6.

OPERABLE UNIT 1 - WASTE PIT 6 CHARACTERISTICS

Item No.	Description	Quantities and Units	References[a] and/or Comments
1.	Area	32,400 ft^2 (0.75 acres)	Reference 1, 5
2.	Contents: Depleted slag, scrap green salt, process residues, filter cake, and asbestos	11,556 yd^3	Reference 2
3.	Surface water	Unknown	Approximate quantity, volume directly related to precipitation and evaporation - Reference 1
4.	Geotechnical data:		Reference 3
	Dry density	101.2 lb/ft^3	
	Specific gravity	2.87	
	Moisture content[b]	25.4 percent	
5.	Material consistency: Saturated, soft, coarse to fine, sand-sized, and clay-sized materials.		Reference 4
6.	Radioactive material concentrations		Reference 1
	Radium-226	16 to 30 pCi/g	
	Uranium-235	350 to 1,750 pCi/g	
	Uranium-238	12,500 to 18,700 pCi/g	
	Thorium-230	14 to 41 pCi/g	
	Thorium-232	0.2 to 1.2 pCi/g	
	Technetium-99	84 to 164 pCi/g	
7.	Radioactive material quantities		Reference 2
	Uranium-235	843,142 kg	
	Uranium-238	1,740 kg	
	Thorium-230	Unknown	
	Total curies	178 Ci	

TABLE C-6.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
8.	Volatile inorganics Arsenic Mercury	 7.61 mg/kg 0.03 to 0.07 mg/kg	Reference 1
9.	Organics		The concentration level for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
10.	HSL semivolatiles		The concentration level for all HSL semivolatiles analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
11.	HSL inorganics Aluminum Calcium Iron Magnesium Lead Silver	 4,730 mg/kg 22,190 mg/kg 2,750 mg/kg 32,101 mg/kg 5 to 60 mg/kg 158 mg/kg	Reference 1
12.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity.
13.	Listed hazardous materials 1,1,2,2-tetrachloroethane (U209)	Maximum concentrations 29,000 ppb	Reference 1

[a]References are listed in Table C-8
[b]By percent of dry weight

TABLE C-7.

OPERABLE UNIT 1 - BURN PIT CHARACTERISTICS

Item No.	Description	Quantities and Units	References[a] and/or Comments
1.	Area	21,724 ft^2 (estimated)	Reference 1, 5
2.	Contents: Pyrophoric and reactive chemicals, oils, and combustible wastes	Unknown	This pit was used to burn various materials. The materials and chemicals remaining or otherwise disposed of are unknown - Reference 2
3.	Surface water	None	Pit has been covered - Reference 2
4.	Geotechnical data:		Reference 3
	Dry density	81.2 lb/ft^3	
	Specific gravity	2.35	
	Moisture content[b]	Unknown	
5.	Material consistency: One area consisted of silt-sized, semisolid material; sand-sized material; and fill with glass, wood, and aluminum. A second area consisted of fine- to medium-sized material underlain with sand-sized, semisolid material.		Reference 4
6.	Radioactive material concentrations		Reference 1
	Radium-226	2.0 to 3.9 pCi/g	
	Uranium-235	0.5 to 27 pCi/g	
	Uranium-238	22 to 454 pCi/g	
	Thorium-230	0.1 to 26 pCi/g	
	Thorium-232	0.1 to 7.7 pCi/g	
	Technetium-99	0.4 to 64 pCi/g	

TABLE C-7.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
7.	Volatile inorganics		Reference 1
	Arsenic	4.38 to 20.91 mg/kg	
	Mercury	0.14 to 0.24 mg/kg	
8.	Organics		Reference 1
	PCBs (Aroclors 1016, 1242, 1248, and 1254)	200 to 2,700 µg/kg	
9.	HSL semivolatiles		Reference 1
	Benzo(b)fluoranthene	69 to 170 µg/kg	
	Benzo(g,h,i)perylene	85 µg/kg	
	Chrysene	73 to 77 µg/kg	
	Pentachlorophenol (2)	1,200 to 2,600 µg/kg	
	Phenanthrene	100 to 190 µg/kg	
	2-Methylnaphthalene	50 µg/kg	
	Tetrachloroethene (volatile)	260 µg/kg	
	Ethylbenzene (volatile)	270 µg/kg	
10.	HSL inorganics		Reference 1
	Aluminum	2,912 to 11,936 mg/kg	
	Magnesium	3,859 to 57,079 mg/kg	
	Calcium	10,114 to 116,322 mg/kg	
	Iron	3,747 to 17,445 mg/kg	
	Lead	7 to 53 mg/kg	
	Silver	7 to 506 mg/kg	
11.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity.

TABLE C-7.
(Continued)

Item No.	Description	Quantities and Units	References[a] and/or Comments
12.	Listed hazardous materials	Maximum concentrations	Reference 1
	Chrysene (U050)	77 ppb	
	Fluoroanthene (U120)	220 ppb	
	Phenol (U188)	650 ppb	
	Xylenes (U239)	890 ppb	
	Pyrene (U137)	140 ppb	

[a]References are listed in Table C-8
[b]By percent of dry weight

TABLE C-8.

OPERABLE UNIT 1 - CLEARWELL CHARACTERISTICS

Item No.	Description	Quantities and Units	References and/or Comments
1.	Area	29,450 ft^2 (0.68 acres)	Reference 1, 5
2.	Contents: Clarified process effluents and surface runoff	Unknown	Clearwell was used as a final setting basin for process water from other pits and storm water runoff - Reference 2
3.	Surface water	1,546,265 gallons (estimated)	
4.	Geotechnical data:	Unavailable	
5.	Material consistency	Unavailable	
6.	Radioactive material concentrations		Reference 1
	Cesium-137	18.0 to 450 pCi/g	
	Radium-226	21.9 to 458 pCi/g	
	Uranium-235	24 to 49 pCi/g	
	Uranium-238	548 to 670 pCi/g	
	Thorium-232	0.1 to 39 pCi/g	
	Thorium-230	0.3 to 5,600 pCi/g	
	Technetium-99	0.40 to 278 pCi/g	
7.	Volatile inorganics		Reference 1
	Arsenic	9.11 to 18.46 mg/kg	
	Mercury	0.42 to 4.38 mg/kg	
8.	Organics		Reference 1
	PCBs (Aroclors 1248 and 1254)	308 to 737 µg/kg	
9.	HSL semivolatiles		The concentration level for all HSL semivolatiles analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

TABLE C-8.
(Continued)

Item No.	Description	Quantities and Units	References and/or Comments
10.	HSL inorganics		Reference 1
	Aluminum	12,939 to 23,771 mg/kg	
	Magnesium	16,785 to 44,629 mg/kg	
	Calcium	129,305 to 183,078 mg/kg	
	Iron	19,618 to 21,067 mg/kg	
	Mercury	0.4 to 4.4 mg/kg	
	Arsenic	9 to 18 mg/kg	
11.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP Toxicity.
12.	Listed hazardous materials		The concentration level for all listed hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

References:

1. Weston, Roy F., November 1987, "Characterization Investigation Study Volume 2: Chemical and Radiological Analyses of the Waste Storage Pits," prepared for Westinghouse Materials Company of Ohio, Cincinnati, OH.

2. Advanced Sciences, Inc., October 1986, "Remedial Investigation of the Feed Materials Production Center, Fernald, Ohio, Part I: Evaluation of Current Situation," prepared for Westinghouse Materials Company of Ohio, Cincinnati, OH.

3. Weston, Roy F., March 1988, "Geotechnical Evaluation of Feed Properties of Waste Pit Materials at the Feed Materials Production Center, Fernald, Ohio," prepared for Westinghouse Materials Company of Ohio, Cincinnati, OH.

4. Appendix F of Reference 1 - Geological Description of Waste Pit Borings.

5. U.S. Atomic Energy Commission Drawings (by Index Code) 08C-5500-G-00864; 21A-5500-G-00233; 21X-5500-G-00234; 21A-5500-G-00235; 21A-5500-00202; 21A-5500-G-00222. Westinghouse Materials Company of Ohio Drawings (by Index Code) 75-A-5500-G-00111 Rev. 0.