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DEVELOPMENT OF ALTERNATIVES (TASK 12) FOR THE FEASIBILITY STUDY - REVISION 1 DECEMBER 1988

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REPORT

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REMEDIAL INVESTIGATION
AND
FEASIBILITY STUDY

FEED MATERIALS PRODUCTION CENTER

Fernald, Ohio

DEVELOPMENT OF ALTERNATIVES (TASK 12)
FOR THE FEASIBILITY STUDY
REVISION 1

December 1988

U. S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS

 213

TASK 12 REPORT
DEVELOPMENT OF ALTERNATIVES

PREPARED AS PART OF THE
FEASIBILITY STUDY
FOR THE
FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

REVISION 1
DECEMBER 1988

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1.0 INTRODUCTION

1.1 BACKGROUND

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (U.S. EPA) pertaining to environmental impacts associated with DOE's Feed Materials Production Center (FMPC) in Fernald, Ohio. The FFCA was entered into pursuant to Executive Order 12088 (42 Code of Federal Regulations [CFR] 47707) to ensure compliance with existing environmental statutes and implementing regulations. 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, a sitewide Remedial Investigation and Feasibility Study (RI/FS) is in progress pursuant to Section 106 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The performance of the RI/FS is in conformance with current U.S. EPA guidance and the guidelines, criteria, and considerations set forth in the National Contingency Plan (NCP) and the Superfund Amendments and Reauthorization Act (SARA) of 1986.

A Work Plan for the sitewide RI/FS was originally issued to the U.S. EPA in December 1986. After a series of technical discussions and negotiations, Revision 3 of the RI/FS Work Plan was submitted in March 1988 and received U.S. EPA approval in May 1988. In the approved RI/FS Work Plan, the technical approach to the Feasibility Study (FS) was limited to a general description of nine tasks specified in the "Scope of Work for a Feasibility Study: Feed Materials Production Center," as attached to the FFCA. One reason for the lack of detail on the FS approach was the requirement to prepare a detailed FS Work Plan as a future task of the RI/FS process. The detailed FS Work Plan was subsequently prepared and submitted to the U.S. EPA on August 15, 1988.

Although the nine FS tasks identified in both the FFCA and the RI/FS Work Plan (Revision 3) were maintained for consistency in the FS Work Plan, two significant modifications to the technical approach were introduced in the detailed FS Work Plan. The first involved revisions to the technical approach for each task to achieve conformance with the procedural requirements of the U.S. EPA's "Draft Guidance for Conducting Remedial Investigations and Feasibility Studies." The latter document was issued in March 1988, subsequent to the submission of the RI/FS Work Plan (Revision 3). The second proposed modification to the FS program was the introduction of a remedial action management strategy that is based on operable units. In particular, the individual candidates for remedial action at the FMPC were categorized into six distinct operable units for purposes of the FS, and possibly the concomitant Record(s) of Decision (RODs). The operable unit concept is discussed further in Chapter 2.0.

1.2 PURPOSE

In accordance with the RI/FS Work Plan (Revision 3), and as cited in the detailed FS Work Plan, several interim reports corresponding to distinct FS tasks have been assigned as milestone deliverables. The first of these, the Task 12 report on the Development of Alternatives, is presented herein. One purpose of these interim reports is that they serve as checkpoints that the FS is proceeding on schedule. More importantly, however, is the intent to have the reports solicit the U.S. EPA's input and concurrence on the progressive findings and conclusions as the FS proceeds. Such interim feedback will ensure that the most critical remedial action alternatives being promoted by the respective agencies are being fully considered, thereby supporting the timely issuance of a ROD upon completion of the FS. The opportunity for interagency input at each step of the FS process is also important to the DOE in that the corresponding budget process can proceed with increased confidence that the most probable options are being pursued.

Task 12 represents the initial step in the remedial action decision process. The goal of Task 12 is to develop and retain appropriate remedial action alternatives for the initial comparative screening in Task 13. To put Task 12 into perspective for purposes of this report, each remedial action alternative can be considered in its simplest form as a meaningful combination of individual types of technologies (e.g., waste removal, treatment, stabilization, etc.). More specificity can be introduced by the identification of individual process options within each technology type or grouping (e.g., air stripping as a treatment option). Under this simplified definition, the purpose of Task 12 is to select those combinations of technologies and process options that form a plausible set of remedial action alternatives in relation to both technological viability, and responsiveness to the remedial action objectives.

Task 12 is achieved by first forming a complete set of response actions consistent with the remedial action objectives for each operable unit. A universe of technology groupings is then identified and combined around these general response actions. Each technology type is technically evaluated based on implementability and effectiveness in meeting the remedial action objectives. Technologies not satisfying these general technical criteria are eliminated from further consideration. The elimination of a given technology in Task 12 necessarily eliminates from further consideration each remedial action alternative that would have relied on that technology. On the other hand, each combination of technologies comprised only of technologies that survive the initial screening is considered as a candidate remedial action alternative for further screening in Task 13.

The process of technology screening in Task 12 should not be construed as a screening of alternatives. The elimination of potential remedial action alternatives in Task 12 occurs strictly at the technology level; no comparative evaluation of alternatives is attempted. The latter effort is the subject of Task 13.

2.0 TECHNICAL APPROACH

2.1 OVERVIEW

In accordance with the FS Work Plan and the U.S. EPA's current guidance, the development of alternatives in Task 12 is to be accomplished through the completion of the following six activities:

- Identification of the volumes and areas of media/wastes
- Refinement of remedial action objectives
- Development of general response actions
- Identification and screening of remedial technologies and technology process options
- Evaluation of technology process options
- Assembly of alternatives

The volumes and areas of the media and/or wastes are presented for each operable unit in Chapter 3.0. In addition to this baseline data, other types of information provided in Chapter 3.0 include the physical properties of the media and wastes, the contaminants of concern, and any special characteristics of the operable units that could affect the screening of technologies and the development of remedial action alternatives.

The remedial action objectives are presented in Chapter 2.0 within the framework of the overall technical approach. A discussion will also be presented in Chapter 6.0 on the relative degree to which each remedial action alternative developed in Task 12 would satisfy the specified objectives. At this stage of the FS process, the remedial action objectives are kept general and do not reach the point of specifying the acceptable levels of each contaminant of concern for all pathways and receptors. One reason is that the range of remedial action alternatives being maintained for each operable unit includes options that achieve full removal of a source, total elimination of a pathway, and/or complete protection of receptors for a given pathway. The technology combinations also remain flexible enough to accommodate a broad range of radionuclides and chemicals found to be of critical concern at a later date. Under this scenario, the screening of technologies and the development of alternatives being performed in Task 12 are not highly sensitive to specific contaminants or cleanup levels. It should be noted, however, that information on the contaminants of concern, the exposure pathways and receptors, and the acceptable contaminant levels is being concurrently developed as part of the RI/FS risk assessment.

The remaining four activities of Task 12 are the subject of Chapters 4.0 through 6.0. In Chapter 4.0, a comprehensive set of response actions is identified for each operable unit through a series of technology flow charts that begin with the three general response actions of removal, nonremoval, and no action. These flow charts set the stage for the screening of technologies and the development of remedial action alternatives in Chapters 5.0 and 6.0, respectively.

The evaluation and screening of technologies and process options are accomplished in two steps in Chapter 5.0 A preliminary screening is first performed to determine, by engineering judgment, those technologies or process options that are not technically applicable to the conditions associated with the site as a whole or with a specific operable unit. Any technology or process option so designated is then dropped from further consideration. In the second step, each technology or process option that remains is addressed in more detail in terms of its underlying scientific principles, its pertinent applications, and its current status (i.e., proven, pilot-scale, developmental, etc.). A qualitative, comparative evaluation of technologies is then performed based on the criteria of effectiveness, implementability, and costs.

The results of the technological evaluation are used in Chapter 6.0 to develop up to ten remedial action alternatives for each operable unit, although the inclusion of several process options for a single technology grouping creates numerous variations for some alternatives. Care was taken to preserve at least one of each general category of alternative required under CERCLA/SARA.

2.2 OPERABLE UNITS

Several references have been made in previous sections to the concept of operable units and the intent to utilize an operable unit approach for the FS at the FMPC. The principal reason for the use of operable units--the need to address a wide variety of complex problems for numerous types of facilities--is technically based. An equally important advantage, however, is that the operable unit approach can accommodate separate FS schedules such that the FS process for each operable unit can be finalized at the earliest possible date. In comparison, a single sitewide FS could only be considered complete once the RI data base and FS analysis are completed for every unit of the FMPC.

The individual components of each operable unit, as previously proposed in the detailed FS Work Plan, are given in Table 2.1. One exception is Operable Unit 3, which has been modified to achieve consistency with the facilities testing program. At the time of the FS Work Plan submittal, Operable Unit 3 was defined by a large number of individual facility types and suspect areas considered to represent the most likely points of past or current environmental releases. Since that time, revisions to the underlying framework for the investigation of the facilities and suspect areas occurred as the revised Facilities Testing Work Plan was developed. The relevant units of Operable Unit 3 are now more effectively defined by the components shown in Table 2.1. A second change is that the metal scrap piles located within Operable 2. However, because WMCO continues to segregate and remove the metal scrap and the recently submitted Facilities Testing Work Plan incorporates the investigation of the piles, the metal scrap piles have been transferred to Operable Unit 3 for purposes of the FS.

The technology screening and development of remedial action alternatives reported herein address each of the operable units separately. However, the level of detail to which each operable unit is addressed varies. Operable Units 1, 2, and 4 are considered in relatively more detail than the other operable units. With reference to Table 2.1, these three operable units are comprised of units representing potential sources of contamination to ground

TABLE 2.1

COMPONENTS OF OPERABLE UNITS

OPERABLE UNIT NO. 1
WASTE STORAGE UNITS

Pits 1,2,3
Pit 4
Pit 5
Pit 6
Clear Well
Burn Pit

OPERABLE UNIT NO. 2:
SOLID WASTE UNITS

Lime Sludge Ponds
Fly Ash Piles
Sanitary Landfill
South Field Area

OPERABLE UNIT NO. 3:
FACILITIES AND SUSPECT AREAS

Production Area Facilities
Production Area Suspect Areas
Fire Training Area
Incinerator Area
Rubble Mounds
Abandoned Drum Locations
Area Near Flagpole

OPERABLE UNIT NO. 4:
SPECIAL FACILITIES

K-65 Silos
Metal Oxides Silo
Thorium Inventory

OPERABLE UNIT NO. 5:
ENVIRONMENTAL MEDIA

Soils
On-Site Ground Water
Flora and Fauna
Regional Aquifer
Ambient Air

OPERABLE UNIT NO. 6
SURFACE WATER COURSES

Paddy's Run
Great Miami River
Storm Water Outfall Ditch

water and other environmental media. The remedial action objectives for these units are, therefore, centered in source control. The development of remedial action alternatives for the units will be highly driven by the implementability and effectiveness of technologies and combinations of technologies. As such, the screening of technologies and the development of alternatives in Task 12, which focus on the technical suitability of remedial technologies, are centrally important to the future direction of the FS for Operable Units 1, 2, and 4.

The facilities and suspect areas represented by Operable Unit 3 also represent potential candidates for source control actions. In this case, however, many of the expected actions will likely be routine "fixes" carried out as part of Westinghouse Materials Company of Ohio's (WMCO) ongoing operations to satisfy, among other requirements, the Spill Prevention Control and Countermeasure (SPCC) Plan and the Best Management Practices (BMP) Plan. Examples may include equipment repair or replacement, abandoned drum removal, runoff control, and localized soil removal. Even major response activities that are associated with active operations (e.g., decontamination and decommissioning [D&D] activities, waste treatment, etc.) can be expected to be performed through an operations-based decision process and may not require a formal FS under the subject RI/FS process. Another possible scenario for Operable Unit 3 is that any associated contamination of soils and ground water may be better addressed along with the sitewide environmental media in Operable Unit 5. For these reasons, a detailed screening of technologies and the development of alternatives for Operable Unit 3 will not be performed at this time. Any future FS activities for Operable Unit 3 will be completed, as necessary, based on the findings of the facilities testing program and related designations of program responsibility (e.g., BMP versus RI/FS). The remedial action objectives for Operable Unit 3 may best be accomplished through problem-specific interagency agreements. These could involve a series of focused evaluations and recommendations agreed to by the involved agencies rather than a formal RI/FS and ROD process.

Remedial actions associated with Operable Units 5 and 6 will be oriented toward the management of migration (i.e., pathway elimination or modification) and/or receptor modification. The physical and chemical/radiological composition of the environmental media being addressed is not as varied or complex as is the case with the waste storage units in Operable Units 1, 2, and 4. Consequently, the technologies required to achieve the objectives of Operable Units 5 and 6 are more straightforward and within the bounds of established engineering practice. The limited number of technologies requiring consideration and their generally proven performance limits the need for a comparative evaluation of technologies in Task 12. The technology evaluation process has, therefore, been performed at a lesser degree of detail without impacting the direction or progress of subsequent FS tasks. A more refined evaluation will be provided during the initial screening and detailed evaluation of alternatives in Tasks 13 and 14, respectively.

Complicating factors to the overall concept of an operable unit approach are the till layer and any associated perched ground water. If either the subsurface soils or the ground water are contaminated, the till zone could be interpreted as a potential source of contaminant release to the more important sand and gravel aquifer. Within the context of this interpretation, it would be appropriate to address the till and perched ground water under a source control scenario as part of the operable unit corresponding to the ultimate source of the contamination (e.g., the waste pits in Operable Unit 1). On the other hand, contaminated subsurface soils and perched ground water represent, in and of themselves, impacted environmental media that could be addressed under Operable Unit 5. An argument for the latter interpretation is that the associated need for and extent of remedial action would be more appropriately analyzed from a risk-based approach than by evaluating these media as waste sources.

The approach to be followed in the FS will be to evaluate the till zone and perched ground water on a case-by-case basis. For example, any contaminated till or ground water underlying either the waste pits or the Production Area are confined within the institutional control zone of the FMPC and would represent an environmental hazard only as a potential source of leachate. From a practical perspective, a responsive remedial action on the till or perched ground water can be more effectively carried out as part of a source control action. Examples of the latter include the removal of soils underlying a waste pit concurrent with the removal of the waste itself, or the installation of a slurry wall that would control releases from both a waste source and the underlying till zone. In those cases where the till or perched ground water are not in direct contact with a waste source, they will be considered as environmental media under Operable Unit 5.

2.3 REMEDIAL ACTION OBJECTIVES

The FS work plan presented 26 medium-specific remedial action objectives for the FMPC. The pertinence of these objectives to each of the six operable units is summarized in Table 2.2. Not all of the objectives identified in the table apply to each of the components of a given operable unit. The specific relationships between the individual components and the objectives are summarized in Table 2.3. The numerical entries in Table 2.3 correspond to the reference numbers for each objective given in Table 2.2.

The configuration of the entries in Table 2.2 supports previous discussions of important differences among the operable units. The objectives for Operable Units 1 through 4 are shown to be mutually consistent and generally aligned with the isolation or control of a waste source. The only areas of overlap with the objectives of Operable Units 5 and 6 are the potential need to consider contaminated surface soils in the Production Area and suspect areas under Operable Unit 3, and with the air releases from the K-65 silos under Operable Unit 4.

The objectives for Operable Units 1 through 4 can be generally satisfied by both the removal and nonremoval (i.e., stabilization/isolation/containment) response actions developed for these units. A key distinction exists between these two types of general response actions, however, a distinction that is directly related to the remedial action objectives. In particular, Objectives 5 and 6 place emphasis on whether a residual release can be

TABLE 2.2

REMEDIAL ACTION OBJECTIVES BY OPERABLE UNIT

REF. NO.	OBJECTIVES	OPERABLE UNIT 1	2	3	4	5	6
1,2	Prevent Ingestion of or Direct Contact with Chemical Wastes (1) or Radiological Wastes (2)	• •	• •	• •			
3	Prevent Release of Airborne Contaminants from Wastes	•	•	•			
4	Prevent Release of Radon Gas from Wastes				•		
5,6	Prevent Migration of Contaminants to Environmental Media that Would Exceed Public Health (5) or Environmental (6) Standards	• •	• •	• •	• •		
7,8	Prevent Ingestion of Ground Water Exceeding Public Health Standards for Hazardous Chemicals (7) or Radionuclides (8)					• •	
9	Restore Ground Water to Meet Environmental Standards					•	
10,11	Prevent Ingestion of Surface Water Exceeding Public Health Standards for Hazardous Chemicals (10) and Radionuclides (11)						• •
12	Restore Surface Water Quality to Meet Environmental Standards						•
13	Restore Surface Water Quality to Avoid Adverse Environmental Impacts						•
14	Prevent Ingestion of Contaminated Sediment						•
15	Prevent Excessive Releases of Contaminants from Sediment						•

TABLE 2.2
(Continued)

REF. NO.	OBJECTIVES	OPERABLE UNIT 1	2	3	4	5	6
16,17 18	Prevent Inhalation of Air Exceeding Public Health Standards For Carcinogens (16), Radionuclides (17), and Non-carcinogens (18)					• • •	
19	Prevent Ingestion of or Contact with Contaminated Soils			•		•	
20	Prevent Release of Airborne Contaminants from Soils			•		•	
21	Prevent Excessive Leaching of Contaminants from Soils			•		•	
22	Prevent Excessive Erosion of Contaminated Soils to Surface Water Courses			•		•	
23	Prevent Direct Contact with Contaminated Structures			•	•		
24	Correct Structural Conditions that Could Lead to Sudden Releases of Chemicals or Radionuclides			•	•		
25	Prevent Ingestion of or Contact with Contaminated Flora/Fauna					•	
26	Prevent Excessive Uptake of Contaminants by Flora/Fauna					•	

PRELIMINARY REMEDIAL ACTION OBJECTIVES

TABLE 2.3

OPERABLE UNIT	UNIT	SOLID WASTES	LIQUID WASTES	SLUDGES	GROUND WATER	SURFACE WATER	SEDIMENT	AIR	SOILS	STRUC-TURES	FLORA & FAUNA
1	PITS 1 – 3	5,6	0	5,6	0	0	0	0	0	0	0
1	PIT 4	1,2,3,5,6	0	1,2,3,5,6	0	0	0	0	0	0	0
1	PIT 5	1,2,3,5,6	1,2,3,5,6	1,2,3,5,6	0	0	0	0	0	0	0
1	PIT 6	5,6	1,2,3,5,6	5,6	0	0	0	0	0	0	0
1	CLEAR WELL	0	1,2,3,5,6	1,2,3,5,6	0	0	0	0	0	0	0
1	BURN PIT	5,6	0	5,6	0	0	0	0	0	0	0
2	LIME SLUDGE PONDS	0	1,5,6	1,5,6	0	0	0	0	0	0	0
2	FLY ASH PILES	1,2,3,5,6	0	0	0	0	0	0	0	0	0
2	SANITARY LANDFILL	1,2,3,5,6	0	0	0	0	0	0	0	0	0
2	SOUTH FIELD AREA	2,5,6	0	0	0	0	0	0	0	0	0
3	PRODUCTION AREA FACILITIES	0	0	0	0	0	0	0	21,22	23,24	0
3	PROD. AREA SUSPECT AREAS	1,2,3,5,6	0	0	0	0	0	0	19,20,21,22	0	0
3	FIRE TRAINING AREA	0	1,2,3,5,6	0	0	0	0	0	19,21,22	24	0
3	INCINERATOR AREA	0	0	0	0	0	0	0	21,22	23	0
3	RUBBLE MOUNDS	1,2,3,5,6	0	0	0	0	0	0	0	0	0
3	ABANDONED DRUM LOCATIONS	0	0	1,2,3,5,6	0	0	0	0	0	0	0
3	AREA NEAR FLAG POLE	5,6	0	0	0	0	0	0	0	0	0
4	THORIUM INVENTORY	0	0	0	0	0	0	0	0	23,24	0
4	K-65 SILOS	4,5,6	0	0	0	0	0	0	0	23,24	0
4	SILO 3 (METAL OXIDE)	4,5,6	0	0	0	0	0	0	0	23,24	0
5	SOILS	0	0	0	0	0	0	0	19,20,21,22	0	0
5	ON-SITE GROUND WATER	0	0	0	9	0	0	0	0	0	0
5	FLORA AND FAUNA	0	0	0	0	0	0	0	0	0	25,26
5	REGIONAL AQUIFER	0	0	0	7,8,9	0	0	0	0	0	0
5	AMBIENT AIR	0	0	0	0	0	0	16,17,18	0	0	0
6	STORM WATER OUTFALL DIT.	0	0	0	0	0	0	0	0	0	0
6	PADDY'S RUN	0	0	0	0	12,13	14,15	0	0	0	0
6	GREAT MIAMI RIVER	0	0	0	0	10,11,12,13	14,15	0	0	0	0

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accepted under a nonremoval scenario, and if so to what level. This factor could eventually tie Operable Units 1, 2, 3, and 4 back to Operable Unit 5 (and possibly Operable Unit 6) if residual releases influence the evaluation and selection of remedial actions for the environmental receptors.

With reference to Table 2.2, the remedial action objectives for Operable Units 5 and 6 appear to be mutually exclusive. This distinction is because the objectives have been established on a medium-specific basis and differences in environmental media are what distinguishes Operable Units 5 and 6. The objectives are, however, very consistent and related through the common themes of protecting environmental resources and controlling migration to human receptors. The real distinction in this case is the variability in technical options to achieve the objectives. Problems associated with soil and flora/fauna will likely be dealt with by removal or isolation technologies in a manner generally consistent with source control strategies. Sediments will also be treated within the context of source control, whereas response actions to meet the surface water objectives will necessarily fall back on controlling the causal sources rather than "cleaning up" the surface water itself. In the case of the ambient air pathway, any receptor-based effects can be meaningfully dealt with only by controlling the original source(s) of airborne releases.

Potential response actions for ground water are more numerous and dependent on the specific objectives being addressed. Any current problems requiring a response action at a receptor location would likely entail receptor modification options--those options that eliminate an exposure pathway at the receptor itself. Examples would include an alternate water supply or treatment prior to use. The objectives dealing with existing environmental degradation or the future potential for receptor risk from a migrating plume point toward pathway modification/elimination actions. Typical methods could include ground water pumping and treatment, ground water flow control through gradient reversal, subsurface structures for ground water isolation, etc. For those cases where the remedial action objective centers on long-term plume management, it may be most effective to implement control at the source as a single (or supplementary) response action.

The relationship between the overall remedial action objectives for the FMPC and the specific remedial action alternatives developed in Task 12 will be further discussed in Chapter 6.0.

A more quantitative set of remedial action objectives that achieves consistency with the applicable or relevant and appropriate requirements (ARARs) is being developed as part of the ongoing RI/FS risk assessment. A detailed examination of the contaminants of concern, the critical pathways of exposure, and recommended cleanup levels will be completed within the context of specific operable units. The results will be used in subsequent FS tasks as the relationship between the technical adequacy of an alternative and the associated objectives develops. The current lack of qualitative objectives (e.g., specific cleanup levels) has not impacted the progress or direction of the FS through Task 12. Considerable work has been accomplished in the past to affirm that the fundamental objective of protecting human health and the environment will be satisfied by the remedial action objectives presented in Table 2.2, the set of potential candidates for remedial action identified in Table 2.1, and the associated response actions and remedial action alternatives presented in this report.

3.0 CHARACTERISTICS OF OPERABLE UNITS

This chapter includes descriptions of the important physical properties and chemical nature of Operable Units 1 through 6. The descriptions include a brief history, amounts and materials placed in the units, and any special characteristics potentially important to the development of remedial action alternatives. Where applicable, boring information is provided that details the material description and consistency encountered in each unit. The information provided in this chapter is intended as a summary of the current knowledge on each operable unit; more detailed presentations that incorporate all recent findings will be provided in the forthcoming RI report(s).

Tables have also been prepared to summarize the geotechnical parameters and the amounts and concentrations of radioactive material, volatile organics, HSL semivolatiles and inorganics, hazardous materials, and listed hazardous materials. All data presented in Tables 3.1 through 3.18 are taken directly from the referenced sources. Some values were "rounded off" for consistency.

3.1 OPERABLE UNIT 1

Operable Unit 1 consists of Waste Pits 1 through 6, the burn pit, and the clear well. Characteristics of the units in Operable Unit 1 are tabulated in Tables 3.1 through 3.8. The descriptive information, including test boring data and interpretation was obtained from Reference 4 listed in Table 3.8. The material in Waste Pit 4 is considered a mixed waste due to the disposal of hazardous waste materials.

3.1.1 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. The thickness of the clay liner is reported to be 4 feet on the bottom and 1.5 to 2.0 feet on the sides. Waste Pit 1 has a 80,000 square foot surface area with an estimated 40,000 cubic yards of buried waste. It contains neutralization waste filter cake, fly ash, 55-gallon drums, scrap graphite, brick scraps, sump liquor/cake, depleted slag, and an estimated

120,000 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. Neither the origin nor the nature of the materials stored in these drums is known although the photographs indicate that most are empty. In 1959, Waste Pit 1 was backfilled and covered with clean soil. Surface water runoff is diverted to the clear well prior to discharge to the Great Miami River.

The general consistency of the contents in Waste Pit 1 reflects semisolid to saturated conditions at an eight-foot depth below the present pit surface. Borings indicate an apparent cover layer, 0.5 to 1.0 foot thick, consisting of dark yellowish brown to very dark brown clay. Each boring was drilled to a total depth of 12 feet. In no instance was any underlying natural material or liner encountered, indicating that the waste is at least 11 to 11.5 feet thick in Waste Pit 1. Observations of the materials sampled made in each boring are summarized as follows:

Boring 1

- 1 to 7 feet - Very dark brown silt with some clay, maybe fly ash.
- 7 to 12 feet - Light gray silt with some dark yellowish brown clay, moist throughout, becoming wet at about 8 feet.

Boring 2

- 1 to 10 feet - Light gray material with a semisolid consistency, traces of bright yellow clay-like material, moist throughout.
- 10 to 12 feet - Light gray, medium-grained sand grading down into white coarse sand with traces of black and bright yellow material.

Boring 3

- 1 to 10 feet - Grayish brown material with a semisolid or grease-like consistency. Some lime green material, possibly UF_4, observed from 1 to 2 feet. Becoming moist at 6 feet.
- 10 to 12 feet - Bright yellow semisolid material observed from 10 to 11 feet, grading back into grayish brown material.

Boring 4

- 0.5 to 12 feet: Dark gray silt with trace clay becoming damp at 4 feet and wet at about 7 feet. Some white silt in occasional, thin layers. White specks throughout samples from 4 to 12 feet, some red specks observed in sample from 8 to 12 feet. Brown paper observed in sample from 6 to 8 feet.

Boring 5

- 0 to 2 feet - Cover material may contain some fly ash and probably extends to a depth of 2 feet.
- 2 to 7 feet - Brown to yellowish brown clay, moist below 1 foot.
- 7 to 12 feet - Black silty material with a grease-like texture, grading downward into a bright yellow, laminated, clay-like material with a grease-like texture, slightly moist and soft.

Additional characteristics of Waste Pit 1, including the chemical nature of the pit materials, are summarized in Table 3.1.

3.1.2 Waste Pit 2

Waste Pit 2, constructed in 1957, was excavated to a 17-foot depth near a small pond east of Waste Pit 1 and lined with a compacted on-site native clay. Waste Pit 2 has a 48,215 square foot surface area with an estimated 13,000 cubic yards of buried waste. It contains neutralized waste filter cake, graphite, fly ash, 55-gallon drums, brick scrap, sump liquor/cake, and depleted slag. An estimated 2,700,000 pounds of uranium are contained in Waste Pit 2. A large quantity of concrete and other construction rubble are buried in the pit and will require special consideration in the evaluation of removal technologies.

In 1964, the pit was taken out of service, backfilled, and covered with clean soil. Waste Pit 2 is grown over with grass and is fairly level with a gentle slope towards a drainage ditch running alongside Waste Pit 4 on the east. Surface water runoff is diverted to the clear well prior to discharge to the Great Miami River.

TABLE 3.1

OPERABLE UNIT 1
WASTE PIT 1 CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	80,000 ft^2 (1.8 acres)	Reference 1
2.	Contents: Neutralized waste filter cakes, scrap graphite, brick scrap, sump liquor and cakes, 55 gallon drums, depleted slag, and fly ash	40,000 yd^3	Wastes deposited in Pit 1 are "dry" solid wastes - Reference 2
3.	Surface water	None	Pit was covered in 1959 - Reference 2
4.	Geotechnical data:		Reference 3
	Dry density	109.4 lb/ft^3	
	Specific gravity	2.62	
	Moisture content[b]	20.0%	
5.	Material consistency:		Reference 4
	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 texture materials were observed.		
6.	Radioactive material		
	Uranium	360 to 6,980 pCi/g (52,000 kg)[c]	Reference 1
	Uranium	16 to 151 pCi/g (370 kg)[c]	Reference 1
	Thorium - 230	122 to 1,980 pCi/g	Reference 1
	Technetium (Tc-99)	1 to 15 pCi/g	Reference 1 (volatile inorganic)
	Total radiochemistry	761 to 10.407 pCi/g	Reference 1
	Total curies	100 Ci	Reference 2
7.	Volatile inorganics		
	Arsenic (As)	14.46 to 15.2 mg/kg	Reference 1
	Mercury (Hg)	0.26 to 0.36 mg/kg	Reference 1

TAB. 3.1
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
8.	Organics		
	PCBs (Aroclors 1248, 1254, and 1260)	720 to 10,000 ug/kg	Reference 1
	4,4-DDT	1,600 µg/kg	Reference 1
9.	HSL semivolatiles		
	Chrysene	510 µg/kg	Reference 1
	Phenanthrene	770 to 2,300 µg/kg	Reference 1
10.	HSL inorganics		Reference 1
	Aluminum	1,703 to 20,223 mg/kg	
	Calcium	4,756 to 192,498 mg/kg	
	Magnesium	7,613 to 36,957 mg/kg	
	Iron	1,833 to 19,688 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	Maximum concentrations	Reference 1
	Chloroform (U044)	210 ppb	
	Chrysene (U050)	510 ppb	
			The concentration level for all other hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

[a]References are listed in Table 3.8.

[b]By percent of dry weight.

[c]Estimated total quantities from Reference 2.

The general consistency of the contents of Waste Pit 2 indicates semisolid and wet conditions at an eight-foot depth below the present pit surface. Five borings were drilled to total depths of ten feet using a drill rig and split-spoon sampling method. Observations of the materials sampled at each boring are summarized as follows:

Boring 1

- 0 to 0.5 foot - Brown clay.
- 0.5 to 8 feet - Black medium- to coarse-grained sand-sized material, possibly fly ash, traces of lime green clayey material, becoming wet below 6 to 7 feet, some soft, yellowish brown and white clay-like material from 7 to 8 feet, semisolid consistency.
- 8 to 10 feet - No recovery.

Boring 2

- 0 to 2 feet - Brown and yellowish brown clay with traces of lime green and bright yellow clayey material.
- 2 to 8 feet - No recovery, chunks of concrete up to 1 inch in diameter blocked tip of split-spoon sampler.

Borings 3, 4, and 5

- 0 to 0.75 foot - Yellowish brown clay with trace silt and abundant grass roots that appear to be cover material.
- 0.75 to 10 feet - Alternating layers of black, sand-sized material, possibly fly ash, and clay- and silt-sized material with a semisolid consistency; colors of this material included: yellowish brown, olive gray, very pale brown, and white; material is very soft and moist; sand-sized grains of material present and sometimes cemented together into chunks; some gravel also present.

Table 3.2 provides additional data on Waste Pit 2 and the materials disposed in the pit.

3.1.3 Waste Pit 3

Waste Pit 3, with a 27-foot depth, was constructed in 1959 by excavating into the underlying clay lens and placing a layer of clay along the pit walls. Waste Pit 3 has a 238,500 square foot surface area with an estimated

.ABLE 3.2

OPERABLE UNIT 1
WASTE PIT 2 CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	48,215 ft^2 (1.12 acres)	Reference 1
2.	Contents: Neutralized waste filter cakes, scrap graphite, brick scrap, sump liquor and cakes, depleted slag, fly ash, 55 gallon drums, and concrete and construction rubble	13,000 yd^3	Reference 2 - Wastes deposited in Pit 2 are "dry" solid wastes.
3.	Surface water	None	Reference 2 - Pit has been covered
4.	Geotechnical data:		Reference 3
	Dry density	86.3 lb/ft^3	
	Specific gravity	2.59	
	Moisture content[b]	20.3%	
5.	Material consistency:		Reference 4
	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.		
6.	Radioactive material		
	Uranium	53 to 17,900 pCi/g (1,206,000 kg)[c]	Reference 1
	Uranium - 235	1 to 8,780 pCi/g (2,550 kg)[c]	Reference 1
	Thorium - (TH-230)	1.2 to 3,980 pCi/g (400 kg)[c]	Reference 1
	Technetium (Tc-99)	1.0 to 618 pCi/g	Reference 1
	Total radiochemistry	111 to 50,092 pCi/g	Reference 2 (volatile inorganic)
	Total curies	108 Ci	Reference 2

:ABLE 3.2
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
7.	Volatile inorganics		
	Arsenic (As)	2.75 to 10.06 mg/kg	Reference 1
	Mercury (Hg)	0.22 to 0.70 mg/kg	Reference 1
8.	Organics		
	PCBs (Aroclors 1248, 1254, and 1260)	321 to 1,800 ug/kg	Reference 1
	4,4-DDT	580 to 1,400 µg/kg	Reference 1
	Vinyl chloride (volatile)	670 µg/kg	Reference 1
9.	HSL semivolatiles		
	Chrysene	920 to 180,000 µg/kg	Reference 1
	Fluoranthene	590 to 460,000 µg/kg	
	Phenanthrene	1,700 to 370,000 µg/kg	Reference 1
	Pyrene	1,600 to 310,000 µg/kg	
	2-Methylnaphthalene	7,000 to 7,000 µg/kg	
	4-Chlorophenyl-phenylether	6,200 to 6,200 µg/kg	
	Acenaphthene	4,300 to 4,300 µg/kg	
	Anthracene	12,000 to 12,000 µg/kg	
	Benzo(a)anthracene	860 to 180,000 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	
10.	HSL inorganics		Reference 1
	Aluminum	7,242 tp 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	
11.	Hazardous materials/wastes		Reference 1 All samples tested were within the established limits for corrosivity, reactivity, ignitability, and EP toxicity.

See footnotes at end of table.

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TABLE 3.2
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
12.	Listed hazardous materials	Maximum concentrations	
	Benzo(a)pyrene (U022)	140,000 ppb	Reference 1
	Chrysene (U050)	180,000 ppb	Reference 1
	Fluoranthene	460,000 ppb	Reference 1
	Indeno(1,2,3,CD)		
	Pyrene (U137)	46,000 ppb	Reference 1
	Naphthalene (U165)	16,000 ppb	
	Vinyl chloride (U043)	670 ppb	Reference 1
	Fluorine (P056)	62,000 ppb	Reference 1

[a]References are listed in Table 3.8.

[b]By percent of dry weight.

[c]Estimated total quantities from Reference 2.

227,000 cubic yards of buried waste. The pit contains lime-neutralized raffinate, raffinate concentrate, slag, slag leach residues, filter cake, 55-gallon drums, fly ash, lime sludge, and an estimated 290,000 pounds of uranium. An unknown (but large) number of drums and wooden pallets were disposed in Waste Pit 3 as evidenced by historic photographs. The drums are generally thought to be empty, but their origin and contents cannot be confirmed.

In 1977, the pit was taken 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 towards a drainage ditch running alongside the burn pit on the east. Surface water is diverted to the clear well prior to discharge to the Great Miami River.

A total of seven borings were drilled in Waste Pit 3 using a drill rig and split-spoon sampling method. In all the borings an apparent cover layer was observed. It ranged in thickness from 0.75 to 8.0 feet and consisted of yellowish brown to very dark clay with some fine- to coarse-grained sand, trace gravel, and abundant rootlets. Wet to saturated conditions were observed at an eight-foot depth below the present pit surface.

Boring 1 was drilled near the greenhouse on the north side of the pit. This boring was terminated after approximately eight feet because good recovery could not be obtained with the split-spoon sampler. Some wood fragments were recovered in the sampler, indicating that wooden pallets had been buried in this area. All other borings were very similar in overall stratigraphy, with the exception of three borings that exhibited a layer of black, medium- to coarse-grained sand-sized material beneath the cover layer. This material was probably fly ash and was observed from 0.75 to 14 feet in Boring 2, from 1 to 5 feet in Boring 3, and from 1 to 4 feet in Boring 6. This black material was underlain by a very soft, moist to wet, semisolid material that varied in color from reddish brown, brown, gray, to white. In the other borings, the latter material underlaid the cover layer and the black material was not present. This material extended to the bottom of the borings at 20 feet below the ground surface, at which point the borings were terminated to prevent intrusion into the underlying clay. Borings 6 and 7 were terminated at 12 to 14 feet, respectively, because the natural underlying material may have been encountered. This material consisted of yellowish-brown to brown clay with some rock fragments one inch across.

Additional information on Waste Pit 3 is presented in Table 3.3.

3.1.4 Waste Pit 4

Waste Pit 4, with a 24-foot depth, was constructed in 1960 in a manner similar to Waste Pit 3, utilizing a clay layer of approximately one-foot thickness along the pit walls. Waste Pit 4 has an 85,685 square foot surface area with an estimated 53,000 cubic yards of buried waste. The pit contains process residues, filter cake, slurries, raffinates, scrap graphite, noncombustible trash, asbestos, and an estimated 1,400,000 pounds of uranium and 140,000 pounds of thorium. An estimated 23,500 pounds of barium chloride was also placed in Waste Pit 4 in 55-gallon drums. Samples collected from the borings in Waste Pit 4 exhibited levels of barium in the parts per thousand range. The presence of barium at these levels has 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 investigation. An earthen berm surrounded the pit to retain surface water runoff. An interim RCRA cap is currently being installed on Waste Pit 4, with completion expected in December 1988.

Four borings were drilled into the pit. Boring and sampling methods used were identical to those described previously. All borings in Waste Pit 4 were advanced to a depth of 20 feet. Similar material was encountered in each boring. The general consistency of the samples indicates semisolid and wet to saturated conditions at a nine-foot depth below the present surface. The following summary of Boring 2 is typical of all borings in the pit:

TAB. 3.3

OPERABLE UNIT 1
WASTE PIT 3 CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	238,500 ft^2 (5.48 acres)	Reference 1
2.	Contents: Lime neutralized raffinate, raffinate concentrate, slag, slag leach residues, filter cakes, fly ash, lime sludge, 55 gallon drums, and wooden pallets	227,000 yd^3	Reference 2 - Wastes deposited in Pit 3 are termed "wet" wastes.
3.	Surface water	None	Pit has been covered - Reference 2
4.	Geotechnical data:		
	Dry density	88.3 lb/ft^3	Reference 3
	Specific gravity	2.54	
	Moisture content[b]	30.1%	
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		
	Uranium	134 to 1,380 pCi/g (129,000 kg)[c]	Reference 1
	Uranium - 235	2.5 to 21 pCi/g (1,771 kg)[c]	Reference 1
	Thorium - (TH-230)	15 to 21,900 pCi/g (1,010 kg)[c]	Reference 1
	Technetium (Tc-99)	1.0 to 1,110.0 pCi/g	Reference 1 (volatile inorganic)
	Total radiochemistry	187.5 to 25,542.1 pCi/g	Reference 1
	Total curies	553 Ci	Reference 2
7.	Volatile inorganics		
	Arsenic (As)	15.41 to 3,049.06 mg/kg	Reference 1
	Mercury (Hg)	0.45 to 4.01 mg/kg	Reference 1

See footnotes at end of table.

TAB. 3.3
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
8.	Organics		The concentration level for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
9.	HSL semivolatiles		The concentration level for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
10.	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	
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 other hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

[a]References are listed in Table 3.8.

[b]By percent of dry weight.

[c]Estimated total quantities from Reference 2.

Boring 2

- 0 to 4.5 feet - Yellowish-brown clay, trace silt, little medium to fine gravel, damp.
- 4.5 to 20 feet - Very dark gray silt and very fine sand-sized material. The material is saturated below 9 feet. Weak red staining occurs in the saturated zone and white, fine sand-sized specks occur in the unsaturated zone. Layers of brownish-yellow, clay-sized material occur at 10.5 feet and 17 feet.

Table 3.4 presents additional information on the physical and chemical characteristics of the materials in Waste Pit 4.

3.1.5 Waste Pit 5

Waste Pit 5, with a 30-foot depth, was constructed in 1968 and lined with a 60-ml thick Royal-Seal Ethylene Propylene Rubber (EPDM) elastometric membrane. Occasional joint failures and tears occurred at the surface and were noticed during routine inspections at various times and ascribed to weathering effects (NLO, 1985c). The corrective action has been to reglue the seam and patch the tears. Waste Pit 5 has a 183,737 square foot area with an estimated 102,500 cubic yards of disposed waste. The pit contains solids from neutralized raffinate, slag leach slurry, sump slurry, lime sludge, some construction-based debris, and an estimated 110,000 pounds of uranium and 38,000 pounds of thorium. The pit was taken out of service in 1987 but remains open. The effluent tower is estimated to contain 8,000 pounds of steel and 64,000 pounds of concrete.

The pit is partially covered with 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 this sampling, the waste materials were exposed over the eastern third of the pit. The depth of water in Pit 5 varies, depending on the relative amount of precipitation and evaporation. At a certain depth, water flows over the existing weir in the effluent tower to the clear well so that overtopping of the pit is not a concern.

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TABL ,.4

OPERABLE UNIT 1
WASTE PIT 4 CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	85,685 ft^2 (1.96 acres)	Reference 1
2.	Contents: Process residues, filter cakes, slurries, raffinates, depleted graphite, noncombustible trash, asbestos, and construction rubble.	53,000 yd^3	Reference 2 - Wastes deposited in Pit 4 are termed "dry" wastes.
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%	
5.	Material consistency:		Reference 4
	Silt and sand-sized material with layers of clay-sized material below 10 feet. The material was saturated below 9 feet.		
6.	Radioactive material		
	Uranium	509 to 15,800 pCi/g (3,048,087 kg)[c]	Reference 1
	Uranium - 235	35 to 426 pCi/g (5,529 kg)[c]	Reference 1
	Thorium - (TH-230)	2.2 to 566 pCi/g (61,800 kg)[c]	Reference 1
	Technetium (Tc-99)	6.8 to 225 pCi/g	Reference 1 (volatile inorganic)
	Total radiochemistry	711 to 19,409 pCi/g	Reference 1
	Total curies	233 Ci	Reference 2
7.	Volatile inorganics		
	Arsenic (As)	4.63 mg/kg	Reference 1
	Mercury (Hg)	0.18 to 0.63 mg/kg	Reference 1

See footnotes at end of table.

TABL 3.4
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
8.	Organics		Reference 1
	PCBs (Aroclors 1242, 1248, and 1254)	99 to 1,034 µg/kg	Reference 1
	Pesticides (ethyl and methyl parathion)	82 to 2,100 µg/kg	
9.	HSL semivolatiles		Reference 1
	Chrysene	760 µg/kg	
	Fluoranthene	1,000 to 2,000 µg/kg	Reference 1
	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	
10.	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	
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	Maximum concentrations	
	Chrysene (U050)	760 ppb	Reference 1
	Chloroform (U044)	1,300 ppb	Reference 1
	Fluoranthene (U120)	2,200 ppb	Reference 1
	Trichloroethene (U228)	300 ppb	Reference 1
	Benzo(a)pyrene (U022)	550 ppb	Reference 1
	Pyrene (U137)	1,400 ppb	Reference 1

TABL .4
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
12.	Listed hazardous materials (cont.)		The concentration level for other hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

[a]References are listed in Table 3.8.

[b]By percent of dry weight.

[c]Estimated total quantities from Reference 2.

Six borings were drilled in the pit. These borings were done using a piston ring sampler fabricated for use from a pontoon boat. The sampler was advanced by hand until it was stopped by the waste material or the rubber liner. Care was taken to advance the sampler to minimize the chance that the liner would be damaged. Waste thicknesses ranged from 3 to 29.4 feet.

Data collected from these borings indicate that Waste Pit 5 contains waste material only and that no naturally occurring, geologic materials are present. The moisture content of the material has been observed to be as high as 59.8 percent. The first 2 to 4 feet of waste material consists of dark brown, watery material with some sand-sized grains of material. In each of the borings, an approximate 0.5-foot crust of relatively dry, hard waste material overlies the underlying soft material. Other colors observed in this interval include very dark gray and black. Beneath this upper interval, a wet, semisolid material with very little cohesion was observed to the bottom of each boring. When a sample was composited, the overall color was a dull reddish brown. However, the semisolid material occurred in a variety of other colors, either as streaks or distinct layers. These colors included: reddish brown, yellowish red, yellowish brown, yellow, light gray, pinkish gray, greenish gray, reddish gray , pale green, blue green, brown, very dark brown, and black.

Additional information on the physical and chemical characteristics of Waste Pit 5 is provided in Table 3.5.

3.1.6 Waste Pit 6

Waste Pit 6, with a 24-foot depth, was constructed in 1979 in a manner similar to Waste Pit 5 and lined with an impermeable elastometric 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 9,000 cubic yards of disposed waste. It contains scrap "green salt," filter cake, slag, process residues, and an estimated 1,900,000 pounds of uranium. Thorium has been detected in Waste Pit 6 but the quantity disposed is unknown. The pit was taken out of service in 1985 but remains open. The pit surface is presently

TABLE 3.5

OPERABLE UNIT 1
WASTE PIT 5 CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	183,737 ft^2 (4.2 acres)	Reference 1
2.	Contents: Solids from neutralized raffinate, slag leach slurry, sump slurry, lime sludge, and construction-based debris	102,500 yd^3	Reference 2 - Wastes deposited in Pit 5 are termed "wet" wastes.
	Sludge		
	Sludge volume	102,500 yd^3	Reference 3
	Sludge solids	75×10^6 lbs	Reference 3
	Bulk volume	48,000 yd^3	Reference 3
	Sludge water (@ 57.5 lb/ft^3)	142×10^6 lbs	Reference 3
3.	Surface water	0.75×10^6	Reference 1 - Approximate quantity, volume directly related to precipitation and evaporation.
4.	Geotechnical data:		
	Dry density	62.5 lb/ft^3	Reference 3
	Specific gravity	2.43	Reference 3
	Moisture content[b]	59.8%	Reference 3
			Reference 4
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 material in the pit consists of watery material with some sand-size grains. The remaining 25 feet consists of a wet, semisolid material with very little cohesion.		

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See footnotes at end of table.

TABL. 3.5
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
6.	Radioactive material		
	Uranium	387 to 1,230 pCi/g (50,309 kg)[c]	Reference 1
	Uranium - 235	14 to 79 pCi/g (420 kg)[c]	Reference 1
	Thorium - (TH-230)	3,080 to 20,200 pCi/g (17,000 kg)[c]	Reference 1
	Technetium (Tc-99)	423 to 2,990 pCi/g	Reference 1 (volatile inorganic)
	Total radiochemistry	4,527 to 27,200 pCi/g	Reference 1
	Total curies	327 Ci	Reference 2
7.	Volatile inorganics		
	Arsenic (As)	139 to 2,800 mg/kg	Reference 1
	Mercury (Hg)	1.9 to 6.2 mg/kg	Reference 1
8.	Organics PCBs (Aroclor 1254)	750 ppb	Reference 1 The concentration level for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
9.	HSL semivolatiles		The concentration level for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
10.	HSL inorganics		Reference 1
	Aluminum	6,373 to 15,400 mg/kg	
	Calcium	116,000 to 206,144 mg/kg	
	Iron	59 to 236 mg/kg	
	Magnesium	25,202 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	

See footnotes at end of table.

TAl 3.5
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
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 other hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

[a]References are listed in Table 3.8.

[b]By percent of dry weight.

[c]Estimated total quantities from Reference 2.

covered with up to two feet of standing water, the depth of which varies depending on relative rainfall and evaporation amounts.

Four borings were drilled in Waste Pit 6. These borings were done using the ring sampler method. Borings were advanced until the pit liner or materials impenetrable to the manually operated ring sampler were encountered. Boring depths varied from 4 to 14.5 feet. In each case, this represents the thickness of the waste. The general consistency of the samples indicates that the waste is in a semisolid, saturated condition.

The following summary of Boring 4 is typical of borings in Waste Pit 6:

Boring 4

- 0 to 1.7 feet - Dark olive gray, coarse to fine sand-sized material, trace gravel-sized material, some clay-sized material, saturated, with soft yellow modules of clay-sized material.
- 1.7 to 7.8 feet - Black, medium to coarse sand-sized material, some clay-sized material and yellow clay modules, saturated, loose, petroleum sheen covering individual grains and liquid in sample. Olive, gray, yellow, and white staining throughout.
- 7.8 to 8.3 feet - Yellow coarse to fine sand-sized material, trace fine gravel, and some clay-sized material. Black staining throughout, saturated.
- 8.3 to 10 feet - Black, coarse to fine sand-sized material, some clay-sized material. Yellow and white staining throughout, saturated.

Table 3.6 summarizes additional information on Waste Pit 6.

3.1.7 Burn Pit

The burn pit was constructed in 1957 at the site from which clay had been previously excavated for lining Waste Pits 1 and 2. The boundaries of the burn pit are no longer discernible from covered Waste Pit 4. The depth of the burn pit varies due to 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 unknown. The pit was used to dispose of and

TAB. 3.6

OPERABLE UNIT 1
WASTE PIT 6 CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	32,400 ft^2 (0.75 acres)	Reference 1
2.	Contents: Depleted slag, scrap green salt, process residues, and filter cake	9,000 yd^3	Reference 2
3.	Surface water	485,000 gallons	Reference 1 - Approximate quantity, volume directly related to precipitation and evaporation.
4.	Geotechnical data:		Reference 3
	Dry density	101.2 lb/ft^3	
	Specific gravity	2.87	
	Moisture content[b]	25.4%	
5.	Material consistency:		Reference 4
	Saturated, soft coarse to fine sand-sized material and clay-sized materials.		
6.	Radioactive material		
	Uranium	12,500 to 18,700 pCi/g (863, 142 kg)[c]	Reference 1
	Uranium - 235	350 to 1,750 pCi/g (1,740 kg)[c]	Reference 1
	Thorium - (TH-230)	14 to 41 pCi/g (unknown)[c]	Reference 1
	Technetium (Tc-99)	84 to 164 pCi/g	Reference 1 (volatile inorganic)
	Total radiochemistry	15,009 to 26,109 pCi/g	Reference 1
	Total curies	178 Ci	Reference 2
7.	Volatile inorganics		
	Arsenic (As)	7.61 mg/kg	Reference 1
	Mercury (Hg)	0.03 to 0.07 mg/kg	Reference 1

See footnotes at end of table.

TABL 3.6
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
8.	Organics		The concentration level (except 1,1,2,2-tetrachloroethane) for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
9.	HSL semivolatiles		The concentration level for all semivolatile organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.
10.	HSL inorganics		Reference 1
	Aluminum	4,730 mg/kg	
	Calcium	22,190 mg/kg	
	Iron	2,750 mg/kg	
	Magnesium	32,101 mg/kg	
	Lead	5 to 60 mg/kg	
	Silver	158 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 1,1,2,2-tetrachloroethane (U209)	Maximum concentrations 29,000 ppb	Reference 1

[a]References are listed in Table 3.8.

[b]By percent of dry weight.

[c]Estimated total quantities from Reference 2.

burn laboratory chemicals, including pyrophoric and reactive chemicals, as well as waste oils and other low-level contaminated combustible materials such as wooden pallets. Activities at the burn pit were terminated in the summer of 1960. The burn pit is currently 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.

Six borings were drilled in the burn pit. These borings were done 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 terminated upon the first indication that natural, underlying material had been penetrated. In all the borings an apparent cover layer was observed. It ranged up to two feet thick 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 feet to as many as 16 feet at Boring 3. The consistency of the contents is of varying character, exhibiting properties similar to a sanitary landfill. Preliminary sampling indicates silt-sized semisolids, glass, organic material (e.g., wood, grass, and roots), metal, and carbonized residue remain in the burn pit.

The data collected from the borings indicated at least two distinct areas in the burn pit. The first area is in the northern half of the pit and was defined from Borings 1, 2, and 3. The stratigraphy of these borings consisted of the following:

- Cover material consisting of yellowish brown clay with some sand and silt, ranging in thickness from 1 to 2 feet.
- In Boring 1, a layer of white, silt-sized, semisolid material extended from 2 to 6 feet. In Borings 2 and 3, black, sand-sized material, ranging in thickness from 1 to 3 feet, was found beneath the cover.
- A layer of clay, with sand and silt mixed with some fill material, extends beneath the sand- or silt-sized material to a depth of 12 to 16 feet. The fill material includes glass, aluminum bottle caps,

aluminum wire, wood chips and splinters, and partially decayed grass. In Boring 3, only wet wood chips were recovered from 4 to 10 feet.

In contrast, the stratigraphy of Borings 4, 5, and 6 is similar to the borings from Waste Pits 2 and 3. The stratigraphy of these borings consisted of the following:

- Cover consisting of dark brown or dark yellowish brown clay with some sand and silt, ranging in thickness from 1 to 2 feet.
- A layer of very dark gray, fine- to medium-grained, sand-sized material was observed beneath the cover in all three borings and ranged in thickness from 5 to 7 feet. In Boring 4, this material had a charred appearance.
- Beneath the sand-sized material was a layer of silt-sized, semisolid material occurring in 0.25- to 0.50-inch-thick bands in the following colors: weak red, reddish yellow, pinkish white, pinkish gray, gray, pale green, pink, very dark gray, yellow, and white. This layer ranged in thickness from 3 to 5.5 feet.
- Underlying this layer was a light olive gray to light olive brown clay. This layer may be natural material.

Additional data on the burn pit is provided in Table 3.7.

3.1.8 Clear Well

The clear well was constructed at the time of Waste Pit 1 excavation. It served over the years as a settling basin for process water and a storm water runoff from the waste pits. Most recently, the clear well was used as a final settling basin for process water that passed through Waste Pit 5 prior to its discharge to the Great Miami River via a National Pollutant Discharge Elimination System (NPDES) discharge point. This use was terminated in March 1987 when Pit 5 was removed from the process water treatment scheme.

The clear well currently receives only surface water runoff from the waste pit area. Water of varying depth remains in the clear well at all times. The sediments resulting from material deposition were removed on at least one occasion during the period of operation. The depth of sediment remaining in

TABLl .7

OPERABLE UNIT 1
BURN PIT CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	Unknown	Reference 1
2.	Contents: Pyrophoric and reactive chemicals, waste oils, and combustible wastes	Unknown	This pit was used to burn various materials. The materials and chemicals remaining or otherwise disposed are unknown - Reference 2
3.	Surface water	None	Pit has been covered - Reference 2
4.	Geotechnical data:		
	Dry density	81.2 lb/ft[3]	Reference 3
	Specific gravity	2.35	
	Moisture content[b]	Unknown	
5.	Material consistency: One area consisted of silt-sized, semi-solid 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		
	Uranium	22 to 454 pCi/g	Reference 1
	Uranium - 235	0.5 to 27 pCi/g	Reference 1
	Thorium - (TH-230)	0.1 to 26 pCi/g	Reference 1
	Technetium (Tc-99)	0.4 to 64 pCi/g	Reference 1 (volatile inorganic)
	Total radiochemistry	38 to 1,012 pCi/g	Reference 1
	Total curies	Unknown	Reference 2
7.	Volatile inorganics		
	Arsenic (As)	4.38 to 20.91 mg/kg	Reference 1
	Mercury (Hg)	0.14 to 0.24 mg/kg	Reference 1

TABLE 3.7
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
8.	Organics		
	PCBs (Aroclors 1016, 1242, 1248, and 1254)	290 to 2,700 μg/kg	Reference 1
9.	HSL semivolatiles		
	Benzo(b)fluoranthene	69 to 170 μg/kg	Reference 1
	Benzo(g,h,i)perylene	85 μg/kg	Reference 1
	Chrysene	73 to 77 μg/kg	Reference 1
	Pentachlorophenol (2)	1,200 to 2,600 μg/kg	Reference 1
	Phenanthrene	100 to 190 μg/kg	Reference 1
	2-Methylnaphthalene	50μg/kg	Reference 1
	Tetrachloroethene (volatile)	260 μg/kg	Reference 1
	Ethylbenzene (volatile)	270 μg/kg	Reference 1
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.
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 3.8.

[b]By percent of dry weight.

the clear well is unknown. Additional information on the clear well is provided in Table 3.8.

3.2 OPERABLE UNIT 2

Operable Unit 2 consists of the north and south lime sludge ponds, the sanitary landfill, the upper and lower fly ash piles, and the south field area. The descriptive information, including test boring data was obtained from Reference 1, listed in Table 3.11, all volumes.

3.2.1 Lime Sludge Ponds

Spent lime sludges from FMPC water treatment plant operations (lime-alum sludges and boiler plant blowdown) are conveyed to two unlined ponds for storage. Each pond, designated north and south, is approximately 200 feet by 100 feet by 6 to 8 feet deep, respectively, with a total volume of 5,000 cubic yards per pond. The south pond has been inactive for some time and is overgrown with grass. The other pond is approximately 90 percent full and is partially covered with water. No hazardous materials are recorded as being received at the lime sludge ponds, although some organics were found in samples from the north pond. There are no significant amounts of radioactive materials in the ponds.

A description samples of Boring 2 gives a representative description of the material consistency in the north pond. The log for Boring 2 is summarized as follows:

<u>Boring 2</u>

- 0 to 2.1 feet - Light gray, soupy liquid with some silt
- 2.1 to 3.8 feet - Grayish brown semisolid
- 3.8 to 5.5 feet - Very dark gray to black semisolid, fragments of dark brown silt with clay present
- 5.5 feet - Sampler refusal

The logs for each boring in the south pond were very similar. The waste may be described as a clay-like, semisolid material with very low cohesion. The

TAB. 3.8

OPERABLE UNIT 1
CLEAR WELL CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	25,500 ft^2 (0.58 acres)	Reference 1
2.	Contents: Clarified process effluents and surface runoff	Unknown	Reference 2 Clear well was used as a final setting basin for process water from other pits and storm water runoff.
3.	Surface water	Unknown	
4.	Geotechnical data:	Unavailable	
5.	Material consistency	Unavailable	Reference 4
6.	Radioactive material		
	Uranium	548 to 670 pCi/g	Reference 1
	Uranium - 235	24 to 49 pCi/g	Reference 1
	Thorium - (TH-230)	0.3 to 5,600 pCi/g	Reference 1
	Technetium (Tc-99)	0.40 to 278 pCi/g	Reference 1 (volatile inorganic)
	Total of all measured radionuclides	860 to 8,014 pCi/g	Reference 2
7.	Volatile inorganics		
	Arsenic (As)	8.41 to 18.46 mg/kg	Reference 1
	Mercury (Hg)	0.42 to 4.38 mg/kg	Reference 1
8.	Organics		
	PCBs (Aroclors 1248 and 1254)	308 to 737)g/kg	Reference 1
9.	HSL semivolatiles		The concentration level for all organics analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

See footnote at end of table.

TAB. 3.8
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] 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	8 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 hazardous materials analyzed was below quantification level. See Appendix B of Reference 1 for concentrations.

[a]References:

1. Weston, Roy F., November 1987, "Characterization Investigation Study Volume 2: Chemical and Radiological Analyses of the Waste Storage Pits," Roy F. Weston, Inc.

2. Weston, Roy F., "Site Characterization of the Waste Storage Areas Part 1: Evaluation of Current Situation," Roy F. Weston, Inc.

3. Weston, Roy F., March 1988, "Geotechnical Evaluation of Feed Properties Material Properties of Waste Pit Materials at the Feed Materials Production Center, Fernald, Ohio," Roy F. Weston, Inc.

4. Appendix F of Reference 1 - Geological Description of Waste Pit Borings.

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color of the waste material was either white, light gray, light greenish gray, very pale brown, or very dark gray. Most often, the dominant color was white with the other colors present in streaks or blotches. Brown specks of material were also present in some of the samples.

Additional information on the lime sludge ponds is summarized in Table 3.9.

3.2.2 Sanitary Landfill

The sanitary landfill is located on a three-acre tract in the northeast corner of the Waste Storage Area. The facility is organized into 17 individual cells, 5 of which are full and out of service. The remaining 12 cells are awaiting issuance of an OEPA permit to install. Each cell is estimated to provide approximately 2,000 cubic yards of gross disposal volume. Materials that have been accepted at the facility include nonburnable, nonradioactive sanitary wastes generated on site and nonradioactive, construction-related rubble. Sanitary wastes were deposited at an average rate of 20 cubic yards per week. Small quantities of nonradioactive asbestos were also deposited at the landfill.

The general consistency of the contents indicates a fairly firm, compacted, unsaturated condition. The following summary of Boring 3 is typical of borings advanced into the sanitary landfill:

Boring 3

- 0 to 6.2 feet - Light olive brown clay with traces of silt, medium to fine sand, and medium to fine gravel, damp
- 6.2 to 12.8 feet - Black, fine sand- and silt-sized material slightly cemented with fiberboard and hard dense white foam (roofing material), damp to wet
- 12.8 to 14 feet - Yellowish-brown clay with trace fine gravel, dense, fairly hard

Table 3.10 contains additional information on the sanitary landfill.

TABLE 3.

OPERABLE UNIT 2
NORTH AND SOUTH LIME SLUDGE POND CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area: Approximate dimensions 100 x 200 x 6 x 8' deep (North and South Ponds, respectively)	20,000 ft^2 (each pond)	Reference 2
2.	Contents: Spent lime, lime-alum sludge and boiler plant blowdown	5,000 cu. yd. (each pond)	Reference 1 - North Pond is approximately 90% full. The South Pond is filled and closed.
3.	Surface water		Reference 2
	North Pond: Water depth ranging from 1 to 7 feet	600,000 gal.	
	South Pond	None	
4.	Data from geotechnical evaluation		Reference 2
	Specific gravity	2.33 to 2.49	
	Moisture content[b]	38.8 to 134%	
	Maximum dry density	72.8 lbs/ft^3	
5.	Material consistency: Nonplastic silty-clayey type material	94 to 99% of particles smaller than 74)m	Per ASTM422, silt-sized particles are defined in the 5 - 74)m range.
		10.5 to 16.7% of particles smaller than 5)m	Per ASTMD422, this size designation defines the beginning of clay and colloid particle range.
6.	Radioactive materials Thorium-230	0.5 to 20 pCi/g	All other radionuclide concentrations were at insignificant levels (Reference 1).

TABLE 3.
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
7.	Volatile inorganics		Reference 1
	Arsenic (As)	6.00 to 16.00 mg/kg	North Pond only. South Pond data indicates no As and Hg present.
	Mercury (Hg)		
8.	Organics		Reference 1
	North Lime Sludge Pond		
	Butyl Benzyl Phthalate	370 to 2,800 ug/kg	
	Chlordane	1,200 ug/kg	
	PCBs (Aroclor 1248)	1,200 ug/kg	
9.	HSL semivolatiles		Reference 1
	Phenol	1,200 µg/kg	
10.	HSL inorganic		Reference 1
	Aluminum	4,349 to 18,600 mg/kg	
	Calcium	252 to 333,762 mg/kg	
	Iron	5,042 to 20,600 mg/kg	
	Magnesium	15,141 to 21,200 mg/kg	
11.	Hazardous materials/wastes	Maximum concentrations	Reference 1
	Chlordane (V036)	1,200 ppb	
	Phenol (U188)	1,200 ppb	

[a]References are listed in Table 3.11.

[b]By percent dry weight.

TABLE 3.1.

OPERABLE UNIT 2
SANITARY LANDFILL CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	130,680 ft^2 tract (3 acres)	Reference 1 Land partially covered with grass, dirt, and rubble. Mounds cover 25% of the area.
2.	Contents: Nonburnable, nonradioactive sanitary wastes generated on site (20 cu. yds./wk), some asbestos	Volume of full cells 10,410 cu. yds.	Reference 1 17 individual cells, 5 full, 12 cells awaiting OEPA permit. Each cell provides disposal volume of 2,080 cu. yds.
3.	Surface water	None	Reference 2
4.	Data from geotechnical evaluation		Reference 2
	(a) Specific gravity	2.57 to 2.58	
	(b) Moisture content[b]	17.8%	
	(c) Maximum dry density	100.2 to 114 ft^3	
5.	Material consistency	52 to 60% of particles smaller than 74 μm	Reference 2 Per ASTMD422, silt-sized particles are defined in 5 to 74 μm range.
		23.2 to 30.0% of particles smaller than 5 μm	Reference 2 Per ASTMD422, this size designation defines the beginning of clay and colloid particle range.

TABLE 3
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
6.	Radioactive materials		Reference 1
	Uranium	12 to 35 pCi/g	
	Uranium-235	0.4 to 1.4 pCi/g	
	Thorium-230	0.1 to 0.2 pCi/g	
	Technetium (Tc-99)	0.4 pCi/g	
7.	Volatile inorganic		Reference 1
	Arsenic (As)	3.28 to 6.69 mg/kg	
	Mercury (Hg)	0.14 to 3.42 mg/kg	
8.	Organics		Reference 1
	PCBs (Aroclors 1242 and 1248)	110 to 565 µg/kg	
	2-Methylnaphthalene	66 to 11,000 µg/kg	
	Xylenes (volatile)	320 µg/kg	
9.	HSL semivolatiles		Reference 1
	Chrysene	1,900 to 4,600 µg/kg	
	Acenaphthene	1,300 to 28,000 µg/kg	
	Anthracene	1,900 to 2,800 µg/kg	
	Benzo(a)anthracene	1,900 to 5,100 µg/kg	
	Benzo(a)pyrene	1,900 to 7,000 µg/kg	
	Benzo(b)fluoranthene	1,900 to 6,700 µg/kg	
	Benzo(g,h,i)perylene	1,300 to 6,000 µg/kg	
	Benzo(k)fluoranthene	1,900 to 4,900 µg/kg	
	Dibenzo(a,h)anthracene	560 to 2,100 µg/kg	
	Fluoranthene	1,900 µg/kg	
	Fluorene	1,400 to 2,500 µg/kg	
	Indeno(1,2,3-CD)pyrene	1,400 to 5,700 µg/kg	
	Naphthalene	2,700 to 19,000 µg/kg	
	Phenanthrene	1,900 µg/kg	
	Pyrene	1,900 to 6,300 µg/kg	

TABLE 3.
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
10.	Hazardous materials/waste	Maximum concentrations	Reference 1
	Chrysene (U050)	4,600 µg/kg	
	Benzo(a)pyrene (U022)	7,000 µg/kg	
	Dibenzo(a,h)anthracene (U064)	2,100 µg/kg	
	Fluoranthene (U120)	1,900 µg/kg	
	Indeno(1,2,3-cd)pyrene (U137)	5,700 µg/kg	
	Naphthalene (U165)	19,000 µg/kg	
	Xylenes (U239)	320 µg/kg	

[a]References are listed in Table 3.11.

[b]By percent of total dry weight.

3.2.3 Fly Ash Disposal Areas

The fly ash disposal areas are located southwest of the Production Area. Fly ash resulting from the coal-fired boiler plant is loaded into dump trucks and transported to the disposal area. The inactive, retired upper pile contains approximately 50,000 cubic yards of fly ash and is sparsely covered with soil and vegetation. Building rubble such as concrete, gravel, asphalt, masonry, and steel rebar was also discarded in the upper fly ash pile area. These materials are found in the central section of the area where medium fill depths occur. Approximately 2,200 pounds of uranium are estimated to be present from the spreading of waste oils over the fly ash to control dust. The active lower pile located southeast of the upper pile currently contains approximately 33,000 cubic yards of fly ash.

The following is a summary of three boring logs representative of three areas encountered in the upper fly ash area. The first area is the western section, the second is the central section, and the third is the eastern section.

Boring 11

- 0 to 0.6 feet - Very dark gray silt with some coarse to fine sand and a little fine gravel (fly ash).
- 0.6 to 4.2 feet - Brown clay with a little coarse to fine sand and trace medium to fine gravel.
- 4.2 to 31.2 feet - Very dark gray silt with some coarse to fine sand and a little fine gravel (fly ash).
- 31.2 to 34 feet - Dark gray clay with a trace of fine sand and a little silt, undisturbed. Moisture content was high at the fly ash/ clay interface.

Boring 9

- 0 to 11 feet - Yellowish-brown clay grading to dark yellowish-brown clay with some medium to fine gravel and a little silt. The gravel is angular and small pieces of concrete and brick are present.
- 11 to 14 feet - Light yellowish brown clay with a trace of fine gravel and a trace of medium to fine sand, undisturbed, moist.

Boring 4

- 0 to 2.2 feet - Dark yellowish-brown clay with a little silt and coarse to fine gravel. This material is not in its natural state.
- 2.2 to 4 feet - Dark grayish-brown clay with a trace silt, grades to dark yellowish brown. Areas of oxidation throughout, undisturbed.

The lower fly ash area was an active disposal area for fly ash at the time of the Characterization Investigation Study. See Reference 1, listed in Table 3.11, all volumes. The focus of the investigation in this area was, therefore, the storm water outfall ditch that runs along the southeast side of the fly ash pile. A total of two borings were drilled in this area. The material encountered at both locations was natural and undisturbed with the exception of the first three feet of Boring 1 in which small pieces of brick, concrete, and plastic were found. Boring 1 was advanced 8 feet while Boring 2 was advanced 14 feet, approximately 2 feet below the water table. The following is a summary of the material in the borings:

Boring 1

- 0 to 3 feet - Very dark brown clay with some silt, trace fine sand, and a little medium to fine gravel, moist throughout. Concrete and brick pieces within upper 7 inches, piece of plastic at 3 feet.
- 3 to 4 feet - Yellowish-brown clay with trace silt and some medium to fine sand and gravel, moist, undisturbed.
- 4 to 8 feet - Yellowish-brown sand and gravel with a decrease in fines toward the bottom, moist throughout, undisturbed.

Boring 2

- 0 to 2.6 feet - Dark brown interbedded sand and gravel with occasional clay lenses, moist, undisturbed.
- 2.6 to 8.7 feet - Yellowish-brown sand and gravel, moist, undisturbed.
- 8.7 to 14 feet - Brown sand and gravel, moist to wet, clean, undisturbed.

Table 3.11 contains additional information on the fly ash disposal areas.

TABLE 3.11

OPERABLE UNIT 2
UPPER AND LOWER FLY ASH PILES CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
1.	Area	Unknown	Reference 1
	(a) Upper Fly Ash Piles	50,000 cu/yd	Some general construction rubble identified
	(b) Lower Fly Ash Pile	33,000 cu/yd	
2.	Contents	Fly Ash and Building Rubble	Reference 1
3.	Surface water	None	Reference 2
4.	Data from geotechnical evaluation	None	Reference 2
5.	Material consistency Upper fly ash pile: High- to low-plasticity clays intermixed with sand-sized particles and fly ash		Reference 2 Visual classification
	Low fly ash pile: Well-graded sand with medium to fine, clean gravel (no fly ash identified)		Visual classification
6.	Radioactive material		Reference 1
	Upper fly ash pile: Uranium	3.1 to 50 pCi/g (1,000 kg)	From waste oil sprayed for dust control
	Uranium-234	2 to 48 pCi/g	
	Thorium-230	0.1 to 11 pCi/g	

See footnote at end of table.

TABLE 3.11
(Continued)

ITEM NO.	DESCRIPTION	QUANTITIES AND UNITS	REFERENCES[a] AND/OR COMMENTS
	Lower fly ash pile:		
	Uranium	5.1 to 6.8 pCi/g	
	Uranium-234	4.5 to 5.7 pCi/g	
	Thorium-230	0.7 to 5.3 pCi/g	
7.	Volatile inorganics		Reference 1
	Arsenic (upper)	3.70 to 31.17 mg/kg	Low pile has trace
	Mercury (combined)	0.12 to 1.78 mg/kg	amounts
8.	Organics		Reference 1
	PCBs (Aroclors 1254 and 1260)	250 to 880 μg/kg	
9.	HSL semivolatiles	None	Reference 1
10.	HSL inorganics		Reference 1
	Aluminum	3,857 to 14,636 mg/kg	
	Calcium	3,622 to 187,187 mg/kg	
	Iron	7,282 to 32,006 mg/kg	
	Magnesium	463 to 30,281 mg/kg	
11.	Hazardous material/wastes	None	Reference 1

[a]References:

1. Weston, Roy F., November 1987, "Characterization Investigation Study Volume 2: Chemical and Radiological Analyses of the Waste Storage Pits," Roy F. Weston, Inc.

2. Weston, Roy F., March 1988, "Geotechnical Evaluation of Feed Properties Material Properties of Waste Pit Materials at the Feed Materials Production Center, Fernald, [illegible] Inc.

3.2.4 South Field Area

The south field area is reported by WMCO to be the site where construction rubble containing low levels of radioactivity, including debris from the razing of the old administration building, were disposed. It is assumed that material was dumped down the natural surface of a meander scar formed by Paddy's Run eroding into the till. As material was dumped, the fill extended outward in layers roughly parallel to the natural angle of repose.

The exact boundaries of the south field area are not fully defined. The area's south boundary is the steep slope rising from the floodplain of Paddy's Run just north of the running track. The western boundary is the approximate location of a small drainage ditch leading to Paddy's Run. It appears from the Characterization Investigation Study that the western third of this area is predominantly fly ash. The eastern boundary may lie immediately west of the roadway leading to the running track. The northern boundary location is unknown.

Surface radiological surveys indicate elevated readings in the drainage ditch along the gravel roadway and the drainage ditch along the west side of the area. The general consistency of the contents ranges from that of the fly ash piles to construction debris. The south field area will be further investigated as part of the facilities testing program.

3.3 OPERABLE UNIT 3

The relevant units of Operable Unit 3 are effectively separated into the following three groupings:

- Production Area - The Production Area grouping includes those facilities, suspect areas, and land areas within the inner fence of the FMPC. Active production facilities are included in this grouping. In particular, the following types of facilities and suspect areas are incorporated into the overall investigation of the Production Area:

  -Raw product and waste container storage and transfer facilities
  -Oil burner area (north of boiler plant)
  -Graphite burner area
  -Area southwest of laboratory

-Metal scrap pile area
-Transformer/hydraulic oil area
-Waste solvent drum storage area behind laboratory
-Abandoned drum areas
-Plant 1 shotblaster area
-South interior end of Plant 6

- Special Facilities Within Production Area - Four types of special facilities represent exceptions to the Production Area grouping. Included in the special facilities grouping are the underground storage tanks (USTs), below-grade piping, the main effluent line from the clear well to Manhole 175, and a former drum storage area behind the laboratory. A differentiation of these facilities was necessary to best accommodate the technical requirements of the respective testing programs.

- Suspect Areas Outside Production Area - Several of the identified suspect areas are physically located outside of the Production Area. Included in this grouping are the fire training area, the incinerator area near the sewage treatment plant, several rubble mounds and abandoned drum locations, and an area in the vicinity of the flagpole near the entrance to the administration building.

Environmental problems associated with these facilities and suspect areas, as well as areas within the Production Areas not directly associated with the identified units, will be investigated under the forthcoming facilities testing program. As discussed in Section 2.2, appropriate response actions will be evaluated as specific problems are identified and characterized.

3.4 OPERABLE UNIT 4

Operable Unit 4, waste storage silos, consist of the two K-65 silos (Silos 1 and 2), the metal oxide silos (Silos 3 and 4), and the thorium inventory stored on site. Characteristics of the units in Operable Unit 4 are tabulated in Tables 3.12 through 3.13. Silo 4 was never used and will not be investigated under the RI/FS.

3.4.1 Waste Storage Silos 1, 2, 3, and 4

The waste storage silos are located south of the waste pit area. The 80-foot-diameter silos were constructed with floors of 4-inch-thick concrete over an 8-inch layer of gravel containing an underdrain system of 2-inch-diameter slotted pipe draining to a collection tank. Below the gravel is a

2-inch-thick layer of asphaltic concrete underlain by 18 inches of compacted clay. The walls are 8-inch-thick concrete with a 0.75-inch-thick gunite coating on the exterior. The domed roofs taper from eight inches thick at the silo walls to four inches thick at the apex.

The K-65 silos (Silos 1 and 2) are used for the storage of radium-bearing residues formed as by-products of uranium ore processing. The K-65 silos received waste residues primarily between 1952 and 1958. The sources included slurry from the FMPC; 25,000 drums from a plant in St. Louis, Missouri; and 6,000 drums from Niagara Falls, New York. The K-65 silos also received a small quantity of soil excavated from a drum-handling area previously located to the east of, and adjacent to, Silo 3.

Waste raffinate slurries were pumped into the K-65 silos, where the solids would settle. The free liquid was decanted through a series of valves placed at various levels along the 36-foot height of the silo wall. The clarified liquid was sent to the refinery sump. As the depth of solids reached the level of a given valve, the valve was sealed and the next higher valve was used to decant liquids. Settling and decanting were continued in this way until the silos were filled to approximately 4 feet below the top of the vertical wall.

Silos 3 and 4 were constructed in mid-1952 and were designed to receive dry materials only. Waste raffinate slurries from refinery operations were dewatered in an evaporator and spray calcined to produce a dry waste form for removal to the silos. The waste was blown under pressure into Silo 3. Silo 4 has never been utilized.

The approximate quantities and characteristics of the residues in the silo are presented in Tables 3.12 and 3.13.

3.4.2 Thorium Inventory

Thorium operations were performed from 1954 through 1975 and included purifying thorium by solvent extraction, thorium residue processing, conversion of

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TABLE 3.12

OPERABLE UNIT 4
K-65 SILOS (SILOS 1 AND 2)

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES & UNITS	COMMENTS
1.	Bermed Silos	80 ft in diameter 36 ft high	Domed roof
2.	Contents: By-Products of Uranium Ore Processing; Uranium-bearing residues	7,200 cu. yds.	Total both silos
3.	Radioactive Material		
	Uranium	5.8 - 31 tons	Average radon concentrations[a]: Site boundary - 0.8 pCi/ℓ; silo fence - 3.9 pCi/ℓ
	Radium	1600 - 4600 Ci	
	Thorium	Unknown	
	Radon	Secular Equilibrium	
4.	Other Metals		
	Silica	41%	
	Lead	10%	
	Calcium	9%	
	Alumina	3.4%	
	Magnesia	2.3%	
	Iron (oxide)	3.8%	
5.	Other Compounds		
	Organics	None expected	
	Hazardous materials/waste	None expected	

[a]Based on measurements taken after the installation of a foam layer on the exterior of the silo domes in 1987.

TABLE 3.13

OPERABLE UNIT 4
SILO 3 CHARACTERISTICS

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

ITEM NO.	DESCRIPTION	QUANTITIES & UNITS	COMMENTS
1.	Silo	80 ft in diameter 36 ft high	Domed roof
2.	Contents: Calcined Waste Raffinate Powder (metal oxides)	5,100 cu. yds.	
3.	Radioactive Material		
	Uranium	20 tons	
	Radium	15 Ci	
	Thorium	unknown	
4.	Other Metals		
	Silica	>12%	
	Lead	0.3%	
	Calcium	3.0%	
	Aluminia	<2.0%	
	Magnesia	5.0%	
	Iron Oxide	>4%	
5.	Other Components		
	Organics	None expected	
	Hazardous materials/waste	None expected	

thorium nitrate solution to a storable thoria gel oxide, production of dense thoria, and production of thorium cores. The FMPC also serves as the thorium repository for the DOE, maintaining long-term storage facilities for a variety of thorium materials. A total of 13,000 containers of thorium-bearing materials are present at the FMPC, representing 110,000 cubic feet of material and 2,800 tons of thorium.

The thorium inventory is currently stored in a variety of containers and locations within the Production Area. However, efforts are currently underway to repackage all thorium into drums or overpacks for controlled storage inside designated warehouses. A large volume of thorium currently stored in a silo and bins at Plant 8 is being repackaged into drums for eventual storage in a temporary building structure. The thorium contained in 212 metal containers is scheduled for overpacking early in 1989, with subsequent storage in Building No. 64. Disposition alternatives for warehoused thorium are also under consideration. For purposes of evaluating final disposition options in the FS, it is assumed that all thorium has been properly stored in drums or overpacks.

3.5 OPERABLE UNIT 5

Operable Unit 5 encompasses the principal environmental media potentially impacted by past and present activities at the FMPC. In particular, the media include on-site ground water, soils, flora and fauna, regional aquifer, and ambient air. For purposes of the screening of technologies and the development of alternatives in this report, only the specific features of the principal ground water-bearing zones require presentation in this section.

The uppermost geological feature, the surficial till water-bearing unit, is a glacial till consisting of silty clay with lenses of sand and gravel. The till thickness varies from zero at Paddy's Run to greater than 40 feet in the northwest portion of the FMPC Production Area. The till has hydraulic conductivity values ranging from 0.2 to 2.5 feet per day. Ground water contaminant concentrations for uranium and its decay products vary greatly across the FMPC facility, with the highest observed uranium concentration in ground water in the till being 15,300 micrograms per liter (μg/ℓ) in the waste pit area. For a more complete characterization of the till water-bearing unit, refer to Table 3.14.

The Great Miami Aquifer is a regional sand and gravel aquifer that lies immediately below the surficial till water-bearing unit. It consists of glacial outwash sands and gravels separated over a portion of the site into two units by a 10- to 20-foot-thick, discontinuous silty clay layer. The aquifer has an average thickness of 180 feet, with hydraulic conductivity values ranging from 270 to 370 feet per day. Ground water contaminant concentrations for uranium and its decay products in the sand and gravel aquifer vary greatly across the FMPC. The highest observed uranium concentration is 218 μg/ℓ under the waste pit area. For a more complete characterization of the sand and gravel aquifer, refer to Table 3.15.

3.6 OPERABLE UNIT 6

Operable Unit 6 consists of surface water courses receiving FMPC discharges. It includes the Great Miami River, Paddy's Run, and the storm water outfall ditch. For characterization of these surface water courses, refer to Tables 3.16 through 3.18.

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TABLE 3.14

OPERABLE UNIT 5
ENVIRONMENTAL MEDIA - ON-SITE GROUND WATER
TILL WATER-BEARING UNIT

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

NO.	DESCRIPTION	QUANTITIES/UNITS	REFERENCES[a]/COMMENTS
1.	Geology	Glacial till consisting of silty clay and lenses of sand and gravel	Reference 5
2.	Dimensions		
	Area	45.7 x 10^6 ft^2 (1,050 acres)	Reference 3
	Thickness	Ranges from zero where Paddy's Run and outfall ditch have eroded into sand and gravel unit to greater than 40 feet in waste pit area and north-west portion of production area	Reference 6
3.	Hydrogeology		
	Conductivity	0.2-2.5 ft/day	Reference 5 - Range
	Depth to water	4-9 ft	Reference 5 - Range, unsaturated till is also common
4.	Contaminants in Ground Water		
	Uranium	2-15,300 µg/ℓ (waste pit area)	Reference 7
	Uranium	<1-326 µg/ℓ (excluding waste pit area)	Reference 7
	Thorium and radium isotopes	Typically <10 pCi/ℓ (waste pit area)	Reference 7
	Thorium and radium isotopes	Typically <5.0 pCi/ℓ (excluding waste pit area)	Reference 7
	Techctium (Tc-99)	Max. 67.6 pCi/ℓ (waste pit area)	Reference 7
	Organics	Not significant	Organics have been detected in ground water only sporadically and at very low concentrations

TABLE 3.15

OPERABLE UNIT 5
ENVIRONMENTAL MEDIA - ON-SITE GROUND WATER
SAND AND GRAVEL AQUIFER

(NOTE: ALL QUANTITIES ARE APPROXIMATE)

NO.	DESCRIPTION	QUANTITIES/UNITS	REFERENCES[a]/COMMENTS
1.	Geology	Glacial outwash sand and gravel separated into two units beneath part of the site by a 10- to 20-ft-thick silty-clay discontinuous layer	Reference 5
2.	Dimensions		
	Area	45.7 x 10^6 ft^2 (1,050 acres)	Reference 3
	Thickness	180 ft	Reference 2 - Average, from cross sections
3.	Hydrogeology		
	Hydraulic Conductivity	270-370 ft/day	Reference 5 - Range
	Porosity	25%	Reference 5
	Ground Water velocity	1.1-9.3 ft/day	Reference 5
	Depth to water	60-90 ft	Reference 5 - Below land surface
4.	Contaminants in Ground Water		
	Uranium	<1-218 µg/ℓ (waste pit area)	Reference 7
	Uranium	<1-168 µg/ℓ (on site excluding waste pit area)	Reference 7
	Thorium and radium isotopes	Typically <10 pCi/ℓ (waste pit area)	Reference 7
	Thorium and radium isotopes	Typically <5.0 pCi/ℓ (on site excluding waste pit area)	Reference 7
	Technetium (Tc-99)	Max. 912 pCi/ℓ (waste pit area)	Reference 7
	Technetium (Tc-99)	Max. 36 pCi/ℓ (on site excluding waste pit area)	Reference 7
	Organics	Not significant	Organics have been detected in ground water onl sporadically and at very low concentrations

TABLE 3.16

OPERABLE UNIT 6
SURFACE WATER COURSES - GREAT MIAMI RIVER
(NOTE: ALL QUANTITIES ARE APPROXIMATE)

NO.	DESCRIPTION	QUANTITIES/UNITS	REFERENCES[a]/COMMENTS
1.	Dimensions Length	48,000 ft	Reference 1 - Measured from upriver end of "Big Bend" to edge of 5 mile radius from site
	Width	345 ft	Reference 2 - Average
	Depth	5.4 ft	Reference 2, Average
2.	Flow Average daily range	3,460 ft^3/s 155 to 108,000 ft^3/s	Reference 2 Reference 2
3.	Uranium in Water Average	1.3 pCi/ℓ	Reference 2 - Average concentration
4.	Uranium in Sediment Average	1.6 pCi/g	Reference 3 - Average concentration for period 6/79 to 10/83 at sample locations from River Mile 27.8 to 19.4
	Range	0.4-4.4 pCi/g	Reference 3 - Range of concentration for period 6/79 to 10/83 sample locations from River Mile 27.8 to 19.4

[a]References are listed in Table 3.18.

TABLE 3.17

OPERABLE UNIT 6
SURFACE WATER COURSES - PADDY'S RUN
(NOTE: ALL QUANTITIES ARE APPROXIMATE)

NO.	DESCRIPTION	QUANTITIES/UNITS	REFERENCES[a]/COMMENTS
1.	Dimensions Length	9,700 ft	Reference 1 - Length within facility boundaries
	Length	19,400 ft	Reference 1 - Length from north edge of facility to confluence with Great Miami River.
	Depth	4 ft	Reference 1 - Typical value, varies considerably by location and season
2.	Flow Range	0.2 - 4.0 ft^3/s	Reference 4 - Flow during January to May, intermittent remainder of year with occasional high flows following heavy rainfall events
3.	Uranium in Water Average	13.5 pCi/ℓ	Reference 5 - Average concentration measured at intersection of Paddy's Run and Willey Road, for period 1975 to 1984
	Range	2.0-804 pCi/ℓ	
4.	Uranium in Sediment Average	66 pCi/g	Reference 3 - Average concentration for period 6/79 to 10/83 at three sampling locations
	Range	1.1-350 pCi/g	Reference 3 - Range of concentration for period 6/79 to 10/83 at three sampling locations

[a]References are listed in Table 3.18.

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TABLE 3.18

OPERABLE UNIT 6
SURFACE WATER COURSES - STORM WATER OUTFALL DITCH
(NOTE: ALL QUANTITIES ARE APPROXIMATE)

NO.	DESCRIPTION	QUANTITIES/UNITS	REFERENCES[a]/COMMENTS
1.	Dimensions Length	2,700 ft	Reference 1 - Length from retention basin to confluence with Paddy's Run
2.	Flow Cumulative Total	29.65 million gal.	Reference 3 - For period 1981 to 1983
3.	Contaminants Uranium Loading	4-190 kg/year	Reference 4 - Assumed loading to ditch per year for period 1956 to 1984
	Uranium in water	288-2,546 pCi/ℓ	Reference 5 - Range of concentration for period 1975 to 1984
	Uranium in sediment	12-255 pCi/ℓ	Reference 5 - Range of concentration for period 1975 to 1984

[a]References:

1. Interim Report, Air, Soil, Water, and Health Risk Assessment in the Vicinity of the Feed Materials Production Center (FMPC) Fernald, Ohio, IT Corporation.
2. Hydrogeologic Study of FMPC Discharge to the Great Miami River, Final Report, IT Corporation; 8/1/88.
3. Ground Water Study Task and Report; Dames and Moore; 10/19/85.
4. "Aquifer Contamination Reports," unpublished, WMCO, 1985.
5. Ground Water Study Task C Report; Dames and Moore; 7/1985.
6. Unpublished Cross Sections, IT Corporation, 1988.
7. Unpublished Data, IT Corporation, Round 1, RI/FS, 1988.

4.0 GENERAL RESPONSE ACTIONS

Response actions are broad categories of remedial action responses that will satisfy one or more of the remedial action objectives. The remedial action objectives for each of the six operable units were previously discussed in Section 2.3. The purpose of this chapter is to identify a comprehensive set of response actions for each operable unit such that appropriate technologies can be identified, evaluated, and combined into remedial action alternatives.

Response actions for each operable unit are developed separately in this chapter. However, with few exceptions, the response actions for each operable unit are organized into the same three general remedial response scenarios. These include:

- The no-action alternative (i.e., maintain the "as is" condition), which will be retained throughout the FS process as a comparative baseline against which other alternatives will be evaluated
- Nonremoval actions, which involve technologies directed toward the reduction of risk without removing the contaminated material
- Removal actions, which attempt to fully respond to a problem by removing the contaminated material and taking additional actions only after the contaminants are removed as a source

In this chapter, technology-based flow charts will be used to establish the full set of response actions under each of these scenarios. The individual technologies and process options comprising each response action are then identified for subsequent screening in Chapter 5.0.

4.1 OPERABLE UNIT 1

Figure 4.1 provides a flow chart depicting the full set of potential response actions for Operable Unit 1. In this and subsequent flow charts, specific response actions can be identified by any complete pathway down through the flow chart. For example, the following combination of technologies shown in Figure 4.1 can be considered as a complete nonremoval response action that incorporates waste isolation and immobilization:

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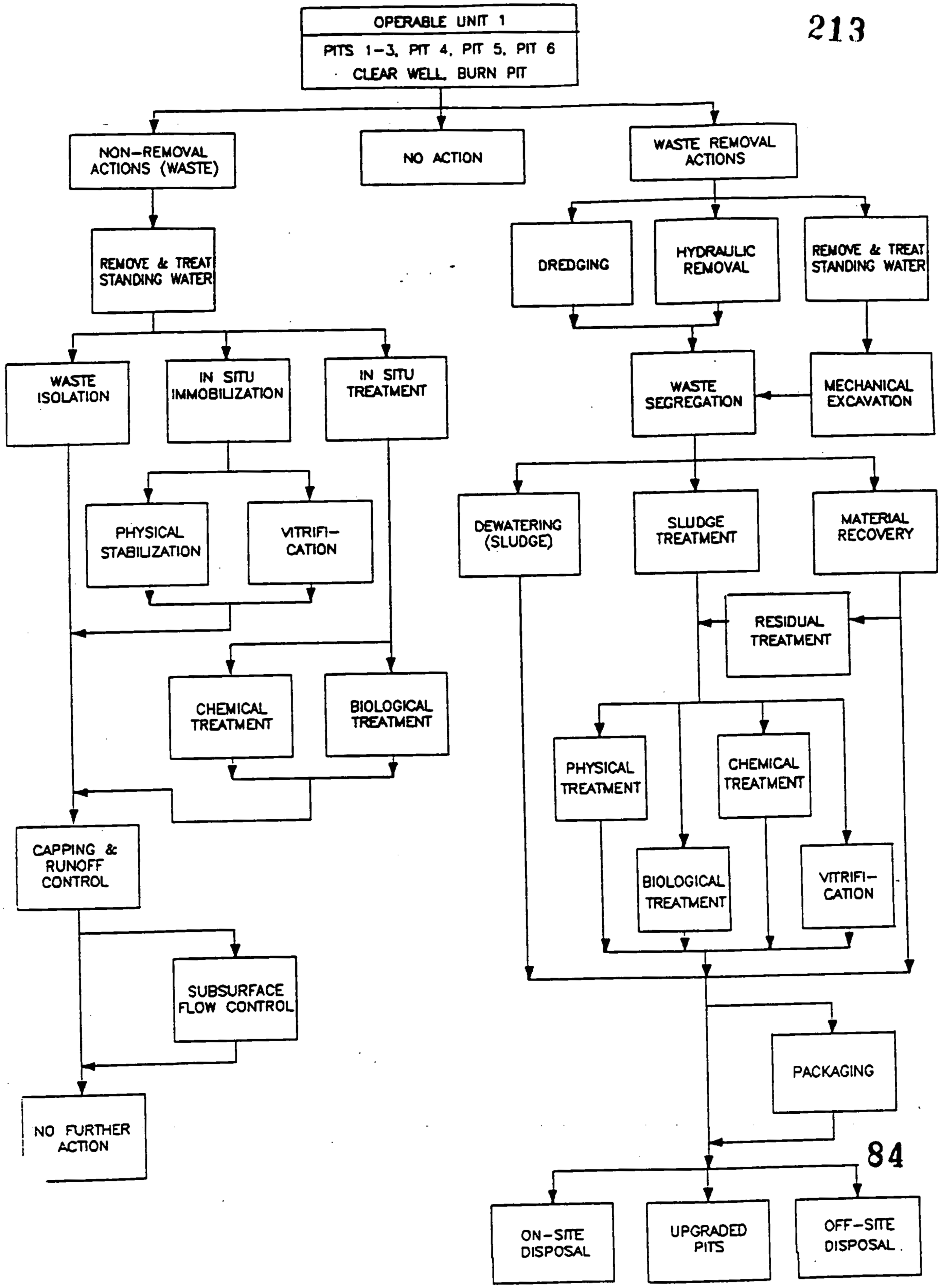
FIGURE 4.1
GENERAL RESPONSE ACTIONS
FLOW CHART



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- Removal and treatment of standing water
- In situ physical/chemical stabilization
- Capping and runoff control

Individual process options for each technology identified in this and subsequent flow charts are presented in Tables 4.1 through 4.13 at the end of this chapter. An index of the tables precedes Table 4.1.

For Operable Unit 1, the nonremoval actions are shown to apply only to the solid waste materials. It is expected that any standing water in Waste Pits 5 and 6 and the clear well will be removed and properly treated and disposed, regardless of the overall recommended action. With reference to Figure 4.1, it is also being assumed that capping of the waste storage units and the associated runoff control actions will be an integral part of any nonremoval scenario. The remaining nonremoval options for the wastes can be segregated into enhanced waste isolation through subsurface flow control technologies, in situ waste immobilization or treatment actions, and combinations of both. Various types of technologies are being considered to immobilize or treat the wastes in place as indicated in the figure.

The waste removal actions for Operable Unit 1 appear in Figure 4.1 to be more complex due to the number of technology options available at each stage of the response action process. In fact, each of these scenarios can be similarly categorized as waste removal, treatment, and either on-site or off-site disposal. The waste removal technologies will likely vary by unit and even within a given unit due to the wide variety of physical waste forms present in the pits. Treatment options for the removed waste range from simple dewatering to various types of physical, chemical, or biological treatment technologies. The options of material recovery and vitrification are also included as postremoval response actions. Several variations on on-site disposal are also being considered, including a specially designed tumulus and redisposal into upgraded pits.

Individual technologies and process options for the response actions are presented in the accompanying tables. These technologies and process options are the focus of a two-phased evaluation and screening process in Chapter 5.0.

4.2 OPERABLE UNIT 2

The potential response actions for Operable Unit 2 are summarized in Figure 4.2. The response actions are observed to be very similar to those previously described for Operable Unit 1. Several exceptions are noteworthy, however. In terms of nonremoval actions, the option of in situ treatment was excluded for Operable Unit 2 due to the nature of the solid wastes (i.e., fly ash, sanitary wastes, construction rubble, and lime sludge) comprising the individual units. On the other hand, since many of the solid waste units are above grade, the option of leachate collection and treatment has been added as a source control candidate.

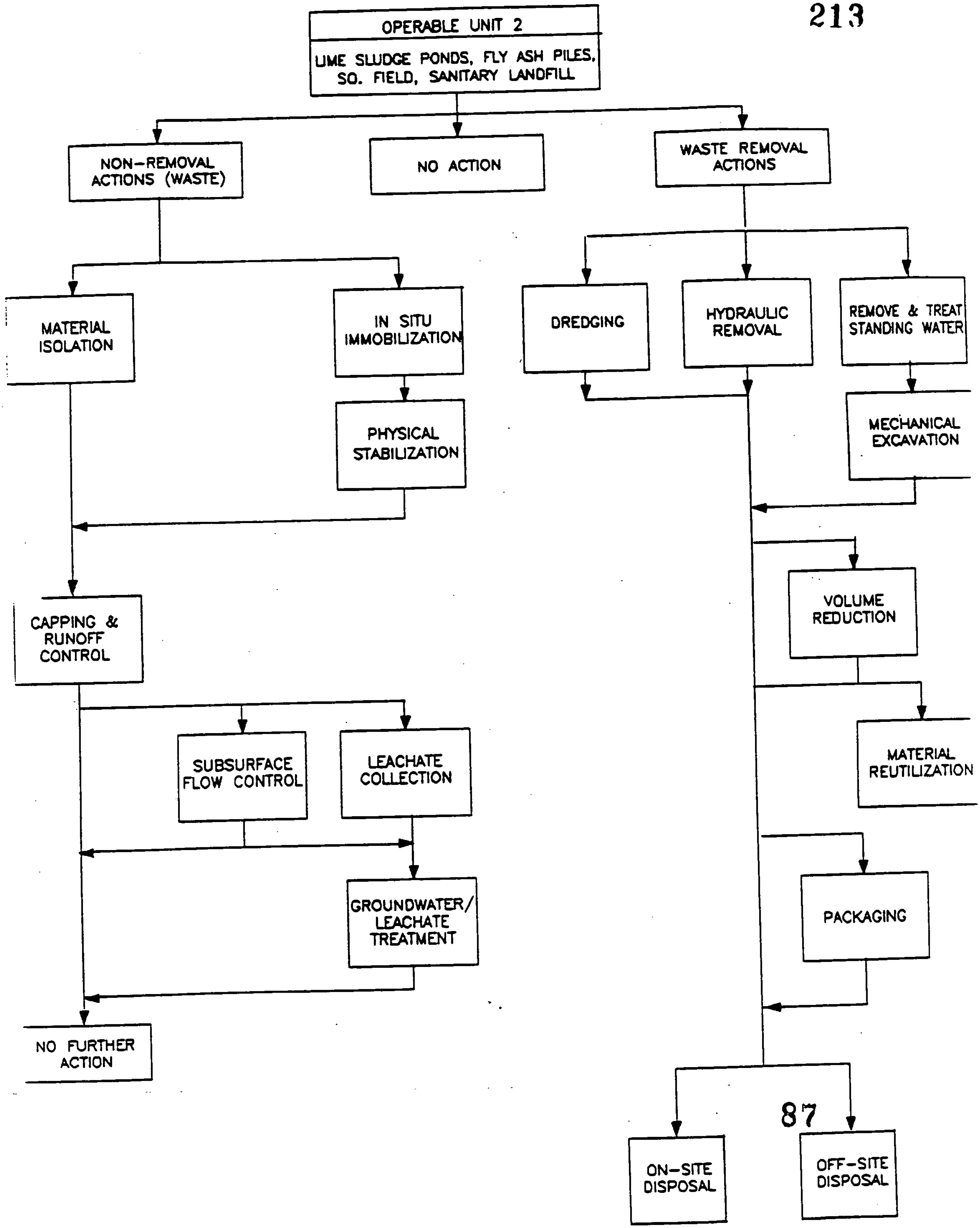
The waste removal actions have also been simplified due to the nature of the wastes. Rather than waste treatment after removal, the postremoval actions are limited to waste volume reduction prior to redisposal and possibly material reutilization (e.g., fly ash utilization as a raw material substitute). The on-site treatment options may also be less complex due to the relatively innocuous nature of the solid waste matrix in Operable Unit 2.

Individual technologies and process options underlying the response actions for Operable Unit 2 are listed in the accompanying tables.

4.3 OPERABLE UNIT 3

As discussed in Section 2.2, the potential response actions for the various facilities and suspect areas comprising Operable Unit 3 are generally dissimilar in comparison with those of other operable units. Figure 4.3 has been prepared to demonstrate the types of "fixes" potentially applicable to the various types of units within Operable Unit 3. The identified response actions are straightforward and typically limited to a single technology or a simple combination of technologies. Other types of response actions may

FIGURE 4.2
GENERAL RESPONSE ACTIONS
FLOW CHART



eventually be found to be necessary for a given unit; however, such actions cannot be fully anticipated at this time and will be developed and evaluated at an appropriate time.

The straightforward nature and widespread acceptance of the technologies shown in Figure 4.3 preclude a need for further development of the response actions in this screening-level document. Consequently, no consideration will be given to Operable Unit 3 in Chapters 5.0 and 6.0.

4.4 OPERABLE UNIT 4

The general response actions for Operable Unit 4, as presented in Figure 4.4, are directed toward source control. As such, they exhibit a high degree of similarity with the response actions for Operable Units 1 and 2. The simplest nonremoval action is rehabilitation of the existing silos, with or without subsurface flow control measures to offset the effects of any leakage through the bottom of the silos. These same actions can also be executed in combination with various technologies for the in situ immobilization of the waste materials in the silos. It is noteworthy that, in the case of the silos, the option of in situ immobilization without any supporting action is considered as a candidate response action. No in situ treatment technology was considered appropriate for the nonremoval response actions for Operable Unit 4.

The waste removal actions for Operable Unit 4 involve various combinations of removal technologies, postremoval actions, and waste disposal options. The potential postremoval actions are shown in Figure 4.4 to include treatment to stabilize the waste, as well as contaminant separation and recovery if found to be technologically and environmentally feasible. The on-site disposal options for the silo materials need to consider both retrievable storage options and nonretrievable containment options. Disposal of treated/untreated wastes in rehabilitated silos is also considered.

The response actions for the on-site thorium inventory are reflected in Figure 4.4 as a special case under the removal options. The reason is the

Figure 4.3
Operable Unit 3
Facilities and Suspect Areas

TYPE OF PROBLEM	POTENTIAL REMEDIAL ACTION
LEAKING/DAMAGED UNIT	REPLACEMENT/REMOVAL → DISPOSAL
ABANDONED TANK	FILL WITH INERT MATERIAL → ABANDON IN PLACE
LEAKING/DAMAGED UNIT	REPAIR/UPGRADE
ABANDONED, CONTAMINATED EQUIPMENT	DISMANTLE → DISPOSAL
LEAKING DRUM	SECONDARY CONT./OVERPACKING → LEAVE IN PLACE; SECONDARY CONT./OVERPACKING → DISPOSAL
LEAKING TANKS, SUMPS	FREE LIQUID REMOVAL → SPECIAL CONTAINMENT → DISPOSAL; FREE LIQUID REMOVAL → TREATMENT → DISPOSAL; FREE LIQUID REMOVAL → DISPOSAL
CONTAMINATED SOIL	SOIL CAPPING → GRADING; RUNOFF CONTROL
CONTAMINATED SOIL	SOIL REMOVAL → SECONDARY CONTAINMENT → DISPOSAL; SOIL REMOVAL → DISPOSAL
LOCALIZED, HIGH LEVELS OF GROUNDWATER CONTAMINATION	FREE PRODUCT RECOVERY / GROUNDWATER COLLECTION → REPROCESSING → DISPOSAL; FREE PRODUCT RECOVERY / GROUNDWATER COLLECTION → TREATMENT → DISPOSAL; FREE PRODUCT RECOVERY / GROUNDWATER COLLECTION → DISPOSAL

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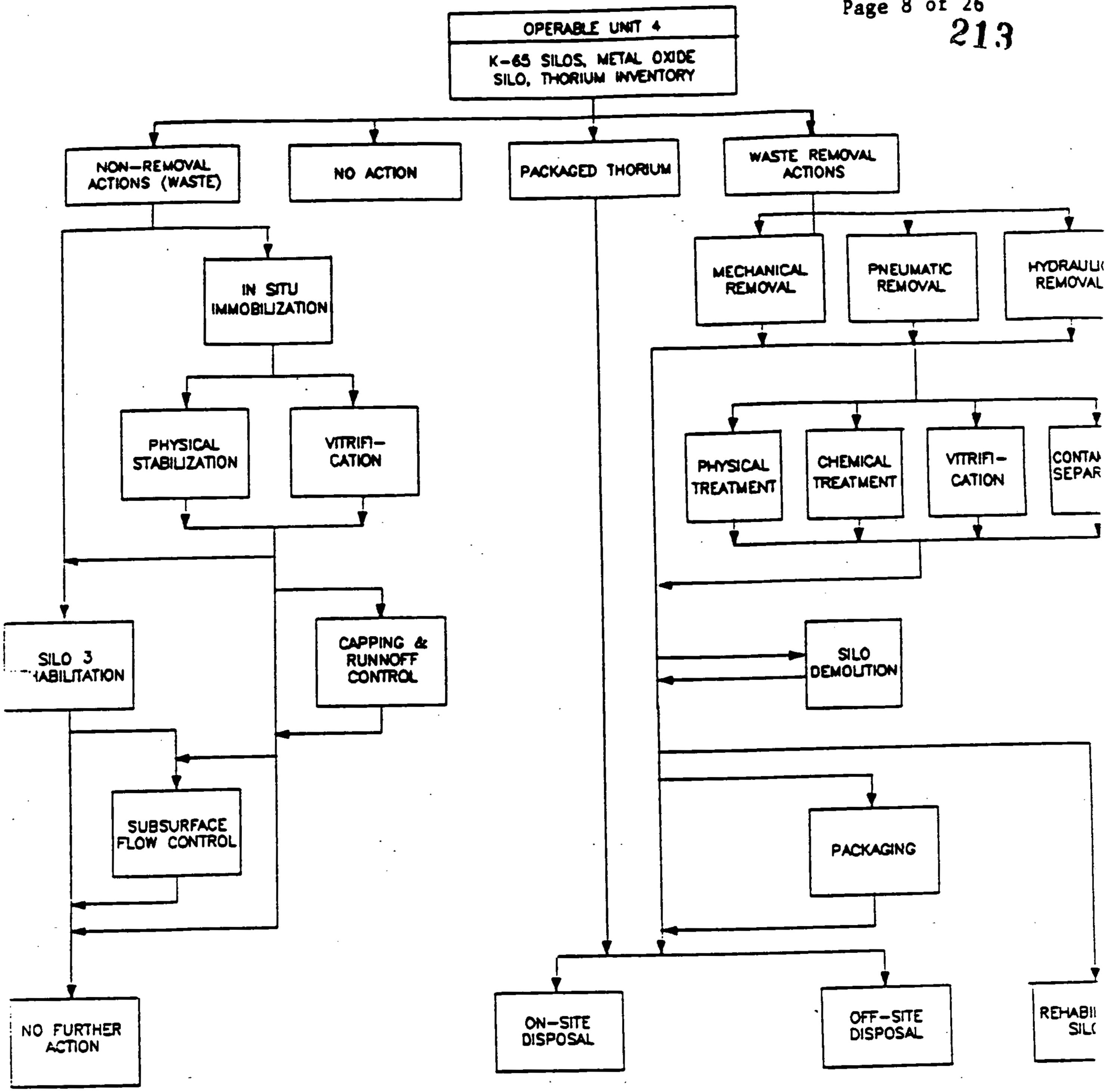
FIGURE 4.4
GENERAL RESPONSE ACTIONS
FLOW CHART



previously discussed assumption that all thorium will be appropriately repackaged and stored in retrievable fashion on site by the time of issuance of a ROD. Consequently, the final disposition options become limited to either approved on-site disposal in a tumulus or similar structure, or off-site disposal. Options are provided to stabilize and/or provide for special packaging of the thorium prior to final disposal.

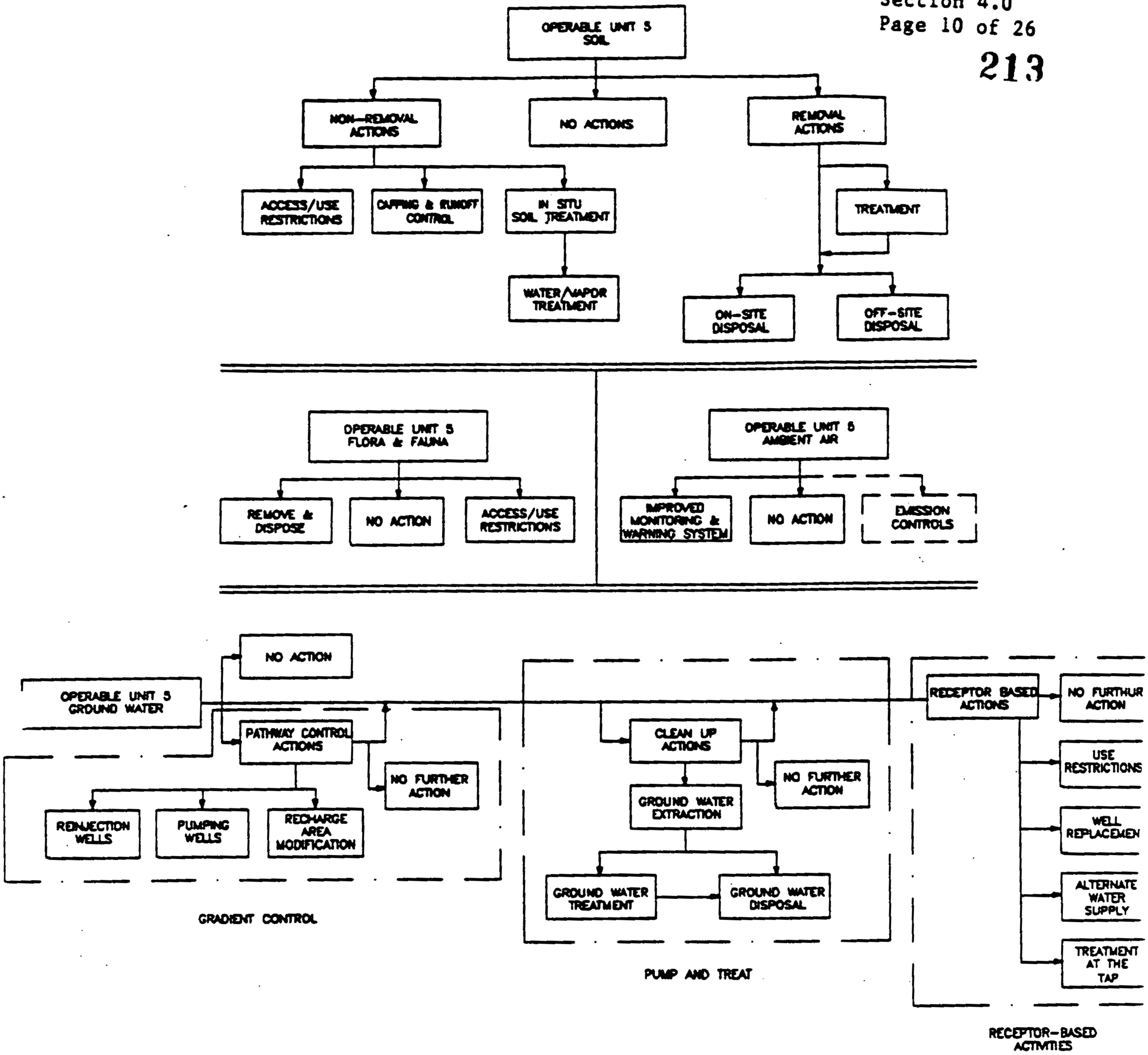
4.5 OPERABLE UNIT 5

As shown in Figure 4.5, the general response actions for Operable Unit 5 are actually a compendium of distinct response actions for each of the environmental media comprising this operable unit. In the case of soil, the potential response actions can be interpreted as a variation of the source control measures previously identified for Operable Units 1, 2, and 4. The actions for soils are more simplified, however, since special removal, post-removal, and disposal technologies included for the various waste units are not necessary considerations for contaminated soils. One nonremoval action, the implementation of access or use restrictions, has been added since it would be responsive to at least one remedial action objective for soils.

In the case of the flora and fauna, the available response actions of removal/ disposal and access/use restrictions are straightforward and will not be considered further in Chapters 5.0 and 6.0. The same is true for the ambient air unit, but in this case, the principal reason for eliminating this unit from further consideration is that any response actions will not be performed on the ambient air itself. Rather, the direct and immediate response of ambient air quality to reduced emissions justifies that only source controls be evaluated either as emission controls from active production facilities or as the elimination of releases from inactive waste storage units. The former activity is an ongoing WMCO operations function that does not require consideration under the FS. The latter will be dealt with as a remedial action objective for the operable units associated with airborne releases.

The ground water unit is shown in Figure 4.5 to be relatively unique in that a given response action could consist of one or more of three types of responses

FIGURE 4.5
GENERAL RESPONSE ACTIONS
FLOW CHART



depending on the objective(s) being pursued. In the first case, the emphasis is on ground water as a migration pathway that could require control to either mitigate an existing problem or to prevent future problems. Ground water cleanup actions, which comprise the second category of response, are targeted to ground water as an environmental receptor that has been degraded relative to established public health or environmental standards. The third category of response actions, termed receptor-based actions, are developed in response to imminent risks associated with ground water usage. As indicated in Figure 4.5, several technologies can be potentially applied to effect the three categories of response actions.

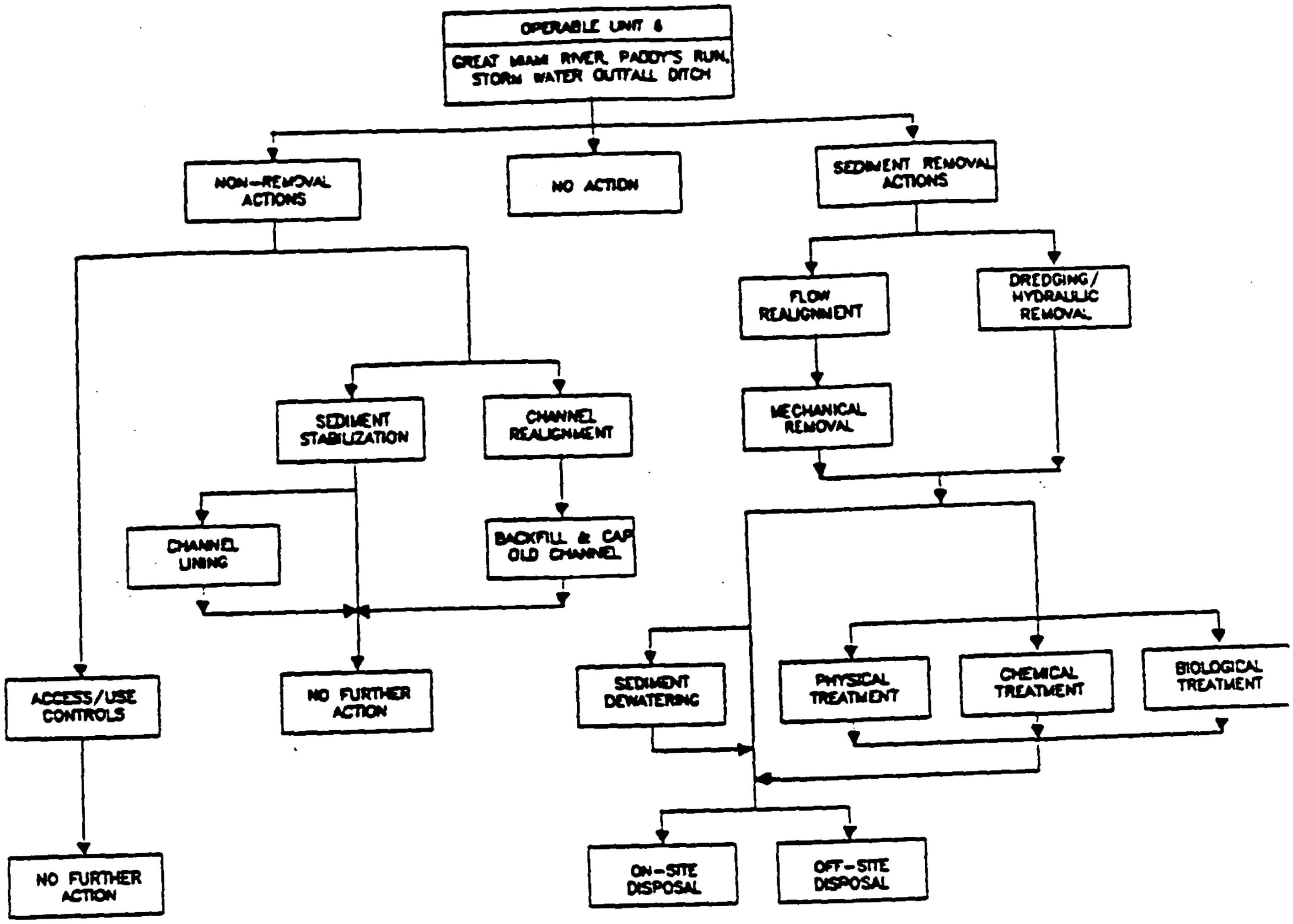
4.6 OPERABLE UNIT 6

The general response actions potentially applicable to the surface water courses in Operable Unit 6 are depicted in Figure 4.6. Although this operable unit is aligned with surface waters, the only response action applicable to the water column itself is the nonremoval option of access or use restriction. As with the ambient air unit, surface water quality is most effectively controlled by source (i.e., loading) reductions rather than direct treatment of the flowing waters.

A special case of a possible source of contaminants to surface water courses is the underlying sediments. Consequently, the remedial response actions given in Figure 4.6 are dominated by sediment source controls. Under a nonremoval scenario, the response actions are targeted to the isolation of the water column from the sediments. This could be accomplished either by covering or stabilizing the sediments or by relocating the water course away from the zone of contamination.

Sediment removal actions involve the typical combinations of removal technologies, postremoval actions, and various disposal options. In this case, an additional disposal option which allows for a new off-site disposal area is considered. This option accounts for the possible development of a shoreline or nearshore disposal area.

FIGURE 4.6
GENERAL RESPONSE ACTIONS
FLOW CHART



INITIAL LIST OF TECHNOLOGIES

TABLE 4.1

REMOVE AND TREAT STANDING WATER/LEACHATE

Physical Treatment:

Air Flotation (Solid/Liquid Separation)
Air Stripping
Centrifugation (Solid/Liquid Separation)
Clarification (Solid/Liquid Separation)
Evaporation
Extraction (Liquid/Liquid Separation)
Filtration (Solid/Liquid Separation)
Flocculation (Solid/Liquid Separation)
Flow Equalization
Oil/Water Separation
Polymerization
Reverse Osmosis
Selective Ion Removal
Soil Aeration
Steam Stripping

Chemical Treatment:

Chemical Dechlorination
Chemical Oxidation/Ozonation/Photolysis
Hydrolysis
Ion Exchange
Neutralization
Precipitation
Reduction

Thermal Treatment:

Drying/Calcination
Incineration
Thermal Desorption

Biological Treatment:

Biodenitrification
Biological Detoxification
Land Farming
Permeable Treatment Beds

TABLE 4.2

CONTROLLED COMPACTION AND DEWATERING

Dynamic Compaction
Electroosmosis
Explosive Charges
Grout Injection Techniques
Pile Driving
Surcharging (Overburdening)
Surface Compaction Using Rollers
Vacuum Extraction
Vertical (Sand or Wick) Drains
Vibro-Compaction/Vibro-Replacement

TABLE 4.3

CAPPING AND RUNOFF CONTROL

Capping:

- Single Layer Capping
- Multilayer Capping

Runoff Control:

- Diversion and Collection
- Grading
- Revegetation
- Sedimentation Basin (Surface Impoundment)

TABLE 4.4

SUBSURFACE FLOW CONTROL

Block Displacement

Cement-Bentonite Slurry Walls

Ground Water Pumping Wells

Soil-Bentonite Slurry Walls

Steel Sheet Piling

Subsurface Drains

TABLE 4.5

DREDGING/PNEUMATIC/VACUUM REMOVAL/HYDRAULIC REMOVAL

Dredging/Hydraulic Removal:

- Air Lift Dredging
- Dredging and Hydraulic Removal
- Oozer Dredging
- "Pneuma" and Pneumatic Dredging
- Vacuum Removal

TABLE 4.6

PITS 1 THROUGH 4 AND BURN PIT

Waste Segregation:

- Flotation
- Magnetic Sorting
- Manual Sorting
- Screening/Sizing

TABLE 4.7

MECHANICAL REMOVAL

Backhoe

Dragline

Front-End Loader

TABLE 4.8

**SLUDGE TREATMENT
INITIAL LIST OF TECHNOLOGIES**

Drying/Calcination

Solidification/Stabilization/Fixation:

- Solidification and Stabilization
- Vitrification

Filtration

Stabilization

Solid/Liquid Separation

TABLE 4.9

ON-SITE DISPOSAL

Below-Grade Vault Without RCRA-Type Closure Caps (Multiple Designs)

Engineered Low-Level Radioactive Waste Trenches

Greater Confinement Disposal Vault (Multiple Designs)

Temporary Storage Structure

Tumulus (Multiple Designs)

Unlined Excavated Pits

Silo Rehabilitation In Situ

TABLE 4.10

OFF-SITE DISPOSAL AT APPROVED FACILITY

Off-Site Disposal

- Rail Transport
- Rail Transport with Truck Transfer Station at Facility
- Truck Transport

TABLE 4.11

VOLUME REDUCTION

Compaction

Drying/Calcination

Shredding

TABLE 4.12

SEDIMENT STABILIZATION

Asphalt/Soil Mixing

Chemical Dust Suppressants

Grout Injection

Pozzolanic (Concrete Grout)/Soil Mixing

Structural Coverage

TABLE 4.13

FLOW REALIGNMENT

Channel Realignment by Excavation (Permanent or Temporary)

Dewatering

Diversion and Collection

5.0 SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

The technologies and process options identified in Chapter 4.0 are screened in this chapter. The purpose of the screening is to select those technologies that will form the basis of the remedial action alternatives in Chapter 6.0. Technologies and response actions determined to be technically nonapplicable through a preliminary screening are discussed in Section 5.1. A second-level screening is performed on the surviving technologies through a comparative evaluation in Section 5.2.

5.1 PRELIMINARY SCREENING

In this section, the comprehensive list of technologies developed in Chapter 4.0 (Tables 4.1 to 4.13) are screened for technical applicability. The applicability of technologies can be gauged on either a sitewide basis or in terms of the conditions and problems of a specific operable unit. For this reason, a two-staged preliminary screening has been adopted. In Section 5.1.1, those technologies that are nonapplicable to the physical and chemical nature of the FMPC wastes and environmental media as a whole are identified and reasons for their exclusion from further consideration are presented. Other technologies that are judged to be nonapplicable only to certain operable units (but applicable to others) are the subject of Section 5.1.2. In either case, any response action that fundamentally depends on the excluded technologies is necessarily eliminated from further consideration in the FS. The latter determination is explained in Section 5.1.3 through the presentation of revised remedial action flow charts.

5.1.1 Nonapplicable Technologies: Sitewide

Based on a preliminary engineering evaluation, the technologies listed below have not been retained for further consideration in the FS. Each technology citation is followed by a brief description and a justification of why it is considered nonapplicable to the FMPC. As noted, the elimination of several treatment technologies applicable to organics removal/destruction is based on the lack of a significant organics problem at the FMPC. If localized actions at a facility (e.g., the fire training area) require consideration of organics, appropriate technologies will be brought back into the evaluation process. This would most likely occur for Operable Unit 3 which is outside of the scope of the technology screening process reported herein.

- Table 4.1, Hydrolysis - Hydrolysis is the decomposition of a chemical compound by reaction with water. The waste materials of concern on site are unable to be hydrolyzed because they are in an elemental form and cannot be further decomposed.

- Table 4.1, Polymerization - Polymerization is the process of uniting two or more monomers to form a polymer. The wastes do not include materials that are capable of being polymerized.

- Table 4.1, Permeable Treatment Beds - Permeable treatment beds are used to destruct and remove biodegradable organic substances. This process is not effective on the waste sludges because of the absence or relatively low levels of biodegradable organics.

- Table 4.1, Chemical Dechlorination - Chemical dechlorination is the process of removing or reducing the amount of chlorine or chlorine compounds from waste materials. The wastes of primary concern are not chlorinated compounds and thus do not include materials that are capable of dechlorination.

- Table 4.1, Flow Equalization - Flow equalization is an appropriate process for a system with a waste flow stream but is not applicable to the standing water in the operable units since flow rate can be controlled by the removal system.

- Table 4.1, Incineration - Incineration uses high temperatures to destroy hazardous organics and to reduce the volume of wastes that are high in combustible materials. Incineration will not be effective because there is little, if any, hazardous organic constituents in the waste. Combustible materials are present in some waste units, but the volume is not sufficient to warrant the implementation of an incineration technology.

- Table 4.1, Air Stripping - Air stripping is a mass transfer process used to remove a volatile substance from an aqueous solution by transfer through an airstream. There are no significant concentrations of volatile strippable organics in the waste material.

- Table 4.1, Steam Stripping - Steam stripping is a distillation process in which steam is injected into an aqueous solution to separate selected components that are more volatile than water. There are no significant concentrations of volatile strippable organics in the waste material.

- Table 4.1, Soil Aeration - Soil aeration is the process of aerating soils through tillage or air injectors to reduce the amount of volatile organics. This process is not feasible due to the low levels of volatile organics in the waste material, soils, or sediments.

- Table 4.1, Oil/Water Separation - Oil/water separation consists of removing the free oil phase from the carrier wastewater through a specific gravity differential. This technology is not applicable because there is not a free oil phase in the wastewater or ground water.

- Table 4.1, Chemical Oxidation/Ozonation/Photolysis - In these processes, organics are destroyed by chemical oxidants such as chlorine compounds, hydrogen peroxide, or ozone. This type of treatment is effective only on organics that are readily oxidized. Since there are at most low levels of organics in the wastes, this process will not be effective.

- Table 4.1, Land Farming - Land farming is a biological treatment process in which a large population of microorganisms are cultured in soil to degrade organic waste placed within the soil matrix. Due to the low levels of organics present, this process is not effective.

- Table 4.1, Biological Detoxification - Biological detoxification uses microbial action to degrade organics. This process is not applicable to wastes with little or no hazardous organic constituents.

- Table 4.2, Specific Waste Stabilization Technologies - Waste stabilization renders noxious constituents chemically nonreactive and/or immobile so that no secondary containment is necessary for safe disposal. Several stabilization techniques that are not applicable to the FMPC wastes are described below:

  - Explosive Charges - With this process, there is a possibility of uncontrolled emissions and possible damage to the protective clay lenses in the till overlying the sand and gravel aquifer

  - Vibro-Compaction/Vibro-Replacement - During this process, uncontrolled emissions from the waste may occur and water may be ejected into the environment

  - Pile Driving - This process may rupture the pit liners and cause release of contaminated pit material and will not densify buried objects

  - Surface Compaction Rollers - This process will not compact the deeper portions of the waste pits

  - Electroosmosis - This process will not be effective for the highly conductive pit wastes.

- Table 4.4, Steel Sheet Piling - With steel sheet piling, structural steel shapes are driven into the soil and joined to isolate the waste from the ground water. This process is not reliable as a means to reduce the ground water flow due to the site geology and the depths of the pits.

- Table 4.4, Block Displacement - Block displacement is an environmental technique for isolating a contaminated block of material. This is not a proven technology and would be impractical for the extent and depths of the pits.

- Table 4.5, Airlift Dredging - Airlift dredging uses compressed air to dislodge and transport sediments. This process requires a minimum depth greater than the depths of standing water in the waste pits.

- Table 4.5, Pneuma Dredging - Pneuma dredging consists of a pump lowered by a crane into the sediments being dredged. The pump is driven by compressed air and operates by positive displacement. The operation is partially dependent upon hydrostatic pressure and sediment clay/silt content. Due to both the shallow depths in the applicable pits and their respective high clay/silt contents, this process would not be effective.

- Table 4.5, Oozer Dredging - Oozer dredging uses a vacuum pressure to pump and remove sediments. The principal advantage of the Oozer dredge is the ability to control turbidity when fine-grained sediments are being removed. All work with the Oozer dredge has taken place overseas. It has been eliminated from further consideration due to limited availability; the requirements of the project can be satisfied by more readily available equipment.

- Table 4.6, Waste Segregation by Flotation - Flotation is a clarification process for removing flocculants and other low-density solids from wastewater. This process is not applicable to the site-specific wastewaters because of the apparent lack of low-density material in the wastewater.

5.1.2 Nonapplicable Technologies: Operable Units

With reference to Figures 4.1 through 4.6, numerous technologies were identified as fundamental components of similar response actions for two or more operable units. Based on the preliminary evaluation, certain technologies were judged to be technically applicable only to a subset of the operable units with which they were associated. Technologies deemed nonapplicable for a given operable unit are identified below and do not require further consideration in the development of remedial action alternatives for that operable unit. These same technologies are retained, however, for further evaluation in relation to other operable units.

Operable Unit 1 (Figure 4.1)

- Nonremoval with in situ treatment was eliminated because it cannot adequately treat the wastes considering the depth of the pits. Either isolation with a slurry wall and cap or immobilization by vitrification will provide more reliable and lower cost response actions.

- Dewatering of sludge as a separate technology was eliminated because physical treatment of sludge is a retained technology which will include a dewatering process option.

- Material recovery was eliminated because there is no significant quantity of recoverable material in the Operable Unit 1 waste units.

- Chemical and biological treatment were eliminated on the basis of technical inappropriateness for the pit wastes. Vitrification or physical treatment will more favorably impact the method or cost of on-site or off-site disposal.

- Disposal in upgraded pits or other below-grade facility was eliminated on the basis that below-grade, on-site disposal above the Great Miami Aquifer will not be acceptable and has cost and maintenance disadvantages compared to above-grade disposal on site.

Operable Unit 2 (Figure 4.2)

- Leachate collection will be considered under subsurface drains in the subsurface flow control group of technologies.

- Hydraulic removal by pumping was eliminated because either mechanical excavation or dredging from a floating facility is more applicable to the lime sludge ponds than conventional pumping.

- Material reutilization of the fly ash as a raw material substitute for commercial products was eliminated because the fly ash is understood to have uranium and potential PCB contamination that was present in oil sprayed on the fly ash for dust control purposes. Use of the fly ash for purposes of remedial actions (e.g., as a bulk stabilizing material) remains under consideration.

Operable Unit 4 (Figure 4.4)

- Subsurface flow control was eliminated as a separate technology grouping. The rehabilitation of Silo 3, including restoration of the integrity of its base, or vitrification that would immobilize the contaminants, would make subsurface flow control unnecessary considering the silo base slab is on grade and a significant distance above the perched ground water.

Operable Unit 5 (Figure 4.5)

- Postremoval and treatment of soil was eliminated because the accepted practice at the FMPC is removal and disposal without treatment. In addition, detoxification of low concentrations of radiological contamination in soil to reduce impacts associated with on-site or off-site disposal has not been demonstrated to be practical or necessary to protect public health and the environment. This justification for eliminating postremoval treatment may not apply if hazardous chemicals are found to be a problem in soils.

Operable Unit 6 (Figure 4.6)

- Physical, chemical, and biological treatment of sediments to reduce radiological substance concentrations and enhance on-site or off-site disposal has not been demonstrated to be necessary to protect public health and the environment. Accepted practice is the removal and disposal of sediments without detoxification or stabilization-type treatment.

5.1.3 Response Action Flow Charts

The elimination of certain response actions and technologies through the preliminary screening resulted in revisions to the general response action flow charts developed in Chapter 4.0 (Figures 4.1 to 4.6). Surviving response actions and technologies are shown in Figures 5.1 to 5.5 for Operable Units 1, 2, 4, 5, and 6.

5.2 TECHNOLOGY DESCRIPTIONS AND COMPARATIVE EVALUATIONS

After deletion of the nonapplicable technologies in Section 5.1, specific technologies remained for further consideration. These technologies are tabulated in Tables 5.1 through 5.13. A brief description and comparative evaluation of each retained technology are presented in Appendix A. Process options for these technologies, where applicable, are described in Appendix B.

A comparative evaluation of each surviving technology was performed to determine its applicability to be part of a remedial alternative. This additional screening was carried out by ranking each technology against screening factors. The screening factors included in the ranking are effectiveness, implementability, and cost. Each factor for each technology was ranked high, moderate, or low. A high effectiveness or implementability ranking is a favorable ranking. It should be emphasized that the rankings are qualitative and apply only to similar technology types. They are not quantitative and do not provide a comparison between technology types. As such, they provide a guide in the reduction of technology options but not a means to rank all options in a fixed order. A comparison of screening factors for the technologies described in Appendix A is shown in Table 5.14.

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FIGURE 5.1
SCREENED RESPONSE ACTIONS
FLOW CHART

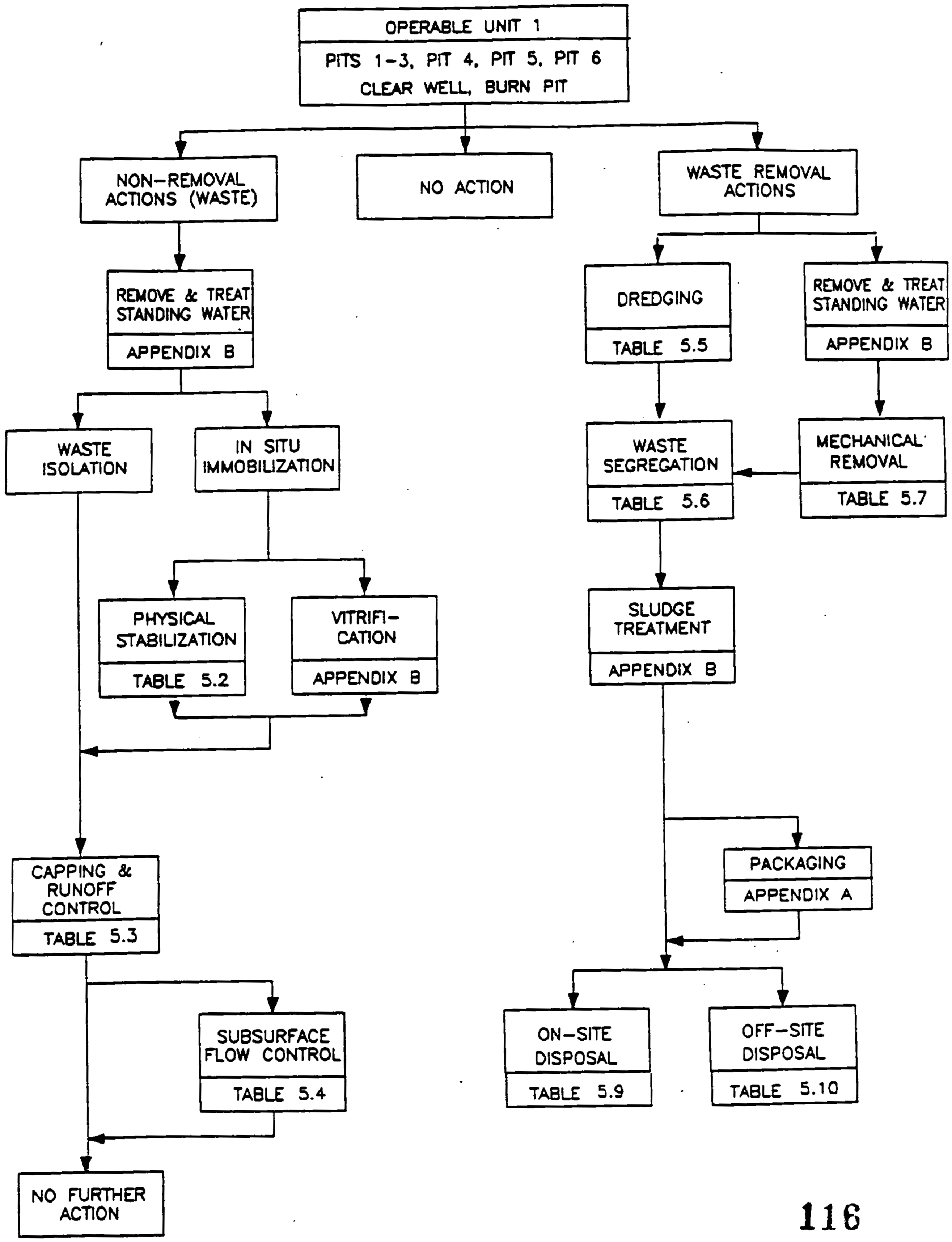


FIGURE 5.2
SCREENED RESPONSE ACTIONS
FLOW CHART

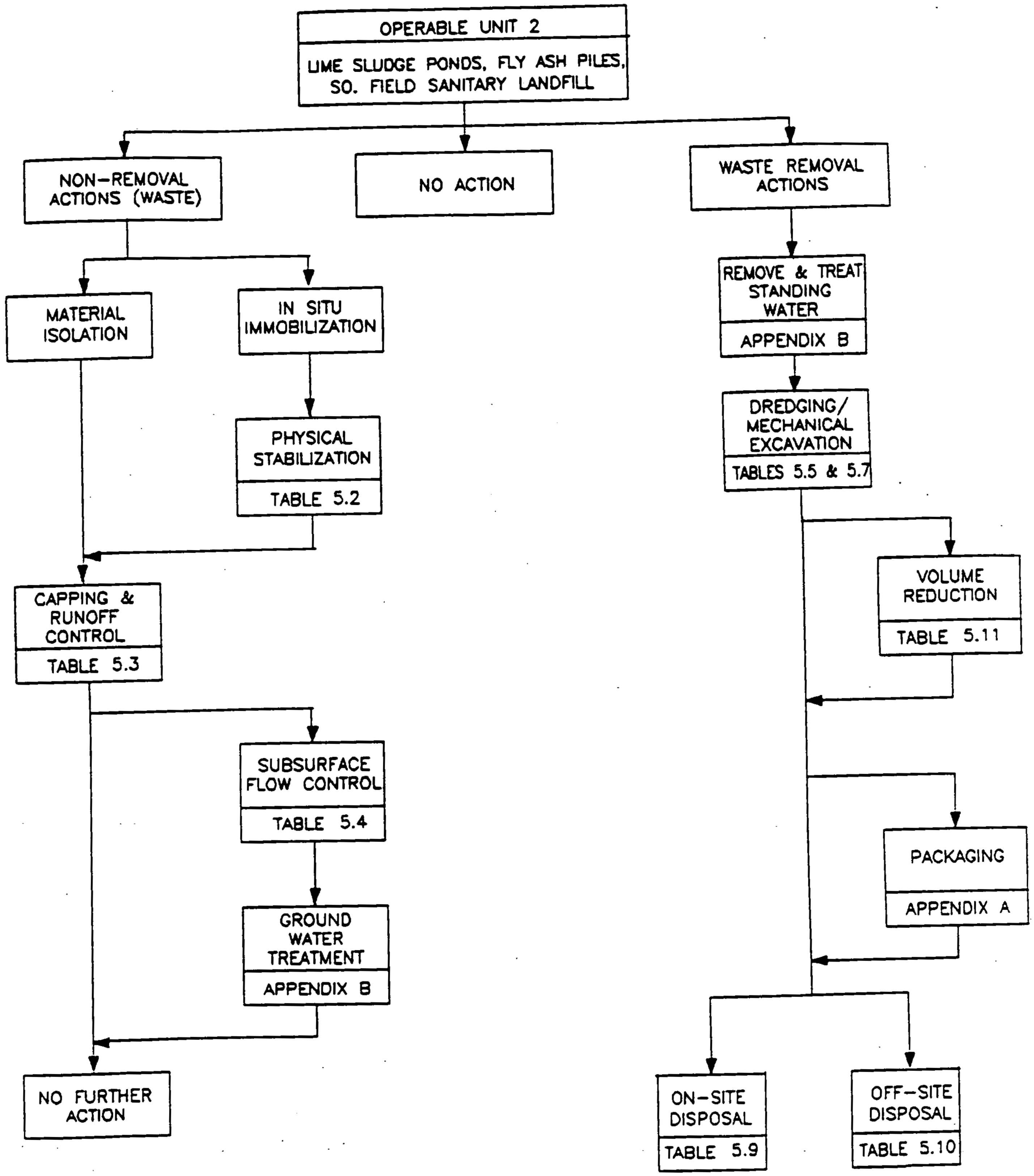


FIGURE 5.3
SCREENED RESPONSE ACTIONS
FLOW CHART

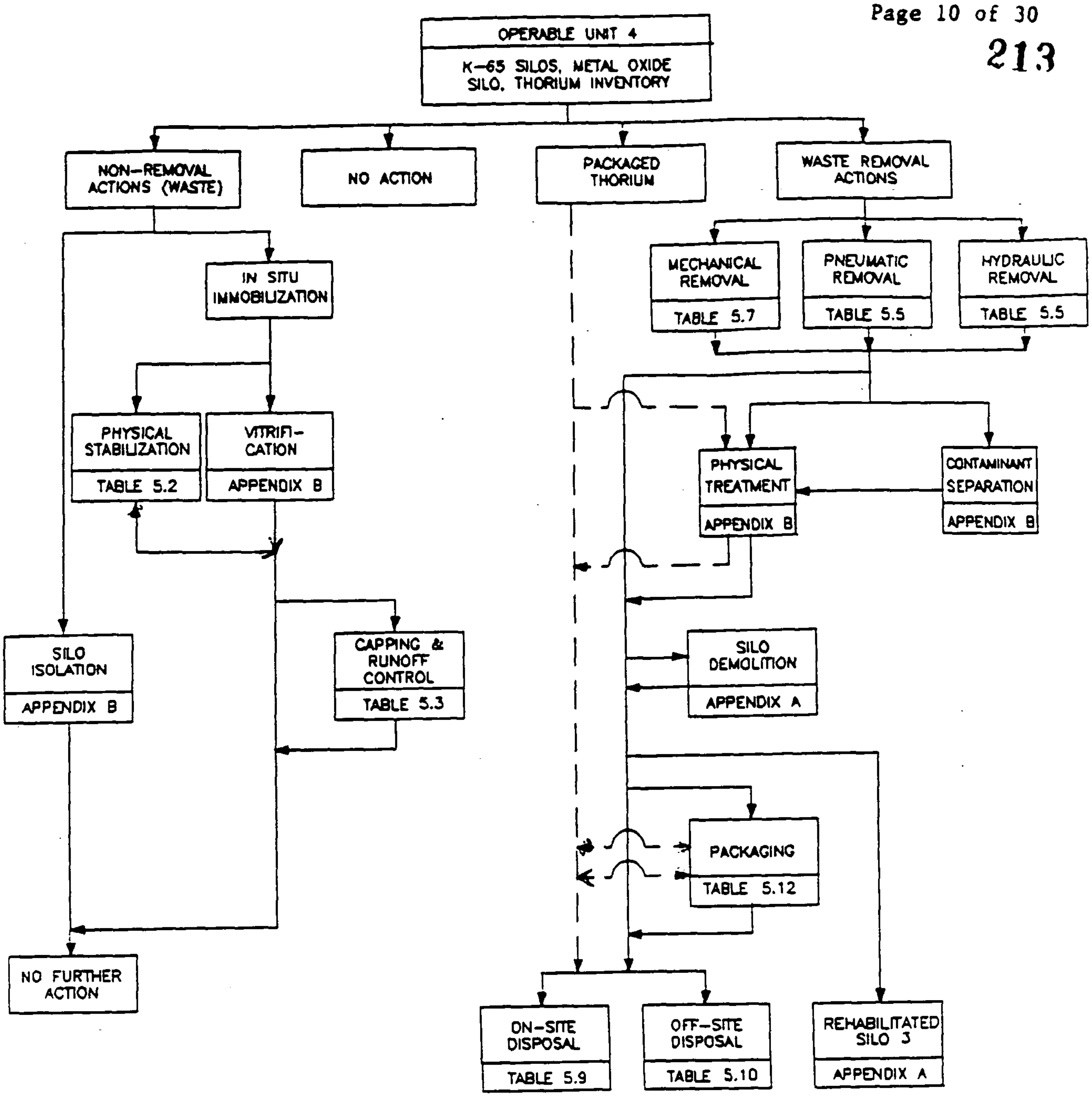


FIGURE 5.4
SCREENED RESPONSE ACTIONS
FLOW CHART

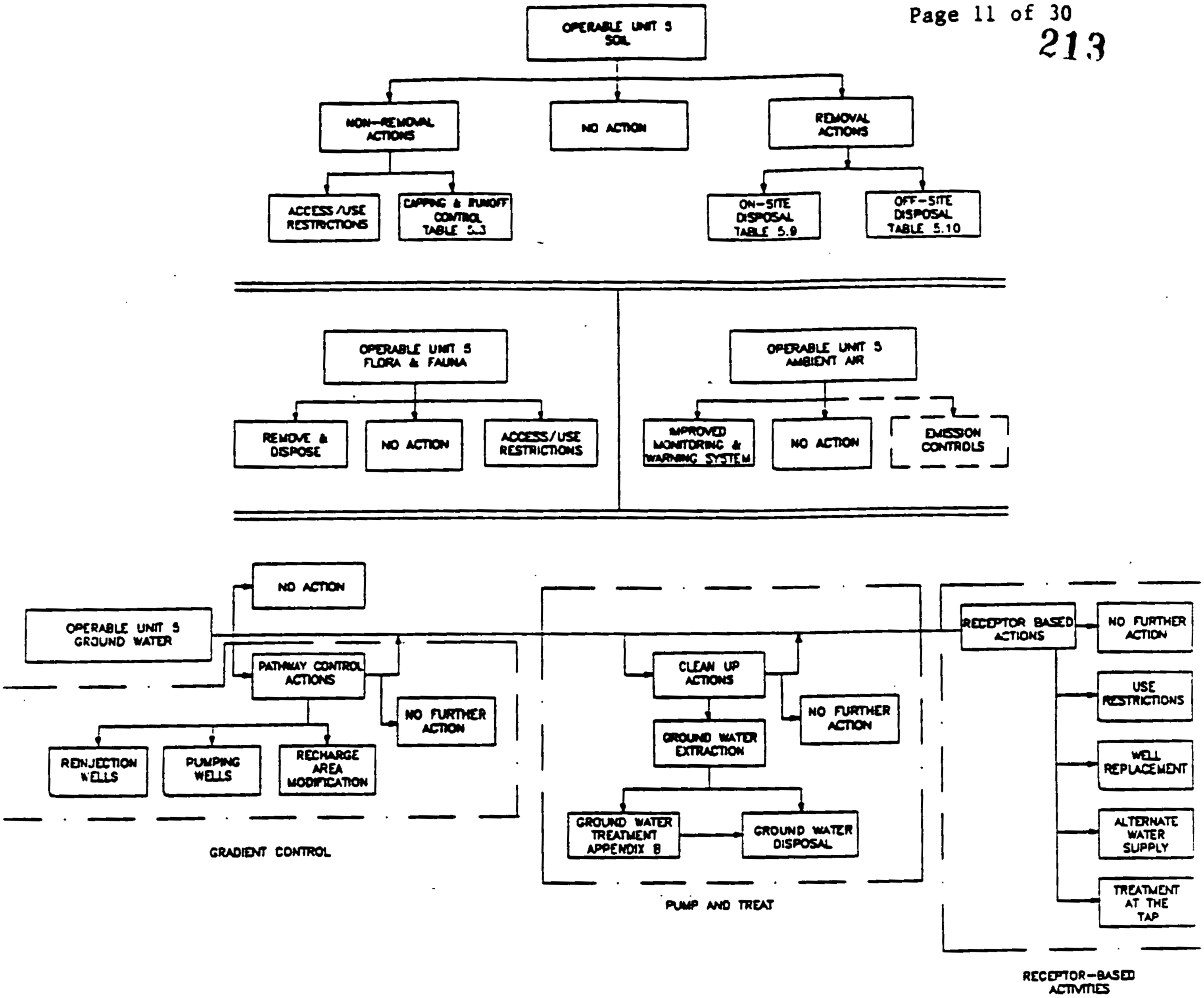
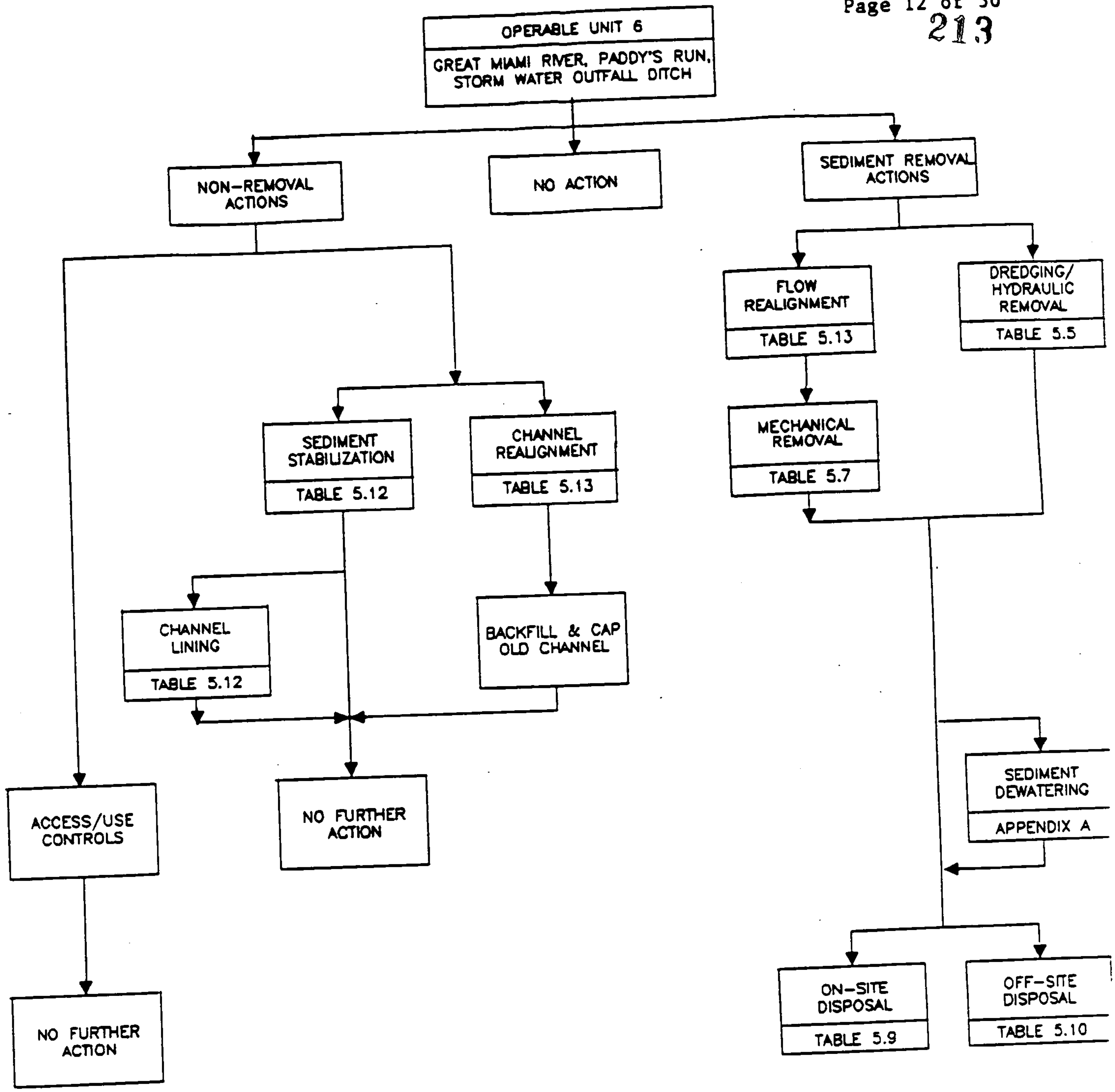


FIGURE 5.5
SCREENED RESPONSE ACTIONS
FLOW CHART



RETAINED LIST OF TECHNOLOGIES

TABLE 5.1

REMOVE AND TREAT STANDING WATER/LEACHATE

Physical Treatment:

- Air Flotation (Solid/Liquid Separation)
- Centrifugation (Solid/Liquid Separation)
- Clarification (Solid/Liquid Separation)
- Evaporation
- Filtration (Solid/Liquid Separation)
- Flocculation (Solid/Liquid Separation)
- Liquid/Liquid Extraction
- Reverse Osmosis
- Selective Ion Removal

Chemical Treatment

- Ion Exchange
- Neutralization
- Precipitation
- Reduction

Thermal Treatment

- Drying/Calcination
- Thermal Desorption

Biological Treatment

- Biological Denitrification

TABLE 5.2

CONTROLLED COMPACTION AND DEWATERING

Dynamic Compaction

Grout Injection Techniques

Surcharging (Overburdening)

Vacuum Extraction

Vertical (Wick Drains)

TABLE 5.3

CAPPING AND RUNOFF CONTROL

Capping:

- Single Layer Capping
- Multilayer Capping

Runoff Control:

- Diversion and Collection
- Grading
- Revegetation
- Sedimentation Basin (Surface Impoundment)

TABLE 5.4

SUBSURFACE FLOW CONTROL

Cement-Bentonite Slurry Walls

Ground Water Pumping Wells

Soil-Bentonite Slurry Walls

Subsurface Drains

TABLE 5.5

DREDGING/PNEUMATIC/VACUUM REMOVAL/HYDRAULIC REMOVAL

Dredging (Hydraulic Removal)

Dredging (Vacuum Removal)

Hydraulic Removal by Pumping

TABLE 5.6

WASTE SEGREGATION

Magnetic

Manual Sorting

Screening/Sizing

TABLE 5.7

MECHANICAL REMOVAL

Backhoe

Dragline

Front-End Loader

TABLE 5.8

SLUDGE TREATMENT

Drying/Calcination

Filtration

Solid/Liquid Separation

Solidification/Stabilization/Fixation

- Solidification and Stabilization
- Vitrification

TABLE 5.9

ON-SITE DISPOSAL

Greater Confinement Disposal (Multiple Designs - See Appendix A)

Tumulus (Multiple Designs - See Appendix A)

Silo Rehabilitation (In Situ)

TABLE 5.10

OFF-SITE DISPOSAL AT APPROVED FACILITY

Rail Transport

Rail Transport with Truck Transfer Station at the Facility

Truck Transport

TABLE 5.11

VOLUME REDUCTION

Compaction

Drying/Calcination

Shredding

TABLE 5.12

SEDIMENT STABILIZATION

Asphalt/Soil Mixing

Chemical Dust Suppressants

Pozzolanic (Concrete Grout)/Soil Mixing

Structural Coverage

TABLE 5.13

FLOW REALIGNMENT

Channel Realignment by Excavation (Permanent or Temporary)

Dewatering

Diversion and Collection

TABLE 5.14

COMPARISON OF TECHNOLOGY SCREENING FACTORS

	Screening Factors		
Technologies	Effectiveness	Implementability	Cost
Air Flotation	M	M	M
Asphalt/Soil Mixing	H	H	L
Biological Denitrification	H	H	L
Capping (Infiltration (Capping)	H/L	H	M (monitoring included)
Cement-Bentonite Slurry Wall (Vertical Containment Barrier)	M	H	H
Centrifugation	M	M	H
Channel Realignment by Excavation (Temporary or Permanent)	H	H	H
Chemical Dust Suppressants	H	H	L to H suppressant dependent
Chemical Reduction	M	M	M
Clarification	M	M	L
Dewatering	H	H	L/M
Diversion and Collection	M	M	L/M
Drying/Calcination	M	H	M
Dynamic Compaction	H	H	L
Evaporation	M	H	M
Filtration	H	H	L
Flocculation	M	H	L
Grading (Surface Water Management System)	H	H	L
Ground Water Pumping	H	M	H

TABLE 5.14
(Continued)

	Screening Factors		
Technologies	Effectiveness	Implementability	Cost
Grout Injection Techniques	L	L	H
Hydraulic Removal/Dredging			
Operable Unit 1/Subunit - North Lime Sludge Pond	H	H	M
Operable Unit 1/Subunit - South Lime Sludge Pond, Fly Ash Piles, Southfield, and Sanitary Landfill	L	L	L
Ion Exchange	H	M	M
Liquid/Liquid Extraction	L	L	H
Mechanical Removal By Backhoe			
Operable Unit 1/Subunit - North Lime Sludge Pond	L	L	L
Operable Unit 1/Subunit - South Lime Sludge Pond, Fly Ash Piles, Southfield, and Sanitary Landfill	M	M	L
Mechanical Removal by Dragline			
Operable Unit 2	L	L	L
Mechanical Removal by Front-End Loader	M	M	L
Neutralization	H	H	L
Off-Site Waste Disposal			
Rail	H	M	L
Truck	M	L	H
Rail with Truck Transfer	H	M	L
On-Site Greater Confinement Disposal (GCD) Vaults			
Design 1A - With Liner and Leachate Collection/Detection System (LCDS)	H	H	H
Design 1B - Without 1A Systems	H	M	M
Design 2A - With Liner System Including LCDS	H	H	H
Design 2B - Without 2A Systems	H	M	H

TABLE 5.14
(Continued)

Technologies	Screening Factors		
	Effectiveness	Implementability	Cost
On-Site Tumulus Waste Disposal			
Design 1			
Dry Cake	L	L	L
Solidified or Containerized	H	H	L
Design 2	H	H	L
Design 3	H	H	L
Pozzolanic/Soil Mixing	H	H	L
Precipitation	M	M	L
Revegetation (Surface Water Management System)	M	H	L
Reverse Osmosis	H	L	M
Sedimentation Basin	H	H	M
Selective Ion Removal	M	M	H
Silo Demolition			
Soil-Bentonite Slurry Walls (Vertical Containment Barrier)	M	H	M
Silo Rehabilitation (In Situ)			
Solidification and Stabilization	M	M	M
Packaging/Containerization			
Off-Site Transportation/Disposal	H	H	H
On-Site Disposal	M	M	H
Structural Coverage	H	H	H
Subsurface Drains (Ground Water Collection System)	M	M	H
Surcharging (Overburdening)	H	H	L
Thermal Desorption	M	M	M

TABLE 5.14
(Continued)

Technologies	Screening Factors: Effectiveness	Implementability	Cost
Vacuum Extraction			
Operable Unit 1	M	M	M
Operable Unit 2			
Lime Sludge Ponds	H	H	M
Fly Ash Piles	L	L	M
Southfield	L	L	M
Sanitary Landfill	L	L	M
Vacuum Removal (Industrial Vacuum Loaders)			
Operable Unit 1/Subunit - North Lime Sludge Pond	M	L	M
Operable Unit 1/Subunit - Fly Ash Piles	M	M	M
Operable Unit 1/Subunit - South Lime Sludge Pond and Sanitary Landfill	L	L	M
Vertical Drains			
When not Utilized in Combination with Surcharging	M	M	L
When Utilized with Surcharging	H	H	L
Vitrification	H	M	M
Volume Reduction	M	H	M
Waste Segregation (Waste Pits, Clear Well, Burn Pit)			
Magnetic	H	H	L
Manual Sorting	H	M	M
Screening/Sizing	M	M	H

L = Low.

M = Moderate.

H = High.

6.0 REMEDIAL ACTION ALTERNATIVES

The preliminary screening of remedial action technologies and process options presented in Section 5.1 determined which of the individual technologies and process options were appropriate to the physical and chemical conditions of Operable Units 1, 2, 4, 5, and 6. This judgmental screening was then followed by a more detailed, comparative evaluation of the remaining technologies and process options to establish the "most appropriate" among them. The technologies remaining after this two-step screening and evaluation process (Tables 5.1 through 5.14) do not singularly represent remedial action alternatives for the FMPC or even for an individual operable unit. The objective of this chapter is to combine the individual technologies and process options into an initial set of complete and implementable alternatives for each operable unit that achieve consistency with the respective remedial action objectives presented in Section 2.3.

By definition, the remedial action alternatives for the various operable units have already been established as those combinations of technologies forming complete pathways on the modified flow charts in Chapter 5.0 (i.e., Figures 5.1 through 5.5). This chapter will, therefore, be used to further develop the individual remedial action alternatives depicted on the flow charts. Each alternative for a given operable unit will be briefly described and referenced to an expanded flow chart for that alternative. The brief descriptions will be followed by an extended description of all technologies associated with the full set of remedial action alternatives for that operable unit. Some technologies will be common to several alternatives for a given operable unit while others may apply to only one alternative. Additional information on specific technologies and process options is included in Appendices A and B, respectively. The descriptions of the remedial action alternatives and associated technologies are then followed by a discussion of the relative degree to which each alternative would satisfy the remedial action objectives.

6.1 OPERABLE UNIT 1

6.1.1 Alternative Descriptions

Upon completion of the engineering and scientific evaluation of remedial action technologies and their various combinations, six potential remedial action alternatives have been developed for the waste pits, the burn pit, and the clear well in Operable Unit 1. These include the no-action alternative, three nonremoval alternatives, and two removal alternatives. Several variations on the removal alternatives also exist due to the possible incorporation of different disposal options. The nonremoval and removal alternatives are described in the following sections.

6.1.1.1 Nonremoval - Slurry Wall and Cap (Alternative 1-NA-A)

The first nonremoval alternative for Operable Unit 1 is intended to isolate the waste from the environment and to prevent the generation and release of contaminated leachate to the underlying sand and gravel aquifer. This alternative is schematized in Figure 6.1.1 and is shown to consist of five technology groupings. (In this and subsequent figures, the inset provides a cross reference of the subject alternative back to the operable unit flow charts in Chapter 5.0.) With reference to Figure 6.1.1, the five technology groupings include 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. As will be discussed below, the subsurface flow control measures combine a slurry wall, subsurface drains, and a temporary ground water extraction system. More details on these technology groupings are provided in Section 6.1.2.

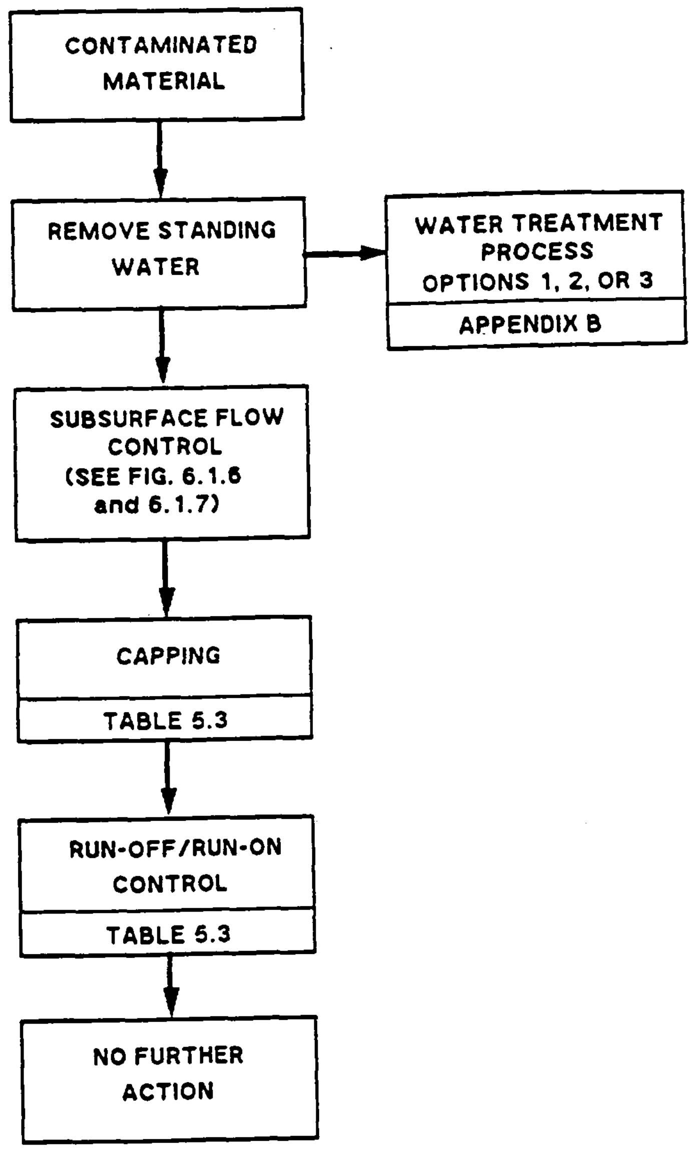
The alternative reference number cited above (i.e., 1-NA-A) will be used in subsequent sections to distinguish this alternative from others involving either the same operable unit or similar technologies for a different operable unit. The first entry in the reference number identifies the operable unit of concern, the "NA" signifies a nonremoval action (as opposed to "RA" for a removal action), and the letter designation of "A" indicates that the alternative is the first nonremoval action for the given operable unit.

Fig. 6.1.1

Remedial Action Alternative 1-NA-A

Operable Unit 1

Non-Removal - Slurry Wall and Cap



6.1.1.2 Nonremoval - Physical Stabilization, Slurry Wall, and Cap (Alternative 1-NA-B)

The second nonremoval alternative for Operable Unit 1 is identical to Alternative 1-NA-A with the exception that an additional waste stabilization step has been incorporated. The purpose of this additional process is to promote the compaction and dewatering of the waste in a controlled manner so as to minimize the potential for long-term waste settlement and the release of contaminated waste pit water into the underlying till. The future maintenance of the cap because of settling will be correspondingly reduced.

The technological sequencing of this alternative is presented in Figure 6.1.2. Descriptions of two options for the physical stabilization of the wastes are provided in Section 6.1.2.

6.1.1.3 Nonremoval - Vitrification and Cap (Alternative 1-NA-C)

This alternative is similar to Alternative 1-NA-B in that a waste immobilization step has been incorporated into the nonremoval scenario. However, with reference to Figure 6.1.3, the immobilization step now specifies vitrification technologies rather than the physical stabilization technologies called for under Alternative 1-NA-B. A second important difference is that the subsurface control measures are not included in Alternative 1-NA-C. The reason for this exclusion is that the resultant vitrified mass should preclude the future release of contaminated water from the waste, thereby eliminating the need for subsurface flow control.

Additional information on the vitrification step is provided in Section 6.1.2 and Appendix B. The capping step under this alternative varies from the capping design proposed for Alternatives 1-NA-A and 1-NA-B; this is further discussed in Section 6.1.2.

6.1.1.4 Removal, Sludge Treatment, Bulk/Packaging, and On-Site Disposal (Alternative 1-RA-A)

The removal alternatives for Operable Unit 1 are intended to completely eliminate the waste source from its current location above the sand and gravel aquifer and to control any future problems through proper handling and disposal

Fig. 6.1.2

Remedial Action Alternative 1-NA-B

Operable Unit 1

Non-Removal - Stabilization, Slurry Wall and Cap

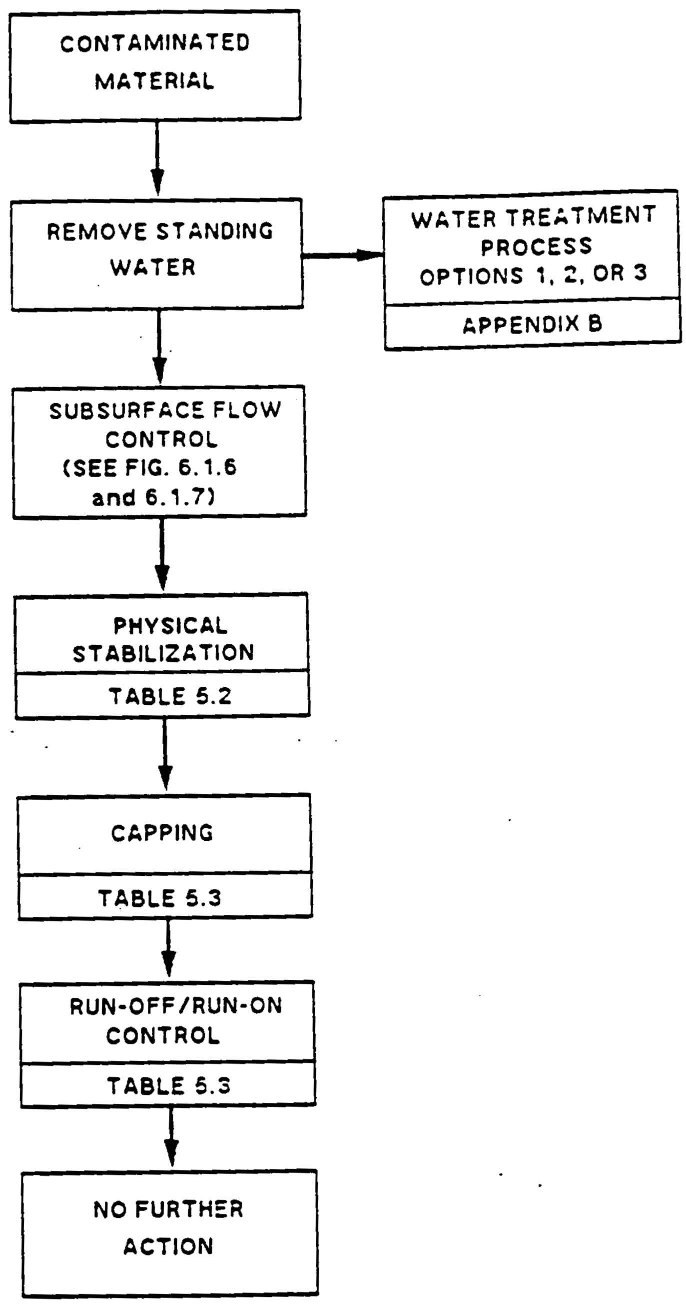
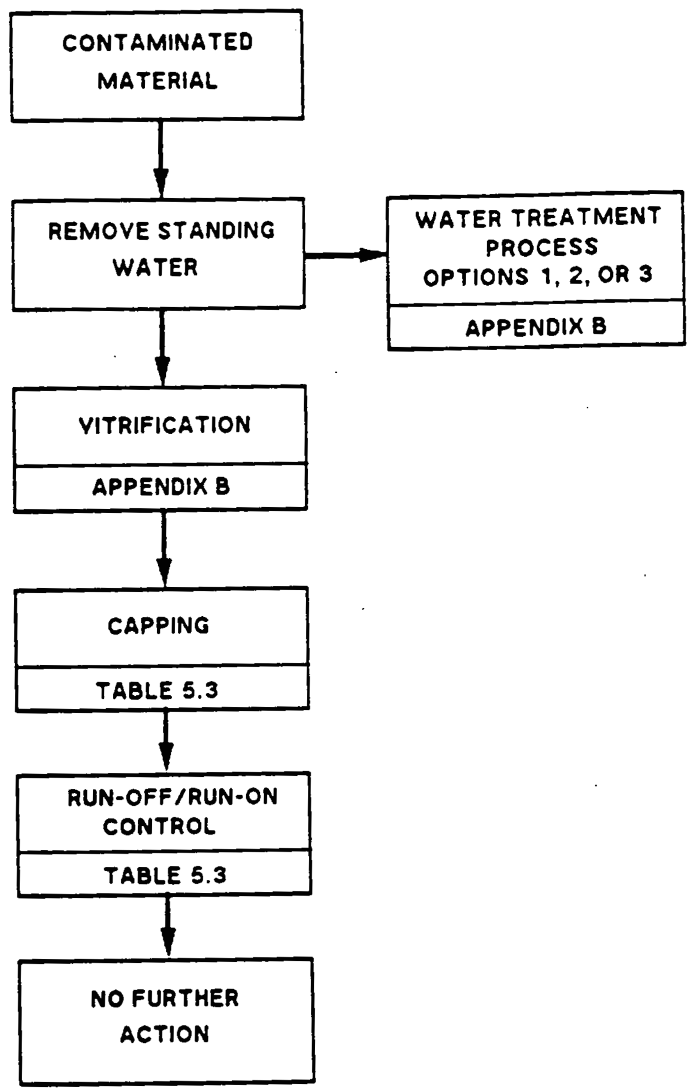


Fig. 6.1.3

Remedial Action Alternative 1-NA-C

Operable Unit 1

Non-Removal - Vitrification and Cap



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of the removed wastes. The first removal alternative is comprised of six principal technology groupings as shown in Figure 6.1.4. These include the removal and treatment of the standing water, waste removal, waste segregation and treatment, and final disposal. Potential support actions such as treatment of residual water and special waste packaging requirements are also indicated in the figure.

Several of the technology groupings shown in Figure 6.1.4 incorporate more than one technology option. These include various options for waste removal, physical treatment and vitrification as optional waste treatment technologies, and two principal options of a tumulus or an above-grade concrete structure for on-site disposal. Each of these options, as well as the remaining technology groupings, are described in Section 6.1.2.

6.1.1.5 Removal, Sludge Treatment, Bulk/Packaging, and Off-Site Disposal (Alternative 1-RA-B)

The second removal alternative is identical to Alternative 1-RA-A with the exception that the treated and packaged waste will be transported and disposed at an approved off-site location. This alternative is illustrated in Figure 6.1.5. The off-site disposal options are discussed in Section 6.1.2.

It is noteworthy that waste packaging may differ depending on whether on-site or off-site disposal is planned. Such differences will be accounted for in subsequent FS tasks involving more detailed, comparative evaluations of the alternatives.

6.1.2 Technology Descriptions

6.1.2.1 Removal and Treatment of Standing Water

Pits 5 and 6 and the clear well have standing water which will require removal and treatment prior to any other action being taken. Process options selected for further consideration include evaporation, reverse osmosis, and ion exchange; ion exchange and denitrification; and metals removal, ion exchange,

Fig. 6.1.4

Remedial Action Alternative 1-RA-A

Operable Unit 1

Removal, Treatment, Bulk/Packaging and On-Site Disposal

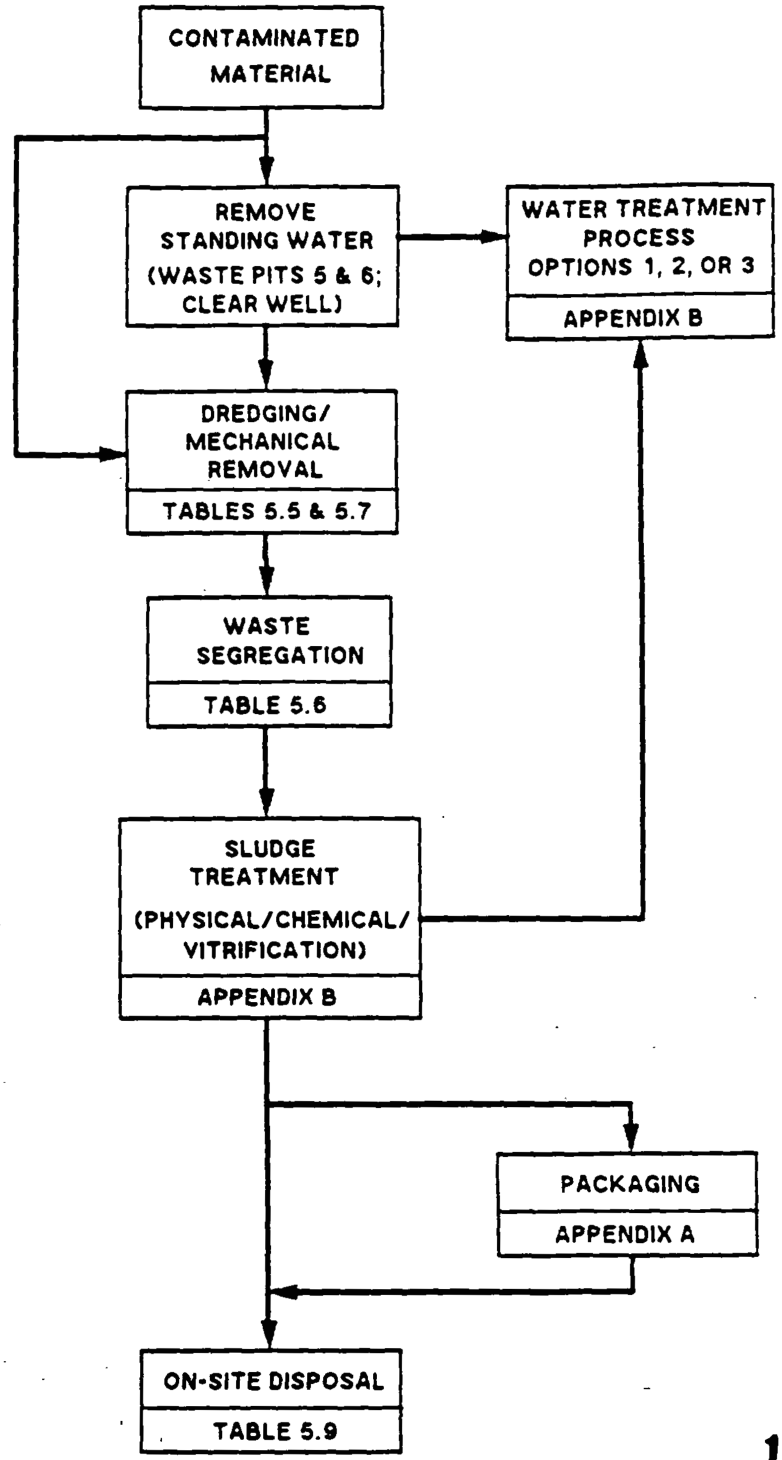
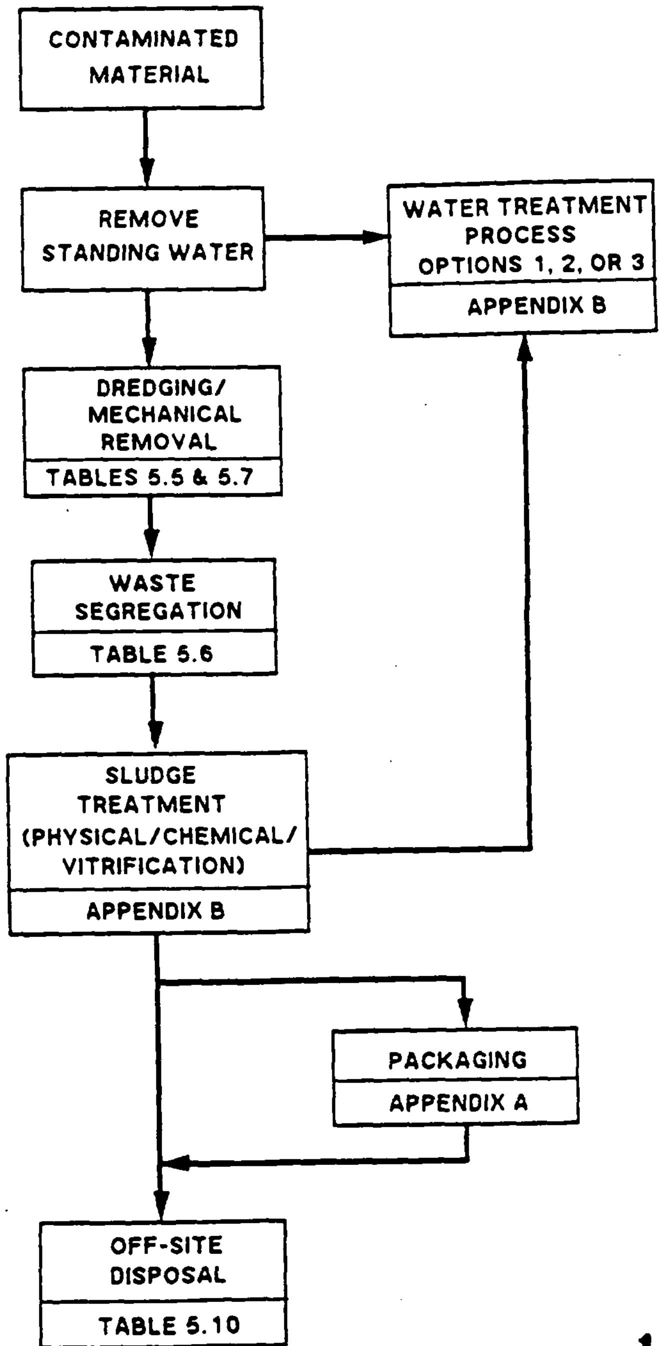


Fig. 6.1.5

Remedial Action Alternative 1-RA-B

Operable Unit 1

Removal, Treatment, Bulk/Packaging, and Off-Site Disposal



and denitrification. These process options are described in Appendix B (Pages B-1, B-2, and B-3, respectively).

6.1.2.2 Subsurface Flow Control

The subsurface flow control technologies will eliminate horizontal ground water flow through the till underlying the Operable Unit 1 area and will minimize the potential for vertical leakage into the sand and gravel aquifer. These technologies are illustrated in Figures 6.1.6 and 6.1.7 and will consist of the following:

- A soil or cement/bentonite partial slurry wall will be placed around the Operable Unit 1 area. The slurry wall will be installed through the surficial till layer into the upper sands and gravels of the underlying aquifer. The slurry wall will prohibit ground water in the till from entering the waste storage area.

- A series of perimeter vertical drains consisting of selected natural granular materials will be placed upgradient from the slurry wall. These vertical drains will facilitate the downward movement of the till ground water outside of the enclosed area, lowering the water table elevation below the bottom of the pits into the more permeable underlying sands and gravels of the upper aquifer.

- Temporary ground water wells will be used to remove ground water from inside the slurry wall area, providing both contaminant (plume) control and reduction of the water available to interact with the in situ waste and to be released to the underlying aquifer. These wells will be removed and grouted shut prior to capping of the site. It is assumed that the withdrawn water is contaminated to some degree and will require treatment prior to discharge.

6.1.2.3 Capping

After removal of the standing water as part of a nonremoval action, the pits will be covered with clean, compacted soils which will be contoured to provide drainage prior to cap placement. The cap will consist of a vegetative cover, a natural or synthetic drainage layer, a flexible membrane liner, and/or a low-permeability clay liner. All cap elements and layers will be contoured to grades which promote drainage while minimizing the effects of waste pit subsidence and storm water erosion.

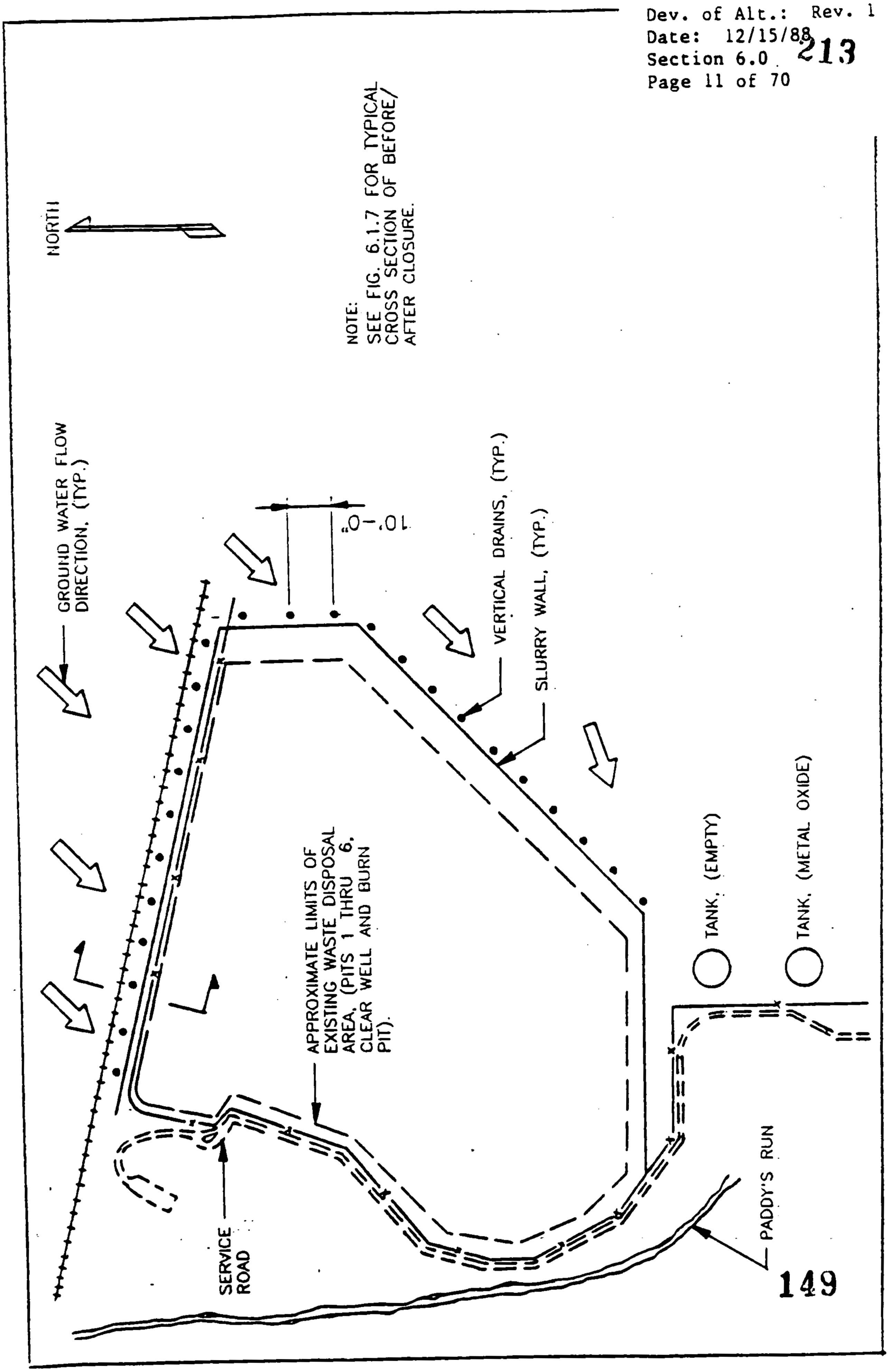
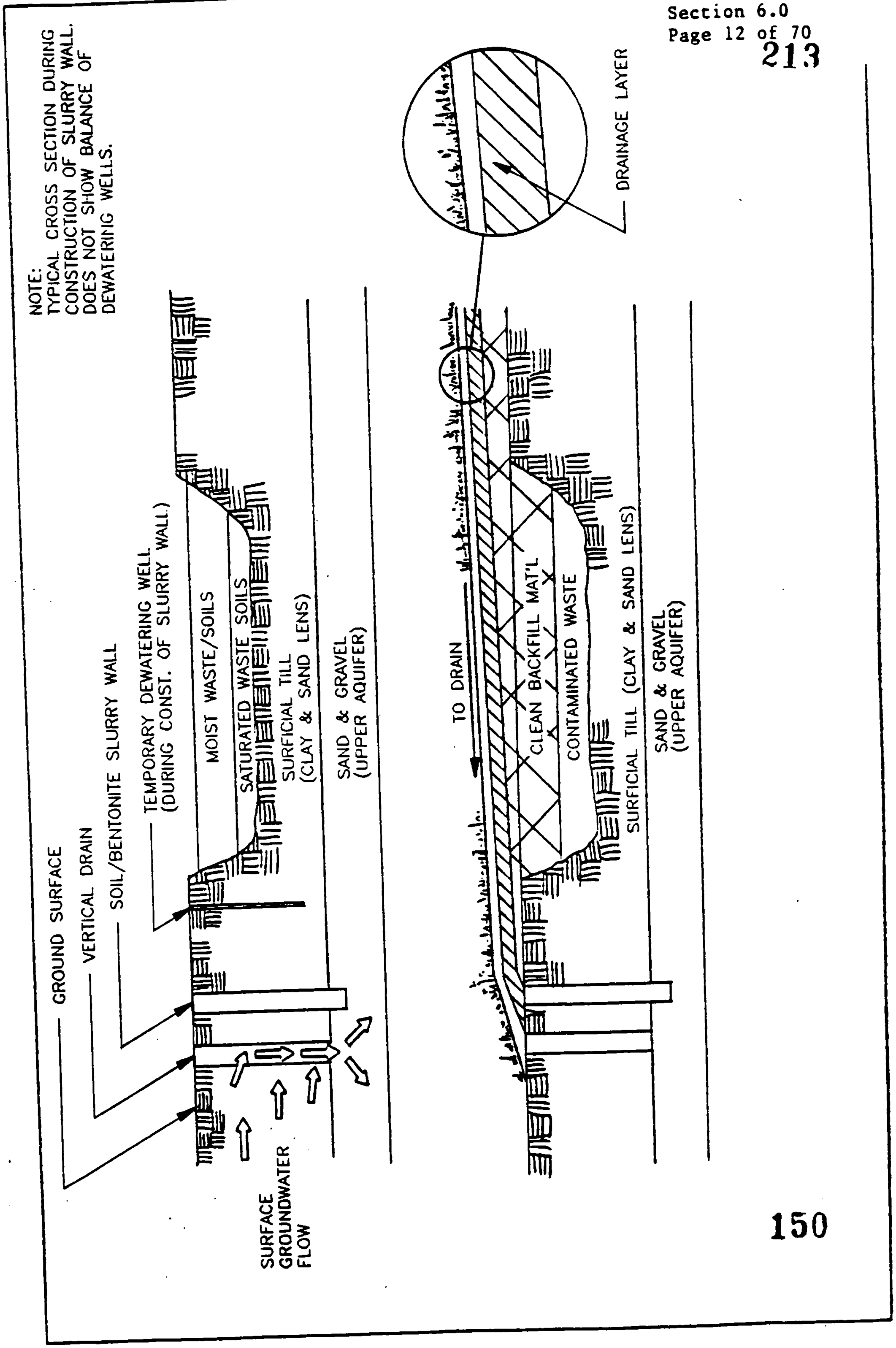


Figure 6.1.6 In Situ Waste Disposal Technology


NOTE:
TYPICAL CROSS SECTION DURING CONSTRUCTION OF SLURRY WALL. DOES NOT SHOW BALANCE OF DEWATERING WELLS.
GROUND SURFACE
VERTICAL DRAIN
SOIL/BENTONITE SLURRY WALL
TEMPORARY DEWATERING WELL (DURING CONST. OF SLURRY WALL)
MOIST WASTE/SOILS
SATURATED WASTE SOILS
SURFICIAL TILL (CLAY & SAND LENS)
SAND & GRAVEL (UPPER AQUIFER)
SURFACE GROUNDWATER FLOW
DRAINAGE LAYER
TO DRAIN
CLEAN BACKFILL MAT'L
CONTAMINATED WASTE
SURFICIAL TILL (CLAY & SAND LENS)
SAND & GRAVEL (UPPER AQUIFER)

In the case of nonremoval using the vitrification process (Alternative 1-NA-C), the cap will consist of a concrete and/or bituminous asphalt layer providing a low-maintenance, nonerodable drainage surface. For removal alternatives, a clay cap will be installed over the backfilled area to minimize the amount of infiltration into the underlying till zone. This will provide a safeguard against residual contamination that may exist in the subsurface soils.

6.1.2.4 Runoff/Run-on Control

Runoff control features will safely remove storm water from the Operable Unit 1 area while run-on control features will direct storm water away from the closed facility. Runoff/run-on control will be accomplished by using one or more of the following: site contour grading, vegetation, and diversion and collection swales and ditches, as well as various physical devices including weirs, baffles, and lined sedimentation basins.

6.1.2.5 Physical Stabilization

Waste Pits Nos. 1 through 6, the clear well, and burn pit all exhibit extremely wet to supersaturated waste conditions. To minimize the potential of long-term waste settlement, cap maintenance, and release of contaminated waste pit water into the surrounding subsoils, the following technology options for controlled compacting and dewatering of the wastes are selected for further consideration:

- Option 1

  Surcharging and Dynamic Compaction - This stabilization option will induce in situ waste subsidence (consolidation) by mounding or over-burdening the operable unit with large quantities of noncontaminated soils for specific periods of time. Vertical drains (wicks) will be installed into the pits to decrease the waste consolidation time by providing additional pathways for contaminated water removal, with all drained water collected by the temporary wells and treated prior to release. After achieving a satisfactory degree of consolidation, the overburden will be partially removed. Pit locations containing buried objects will receive further treatment using dynamic compaction, with the balance of the surcharge removed upon completion.

- Option 2

  Vacuum Extraction and Dynamic Compaction - This stabilization option will remove excess subsurface waste pit water utilizing additional suction wells, wellpoints, and/or ejector wells with the extracted water treated prior to release. Dewatering the pits in this manner will produce only partial consolidation and may increase the soil/waste liquefaction potential resulting in a less than adequate bearing capacity for closure cap support. To complete the stabilization effort, the wells or wellpoints will be removed, a clean soil layer placed, and dynamic compaction applied to the entire operable unit surface. This will cause densification of the partially consolidated waste pit materials, including buried objects.

6.1.2.6 In Situ Vitrification

Prior to initiating vitrification treatment, if required, the pit surfaces will be compacted to provide a safe working platform from which to conduct operations. The vitrification process will add a high silica content sand to the pit wastes, place electrodes into the pit in specified arrays or patterns, and then electrically heat the sand/waste mixture to high temperatures to form a glass-like material. Any process-generated gases will be captured by a hood located over the area being vitrified and treated by an air pollution control device.

For a full discussion of the vitrification technology, see Process Description, In Situ Vitrification, Appendix B.

6.1.2.7 Removal

Dependent on the physical nature of the pit sludges, including water content and the presence of standing surface water, hydraulic dredging and/or mechanical removal technologies can be employed as follows:

- Hydraulic Dredging/Removal - This technology, using vacuuming and pumping, dislodges, captures, and transports the sludges to a central collection/processing point. This dredging method cannot be utilized 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 clear well due to 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.

- Mechanical Dredging/Removal - This technology uses excavation equipment such as backhoes, draglines, and clamshells for sludge removal. The excavated waste is then moved to the treatment area by truck or conveyor system. Prior to mechanical dredging operations, Pits 5 and 6 and the clear well have standing surface water which will require treatment prior to discharge. Process options selected for further consideration are the same as those described in Section 6.1.2.1.

6.1.2.8 Segregation

Prior to sludge treatment, the waste will be segregated to separate various nonsludge components from the balance of the waste stream. As cover material is removed, visual inspection will 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. The following segregation technologies have been selected for further consideration:

- Magnetic Sorting - This method would identify areas of ferrous materials within the pits. Recovered drums or containers will be isolated and sampled to determine the content of hazardous substances and radioactive materials.

- 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, they will be evaluated and removed by the safest method. Special cleaning and decontamination procedures will be necessary for large debris prior to its disposal.

- Screening/Sizing - Physical separation of materials may be required. This will be accomplished by a series of fixed or moving screens sized to retain particles of a desired size range while allowing smaller particles and liquid to pass through the screen surface.

6.1.2.9 Treatment

After segregation, the remaining sludge material will be treated prior to disposal. Dependent on the amount of organics present in the pit sludges, the process options selected for further consideration include drying and/or vitrification and dewatering, stabilization, and/or drying. These process options are described in Appendix B (Pages B-5, B-6, and B-7, respectively).

6.1.2.10 On-Site Tumulus Disposal

After treatment, the resultant waste form may be disposed on site in a tumulus. The tumulus disposal concept basically consists of mounding over waste which has been placed on a stable structural pad. For definition purposes, a tumulus is an aboveground structure and can function as a permanent or temporary disposal unit.

The tumulus design has three slightly different variations:

- Design 1 - High-bermed perimeter incorporating the following:
  - RCRA-type closure cap with leachate collection/detection systems (LCDS)
  - All waste underlaid with liners and LCDS
  - The tumulus can accept solidified and containerized waste
- Design 2 - On-grade reinforced concrete structural pad incorporating the elements listed under Design 1
- Design 3 - Compacted gravel structural pad, incorporating the elements listed under Design 2, except for the concrete pad

Conceptual drawings of these design options are provided along with more detailed descriptions in Appendix A (Figures A.1, A.2, and A.3). As with all on-site disposal technologies, a properly designed site, regularly scheduled monitoring, and facility maintenance programs will be required throughout a specified postclosure period.

6.1.2.11 Above-Grade Structure Disposal

After treatment, the resultant waste form could alternatively be disposed on site in an above-grade structure of reinforced concrete construction designed for permanent waste disposal. This vault's maximum resistance structural design will have the ability to withstand high-intensity earthquakes, cyclonic winds, and rainwater intrusion. For definition purposes, this above-grade structure is termed a greater confinement disposal vault and can accept any dimensionally compatible treated waste form.

The vault has two variations or designs, each with and without a liner system:

- Design 1 - The vault is constructed directly on grade (Figure A.4)
  - Design 1A with a liner system including LCDS
  - Design 1B with only a primary leachate collection system
- Design 2 - The vault is constructed with the structural support slab placed six feet over grade, using an extended height reinforced concrete foundation (Figure A.5)
  - Design 2A with a liner system including LCDS
  - Design 2B with only a primary leachate collection system

Additional information on these above-grade disposal structures is presented in Appendix A. As with all on-site disposal technologies, a properly designed site, regularly scheduled monitoring, and facility maintenance programs will be required throughout some specified postclosure period.

6.1.2.12 Off-Site Disposal

After treatment and appropriate packaging, the FMPC waste could be transported to the DOE Nevada Test Site (NTS) for permanent disposal. Other disposal sites may be considered, depending on their availability and current DOE policies at the time. In either case, a temporary storage structure and/or tumulus-type structure will be required at the FMPC in support of the effort. The transport technology options selected for further consideration include transport by rail, truck, or rail with a truck transfer station at the disposal site. Any special conditions imposed by the disposal facility (e.g., no free liquids, no respirable particulate fires) will be satisfied prior to shipping.

6.1.3 Remedial Action Objectives

The degree to which each of the five alternatives would satisfy the remedial action objectives for Operable Unit 1 varies by alternative and objective. The relative ranking of the alternatives in this regard is presented in Table 6.1.1. A two-step ranking system is indicated, with the numerical entries indicating significant differences in the degree to which alternatives would satisfy a given objective (with "1" the "best") and lower case letters

TABLE 6.1.1

RANKING OF DEGREE OF SATISFYING REMEDIAL ACTION OBJECTIVES
OPERABLE UNIT 1

OBJECTIVE	ALTERNATIVE				
	1-NA-A	1-NA-B	1-NA-C	1-RA-A	1-RA-B
Prevent ingestion of or direct contact with chemical wastes or radiological wastes	1-e	1-d	1-c	1-b	1-a
Prevent release of airborne contaminants from wastes	1-e	1-d	1-c	1-b	1-a
Prevent migration of contaminants to environmental media that would exceed public health or environmental standards	3-b	3-a	2	1-b	1-a

differentiating a "preference" even though two or more alternatives would essentially satisfy the objective to the same degree. For example, in Table 6.1.1, each of the alternatives will prevent direct contact with the wastes, even though it would be preferential to totally remove the wastes away from the FMPC. On the other hand, the removal actions are much more reliable in preventing future releases of contamination to the underlying aquifer, and a properly implemented vitrification process would be expected to reduce future release potential more so than a slurry wall/capping arrangement.

It is noteworthy that the ranking scheme reflected in Table 6.1.1 (and similar tables in subsequent sections) consider anticipated conditions only after an action is satisfactorily completed. Any potential exposures or releases during the period of implementation are not accounted for.

6.2 OPERABLE UNIT 2

6.2.1 Alternative Descriptions

Six potential remedial action alternatives have been developed for the solid waste disposal units comprising Operable Unit 2. In addition to the no-action alternative, three nonremoval alternatives and two removal alternatives remain for further evaluation in Task 13.

6.2.1.1 Nonremoval - Cap (Alternative 2-NA-A)

The first nonremoval alternative represents a minimum action scenario that is intended to isolate the wastes and to minimize the vertical infiltration of rainfall/runoff into and through the solid wastes. As shown in Figure 6.2.1, this alternative is limited to capping of the waste area and implementation of runoff and run-on control measures. Additional information on the specific technologies is presented in Section 6.2.2.

6.2.1.2 Nonremoval - Slurry Wall and Cap (Alternative 2-NA-B)

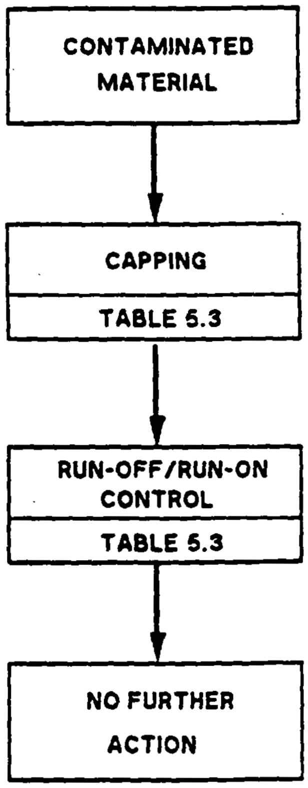
The second nonremoval alternative is an extension of Alternative 2-NA-A and provides for a more proactive approach to leachate control. In particular, a subsurface flow control scheme consisting of a slurry wall and pumping wells

Fig. 6.2.1

Remedial Action Alternative 2-NA-A

Operable Unit 2

Non-Removal - Cap



would be implemented to extract contaminated water from below the waste units and to lower the ground water table to achieve an inward gradient. Technologies for treating any extracted ground water will also be implemented as necessary. The flow chart showing the full set of technology groupings is provided in Figure 6.2.2.

An additional feature of this alternative is the option to include physical stabilization of the wastes prior to capping. The need for this option will be dependent on both the solid waste unit and the geotechnical properties of the underlying natural materials.

6.2.1.3 Nonremoval - Intercepting Trench and Cap (Alternative 2-NA-C)

The final nonremoval alternative for Operable Unit 2 is illustrated in Figure 6.2.3. The alternative is comprised of an interceptor trench for ground water collection and control, associated treatment of any ground water removed, and site closure including capping and runoff/run-on control measures. A comparison of Figures 6.2.2 and 6.2.3 indicates that this alternative is identical to Alternative 2-NA-B with the exception that releases to the underlying aquifer will be controlled through a passive ground water collection trench rather than through the use of a slurry wall and pumping wells.

The option of physically stabilizing the solid wastes prior to site closure is once again included as part of the alternative in case the waste and site conditions favor such a support action.

6.2.1.4 Removal and On-Site Disposal (Alternative 2-RA-A)

An alternative that incorporates removal and on-site disposal of the solid waste material is shown in Figure 6.2.4. Most types of waste would be mechanically removed and directly disposed into an on-site engineered facility, although the option of packaging the wastes prior to disposal is available if deemed to be necessary for certain waste types.

Fig. 6.2.2

Remedial Action Alternative 2-NA-B

Operable Unit 2

Non-Removal - Slurry Wall and Cap

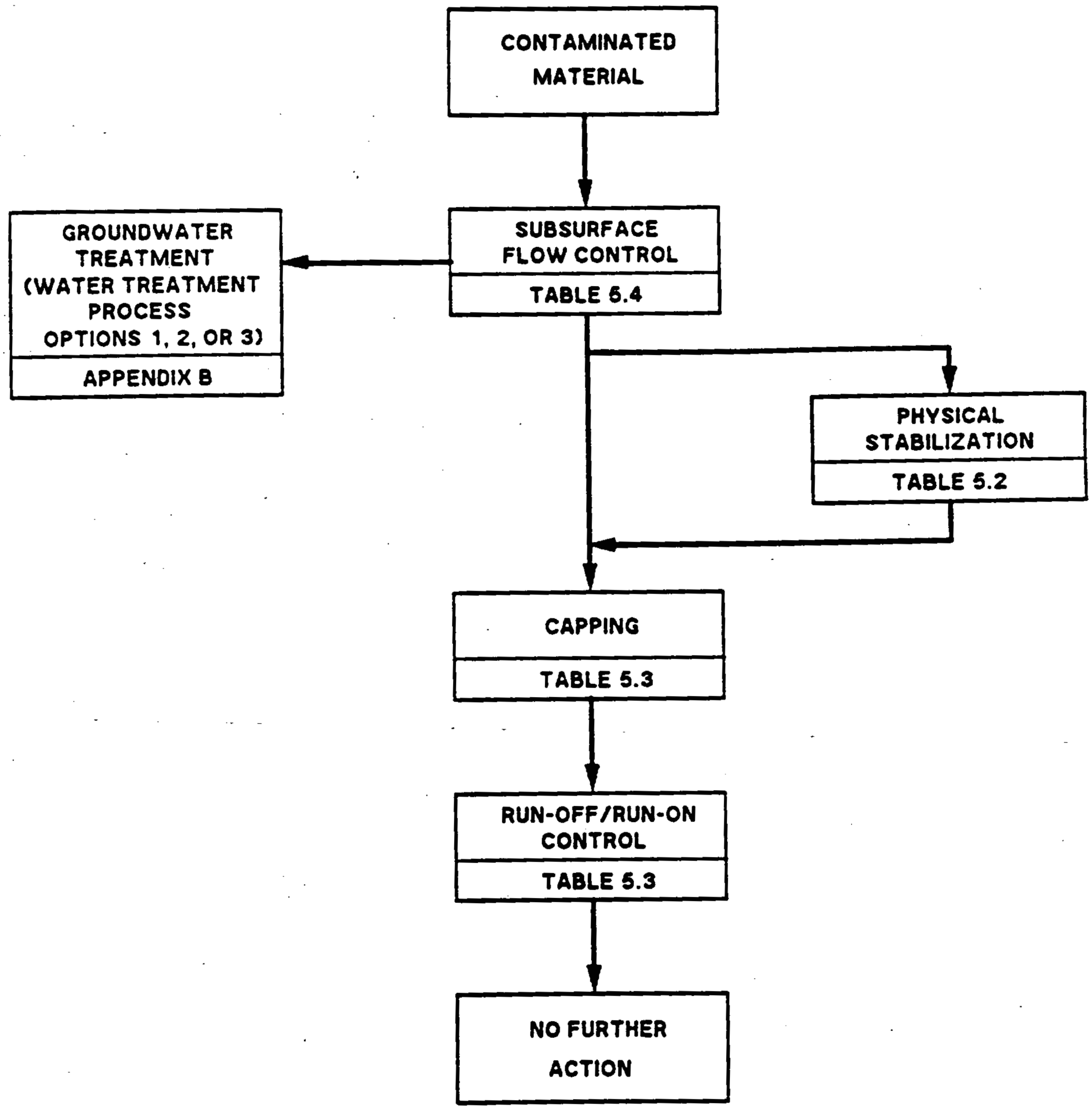


Fig. 6.2.3

Remedial Action Alternative 2-NA-C

Operable Unit 2

Non-Removal - Intercepting Trench and Cap

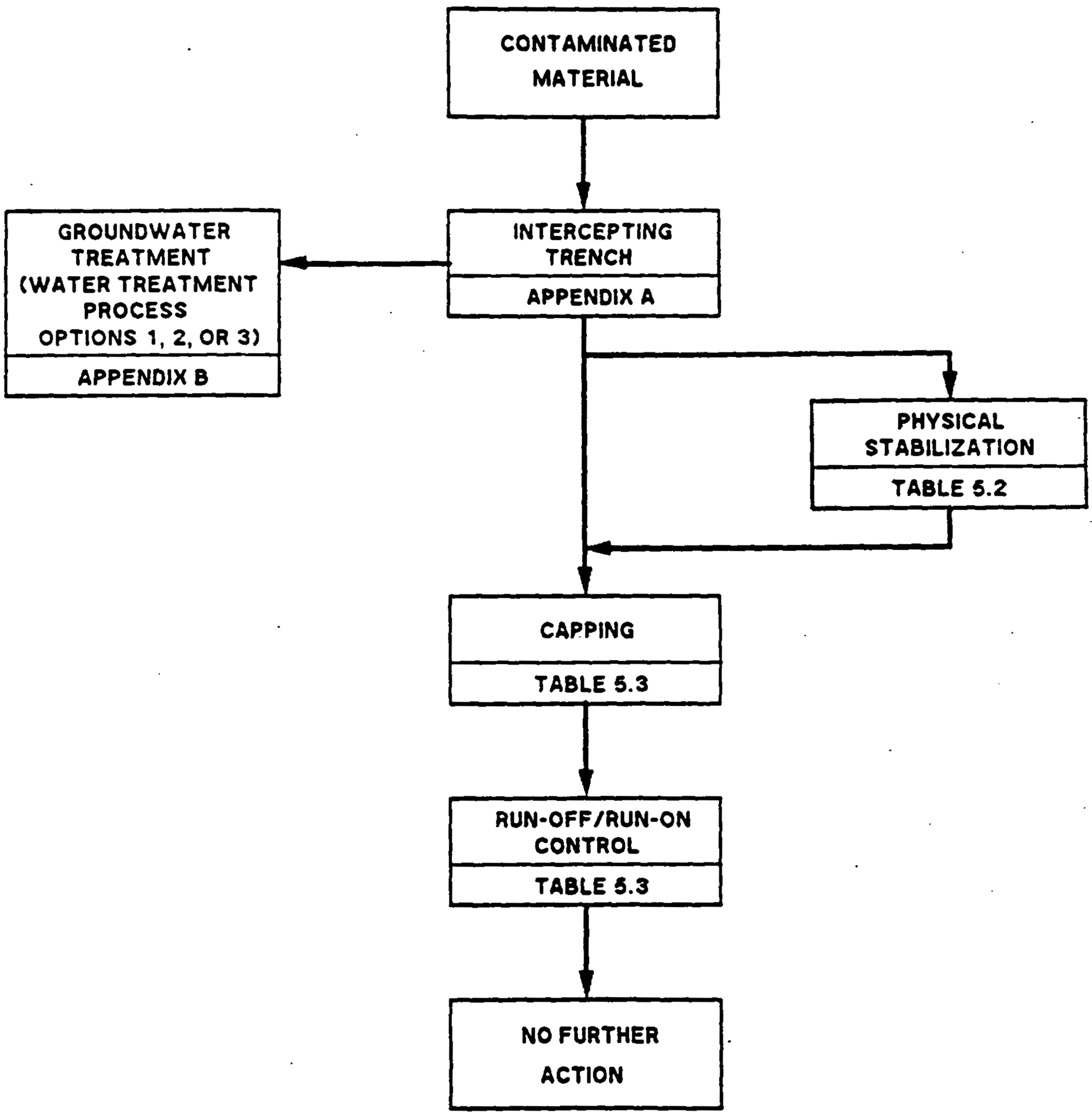
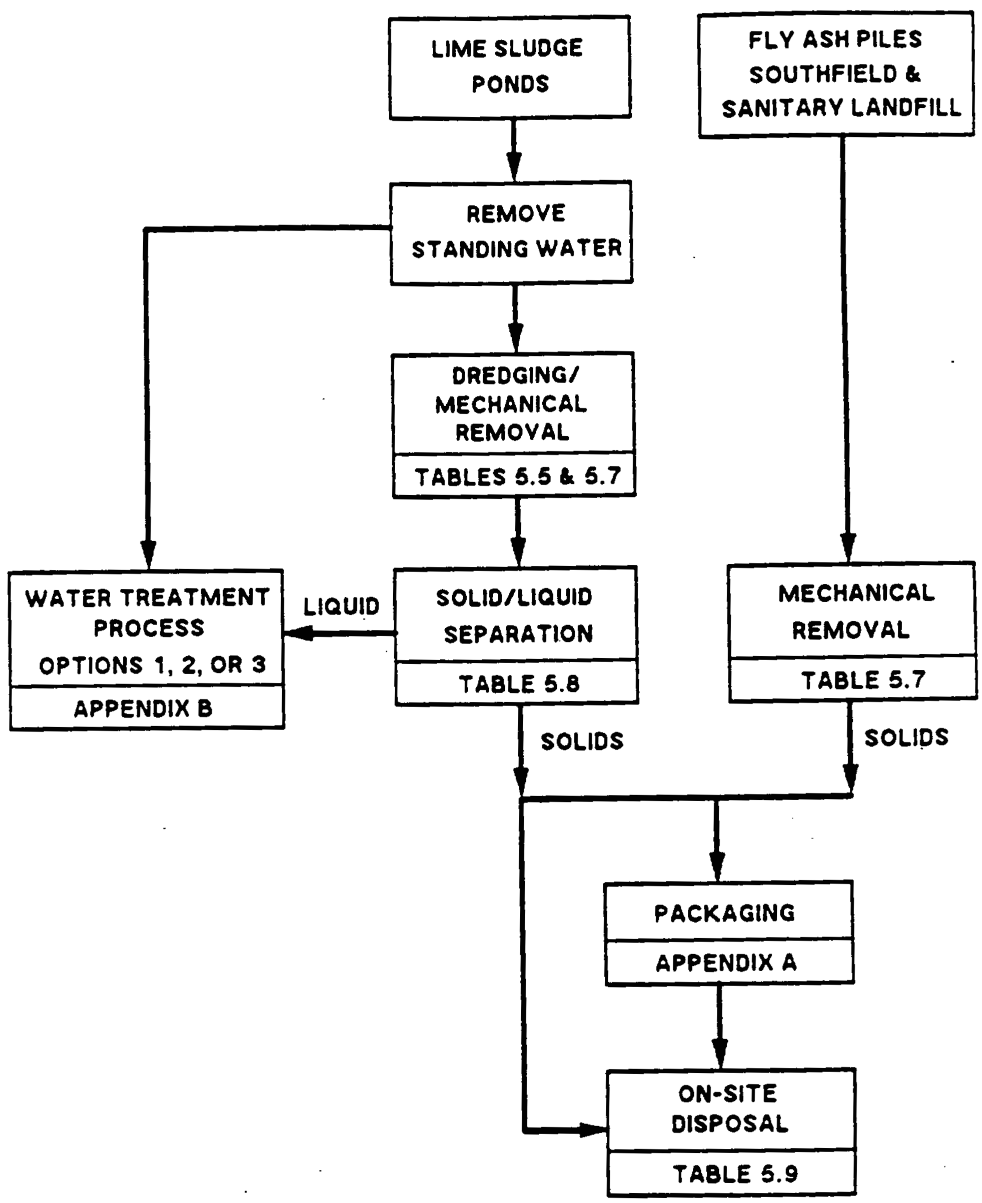


Fig. 6.2.4

Remedial Action Alternative 2-RA-A

Operable Unit 2

Removal, Bulk/Packaging, and On-Site Disposal



Several technology groupings indicated in Figure 6.2.4 have been included in this alternative only to account for the material properties of the lime sludges. The standing water and the saturated condition of the sludge require special removal, dewatering, and treatment considerations. Technologies associated with the latter three activities are identified in Section 6.2.2.

6.2.1.5 Removal, Bulk/Packaging, and Off-Site Disposal (Alternative 2-RA-B)

The second removal alternative, which is illustrated in Figure 6.2.5, is similar to Alternative 2-RA-A except that the removed waste materials will be transported and disposed at an approved off-site location. One concomitant change in this alternative is that the removed waste may likely require some type of packaging prior to off-site transport.

6.2.2 Technology Descriptions

6.2.2.1 Closure Capping

The waste areas will be contour graded with clean compacted fill to provide drainage prior to cap placement. The cap will consist of a vegetative cover, a natural or synthetic drainage layer, a flexible membrane liner, and/or a low-permeability clay liner. All cap elements and layers will be contoured to grades which promote drainage while minimizing the effects of waste subsidence and storm water erosion.

6.2.2.2 Runoff/Run-on Control

Runoff control features will safely remove storm water from the waste area while run-on control features will direct storm water away from the closed area. Runoff/run-on control will be accomplished by using one or more of the following: site contour grading, vegetation, and diversion and collection swales and ditches, as well as various physical devices including weirs, baffles, and lined sedimentation basins.

6.2.2.3 Subsurface Flow Control

The subsurface flow control technologies will eliminate horizontal ground water flow through any till underlying the solid waste areas and will minimize

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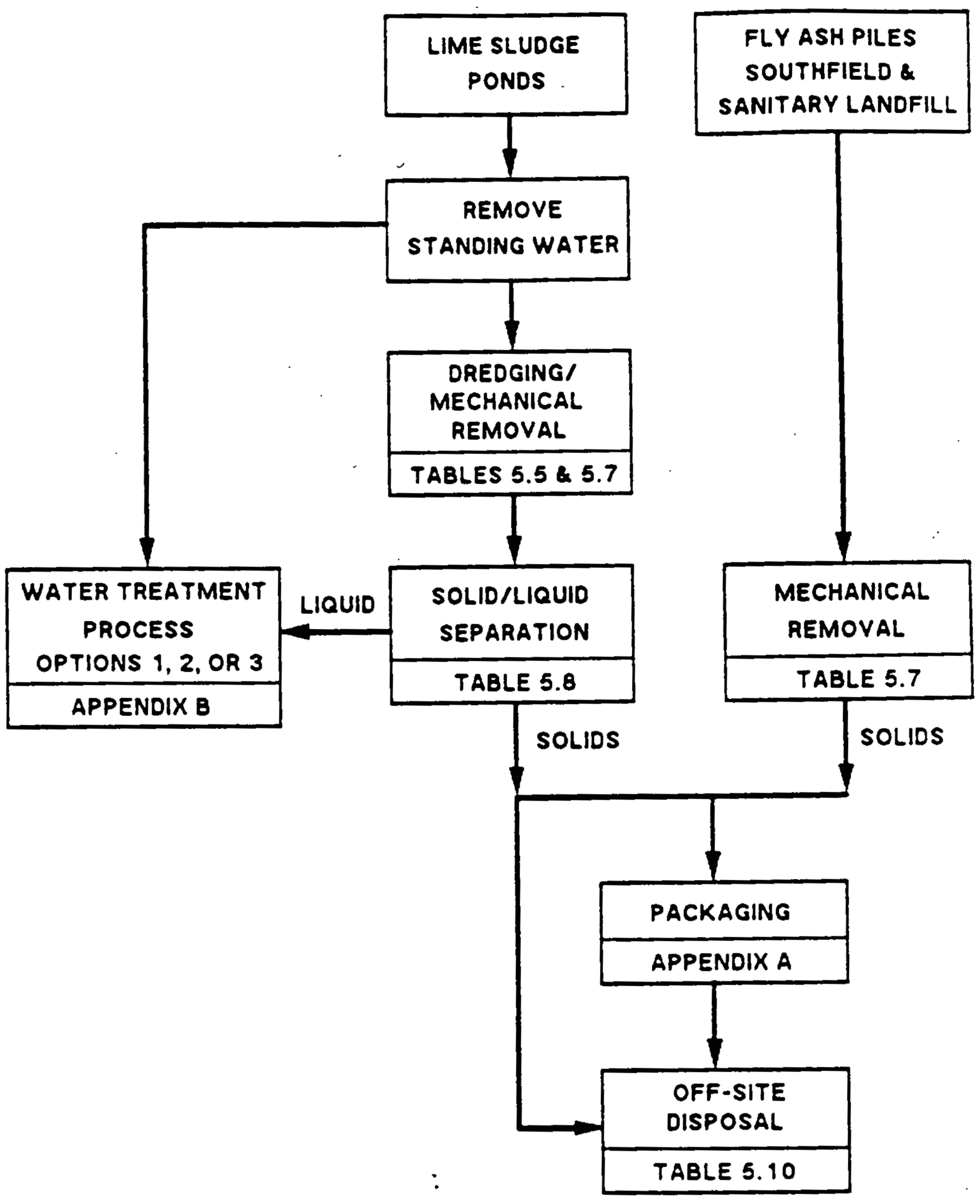
Fig. 6.2.5

Remedial Action Alternative 2-RA-B

Operable Unit 2

Removal, Bulk/Packaging, and Off-Site Disposal



the potential for vertical leakage into the sand and gravel aquifer. These technologies are:

- A soil or cement/bentonite full or partial slurry wall will be placed around the waste area. The slurry wall will be installed through the surficial till layer, if present, into the underlying sands and gravels of the upper aquifer. The slurry wall will divert horizontal flow in the till away from the enclosed area. If no till is present, the slurry wall will be extended further into the sand and gravel aquifer to better control ground water gradients during the active pumpdown period, but the long-term effectiveness of this application would be very limited.

- Ground water wells will be used to remove ground water from inside the slurry wall area, providing both contaminant (plume) control and reduction of contaminated water available to be released to the underlying aquifer. These wells will be removed and grouted shut prior to capping of the area. It is assumed that the withdrawn water is contaminated to some degree and requires treatment prior to discharge.

An important distinction between this subsurface flow control scenario and that described for Operable Unit 1 is the absence of the vertical drains outside the slurry wall. The reason is that the solid waste units either lie above ground level or are very shallow. The need to positively control the elevation of the water table outside the slurry wall is, therefore, not critical to the overall flow control scheme.

6.2.2.4 Ground Water Treatment

The ground water collected from the waste areas will be treated prior to discharge. Any resultant process residue will be sent to an appropriate facility for disposal. Process options selected for further consideration include evaporation; ion exchange and denitrification; and metals removal, ion exchange, and denitrification. These process options are described in Appendix B (Pages B-1 through B-3, B-8, and B-9, respectively).

6.2.2.5 Interceptor Trench

An interceptor trench installed around the perimeter of a waste area, or at a minimum along the downgradient side, will lower the water table in the vicinity of the waste and will capture leachate before it escapes into the sand and gravel aquifer. Wells installed into the lowest point in the trench would be used to pump the collected water to the surface for treatment prior to disposal. This method of ground water collection and control is applicable to Operable Unit 2 since the solid waste units either lie totally above the natural till material or intersect the till to only shallow depths; in either case, the waste units lie above the ground water table. Although the trench system can be maintained on a permanent basis, it is anticipated that reduction in infiltration achieved by the cap and runoff control measures will allow the eventual abandonment of the trench.

6.2.2.6 Physical Stabilization

Before installing the closure cap, and depending on geotechnical field testing results, the waste areas may require in situ stabilization. To minimize the potential of long-term waste settlement, future cap maintenance, and release of contaminated leachate into the surrounding subsoils, the following technology options are selected for further consideration:

- Option 1

  Surcharging and Dynamic Compaction - This stabilization option will induce in situ waste subsidence (consolidation) by mounding or overburdening the solid waste unit with large quantities of noncontaminated soils for specific periods of time. Vertical drains (wicks) will be installed into the waste to decrease the consolidation time by providing additional pathways for contaminated water removal, with all drained water collected by the temporary wells or trench and treated prior to release. After achieving a satisfactory degree of consolidation, the overburden will be partially removed. Waste locations containing buried objects will receive further treatment using dynamic compaction, with the balance of the surcharge removed upon completion.

- Option 2

  Vacuum Extraction and Dynamic Compaction - This stabilization option will remove excess subsurface water utilizing additional suction wells, wellpoints, and/or ejector wells with the extracted water treated prior to release. Dewatering in this manner will produce only partial consolidation and may increase the soil/waste liquefaction potential resulting in a less than adequate bearing capacity for closure cap support. To complete the stabilization effort, the wells or wellpoints will be removed, a clean soil layer placed, and dynamic compaction applied to the entire operable unit surface. This will cause densification of the partially consolidated waste area materials, including buried objects.

6.2.2.7 Removal

Dependent on the physical nature of the waste, including water content and the presence of standing surface water, hydraulic dredging and/or mechanical removal technologies can be employed as follows:

- Hydraulic Dredging/Removal - This technology, using vacuuming and pumping, dislodges, captures, and transports the sludges to a central collection/processing point. This dredging method cannot be utilized for the removal of nonsludge wastes and is potentially applicable only to the lime sludge ponds. Therefore, mechanical removal methods would be employed to complete waste removal at the other solid waste units.

- Mechanical Dredging/Removal - This technology uses excavation equipment such as backhoes, draglines, and clamshells for waste removal. The excavated waste is then moved to the treatment area by truck or conveyor system. Prior to mechanical dredging operations, any standing surface water will require treatment prior to discharge. Process options selected for further consideration were identified previously.

6.2.2.8 Material Segregation

Prior to waste treatment and/or volume reduction, the waste will be segregated to separate various components. As cover is removed, visual inspection will be made to determine the type of material present and the best method for handling and sorting. When removing materials, care will be taken to avoid puncturing drums or other containers. The following segregation technologies have been selected for further consideration:

- Magnetic Sorting - This method would identify areas of ferrous materials within the solid waste units. Recovered drums or containers will be isolated and sampled to determine RCRA constituents and radioactivity.

- 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 will be evaluated and removed by the safest method. Special cleaning and decontamination procedures may be necessary for large debris prior to its disposal.

- Screening/Sizing - Physical separation of materials may be required. This will be accomplished by a series of fixed or moving screens sized to retain particles of a desired size range while allowing smaller particles and liquid to pass through the screen surface.

6.2.2.9 Volume Reduction

After segregation, and depending on the waste composition, the nonsludge waste may be subjected to volume reduction prior to disposal. The following technologies are selected for further consideration:

- Compaction - Physically deforming or compressing the waste into a more dense configuration
- Shredding - Tearing or cutting the waste form into smaller pieces to facilitate handling and disposal

6.2.2.10 Treatment

After segregation, the sludge material from the lime sludge ponds may be treated prior to disposal. The process options selected for further consideration include dewatering, stabilization, and/or drying. These process options are described in Appendix B.

6.2.2.11 On-Site Disposal

As excavation progresses, the solid waste material would be transported and disposed on site. Disposal of solid waste could occur using a tumulus or other concrete structure if such a facility is constructed for other types of wastes and capacity is available. A separate disposal facility could also be developed for the solid wastes since the design criteria may be less stringent than for other wastes.

6.2.2.12 Off-Site Disposal

After treatment or volume reduction, the FMPC waste could be transported to NTS for permanent disposal. However, the nature of the solid wastes is such that alternative off-site disposal options may be available. This will be evaluated in a later task. A temporary storage structure and/or tumulus-type structure will be required at the FMPC in support of the effort. The transport technology options selected for further consideration include transport by rail, truck, or rail with a truck transfer station at the disposal site. Any special conditions imposed by the disposal facility (e.g., no free liquids, no respirable particulate fines) will be satisifed prior to shipping.

6.2.3 Remedial Action Objectives

Table 6.2.1 presents the comparative ranking of the five alternatives for Operable Unit 2 in terms of their value in satisfying the designated remedial action objectives. Each of the five alternatives will effectively eliminate the ingestion of or direct contact with the wastes as well as the release of airborne contaminants from the solid waste storage areas. The indicated differences in the degree to which each alternative would prevent contaminant migration to environmental media are generally a function of ground water protection. Differences in the nonremoval alternatives reflect the types of ground water protection technologies associated with each alternative.

6.3 OPERABLE UNIT 3

As previously discussed in Sections 2.2. and 4.3, specific remedial action alternatives for Operable Unit 3 do not require development at this point in the FS process.

6.4 OPERABLE UNIT 4

6.4.1 Alternative Descriptions

A total of 12 remedial action alternatives have been developed for Operable Unit 4. The reason for this relatively large number of alternatives is the significant differences in material properties associated with the K-65 silos, the metal oxide silo, and the thorium inventory. In addition to the no-action alternative, the alternatives are described as follows:

- K-65 Silos and/or Metal Oxide Silo
  - Two nonremoval alternative
  - Four removal alternatives
- Metal Oxide Silo Only
  - One nonremoval alternative
  - Three removal alternatives

TABLE 6.2.1

RANKING OF DEGREE OF SATISFYING REMEDIAL ACTION OBJECTIVES
OPERABLE UNIT 2

	ALTERNATIVE				
OBJECTIVE	2-NA-A	2-NA-B	2-NA-C	2-RA-A	2-RA-B
Prevent ingestion of or direct contact with chemical wastes or radiological wastes	1-c	1-c	1-c	1-b	1-a
Prevent release of airborne contaminants from wastes	1-c	1-c	1-c	1-b	1-a
Prevent migration of contaminants to environmental media that would exceed public health or environmental standards	5	3	4	2	1

- **Thorium Inventory**
  - Two permanent disposal alternatives

6.4.1.1 Nonremoval - Silo 3 Isolation (Alternative 4-NA-A)

The initial nonremoval action, which is illustrated in Figure 6.4.1, includes technologies for enhancing the performance of the existing silos as permanent disposal facilities. The technologies considered for this alternative are associated with improving the overall integrity of containment in the silo as discussed in Section 6.4.2.

6.4.1.2 Nonremoval - In Situ Stabilization and Cap (Alternative 4-NA-B)

The second nonremoval option includes in situ stabilization of the wastes in both the K-65 silos and the cold metal oxide silo and provides for an option to cover the silos with a cap designed to control surface water runoff away from the solidified mass. This alternative is depicted in Figure 6.4.2. As indicated in the figure, both physical stabilization technologies and vitrification are included as options. Special testing would be required in either case to confirm the technical feasibility of in situ stabilization. Any steam collected during the vitrification of the wastes would be collected, condensed, and sent for treatment. Information on the implementation of the stabilization and vitrification processes is provided in Section 6.4.2 and the appendices.

6.4.1.3 Removal of Metal Oxides (Silo 3) and On-Site Disposal (Alternative 4-RA-A)

Silo 3 contains dry metal oxides. These materials are light and powdery and emit very low levels of radon due to the small amount of radium present. The consistency and relatively low radiological activity of the materials allows for the alternative of removal with on-site disposal in an engineered facility without interim stabilization or treatment of the wastes. As shown in Figure 6.4.3, the full scope of this alternative would include removal and packaging of the material prior to disposal in an on-site facility (e.g., tumulus or other above-grade structure) as well as demolition of the silo itself with appropriate packaging and on-site disposal of the silo debris.

Fig. 6.4.1

Remedial Action Alternative 4-NA-A

Operable Unit 4

Non-Removal - Silo Isolation

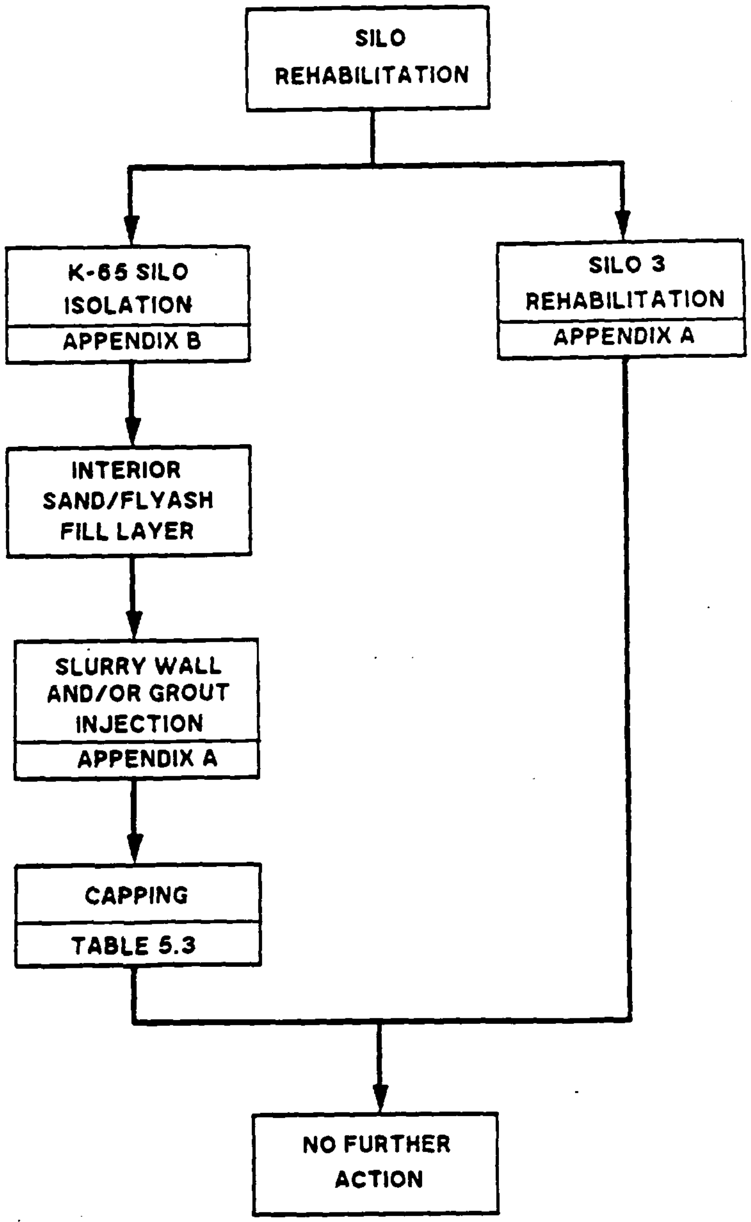


Fig. 6.4.2

Remedial Action Alternative 4-NA-B

Operable Unit 4

Non-Removal - Vitrification and Cap

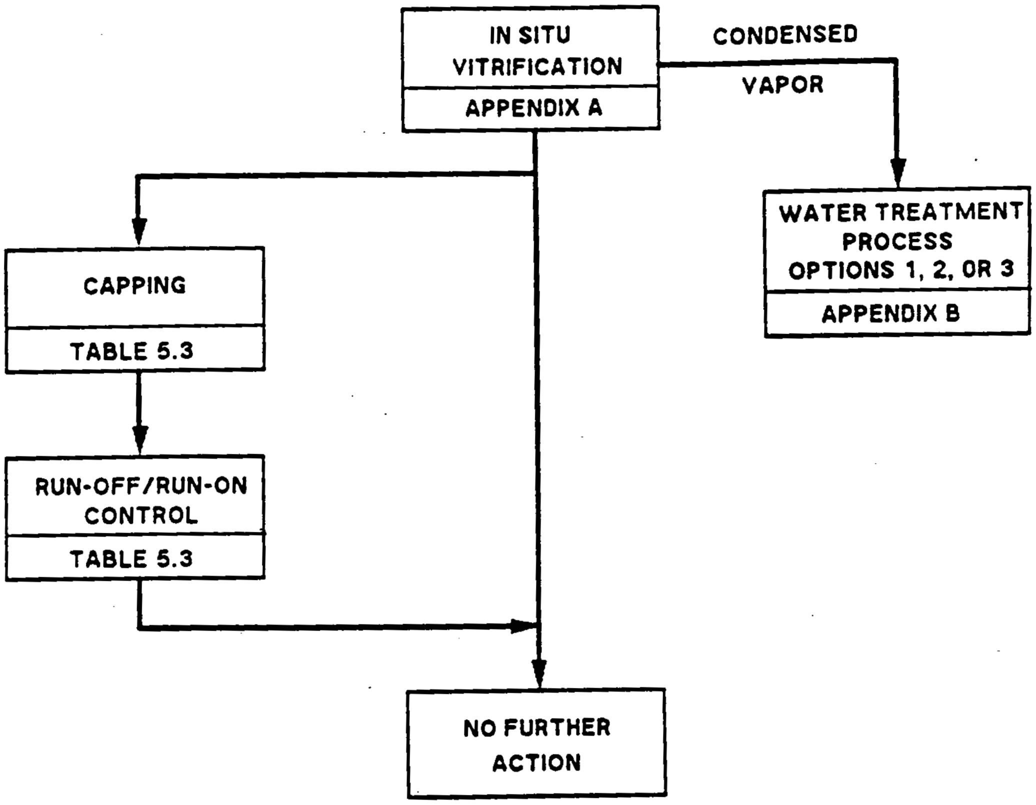
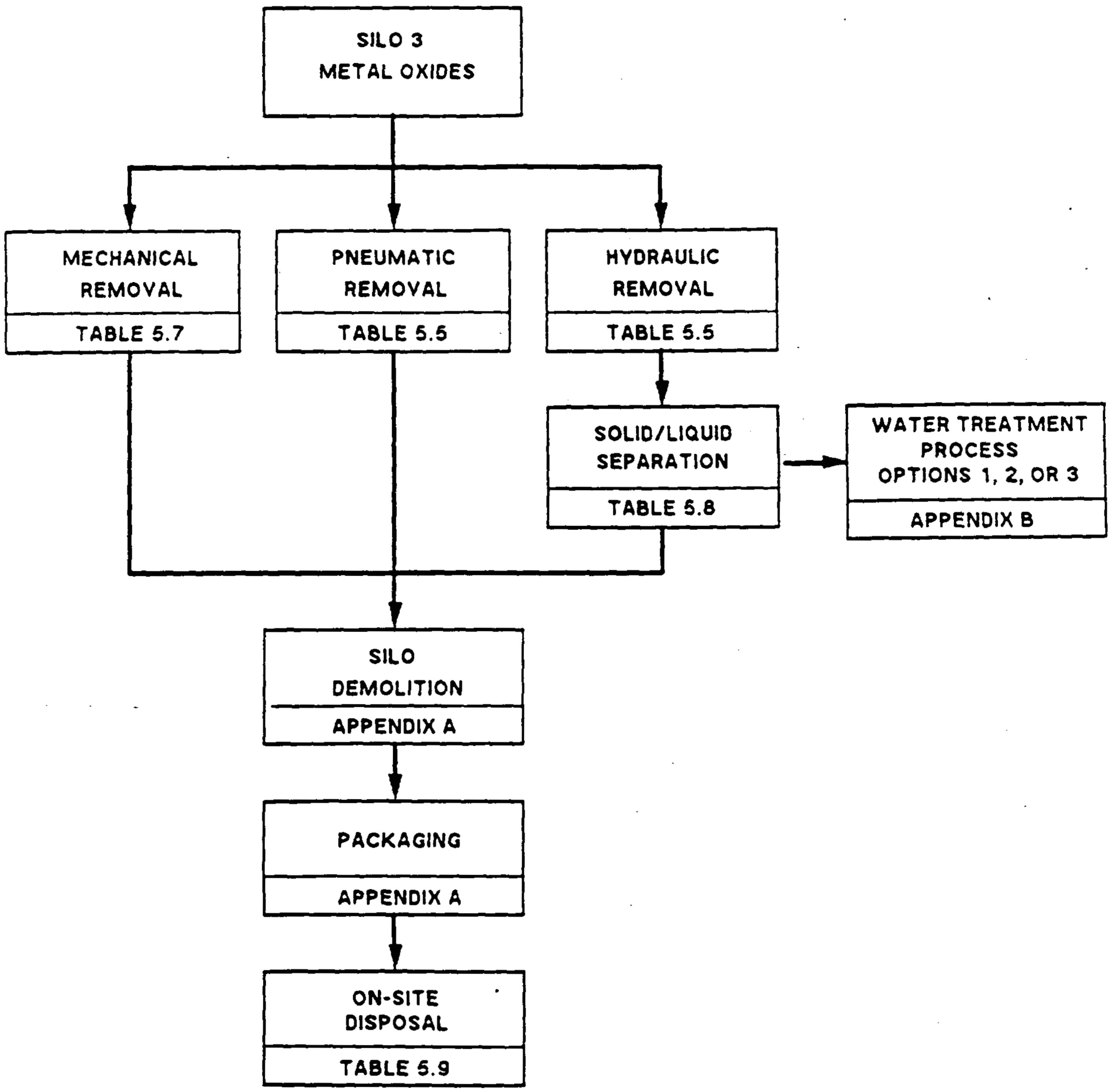


Fig. 6.4.3
Remedial Action Alternative 4-RA-A
Operable Unit 4
Removal and On-Site Disposal of Metal Oxides (Silo 3 only)



The hydraulic removal option would require the addition of large volumes of water to the wastes, which in turn would require dewatering and water treatment steps upon removal of the material. The removal technologies remaining under consideration are described in Section 6.4.2, as are the other technology groupings associated with this alternative.

6.4.1.4 Removal of Metal Oxides (Silo 3) and Off-Site Disposal (Alternative 4-RA-B)

The alternative of removing the cold metal oxides from Silo 3 with disposal at an off-site facility is illustrated in Figure 6.4.4. As can be observed, this alternative replicates Alternative 4-RA-A except for the method of disposal.

6.4.1.5 Removal of Metal Oxides (Silo 3) and Disposal in Rehabilitated Silo (Alternative 4-RA-C)

This alternative combines features of a nonremoval alternative (Alternative 4-NA-A) and a removal alternative (Alternative 4-RA-A). In this case, the materials in Silo 3 are removed and placed in temporary storage prior to rehabilitating the silo. Upon completion of rehabilitation, the silo would be considered an adequate permanent disposal facility and the materials would be redisposed back into the silo. This alternative is illustrated in Figure 6.4.5.

6.4.1.6 Removal of Waste (K-65 Silos), Treatment, and On-Site Disposal (Alternative 4-RA-D)

The fourth removal alternative is the first considered to be applicable to the waste raffinate in the K-65 silos. It is depicted in Figure 6.4.6. When this alternative is compared to its counterpart for Silo 3 (Alternative 4-RA-A), the principal difference is observed to be the inclusion of a postremoval waste treatment step in Alternative 4-RA-D. The reason for this step is to satisfy as low as reasonably achievable (ALARA) principles by reducing radon emissions through waste stabilization/treatment and decreasing the level of radioactivity by waste blending with other select materials. The future threat of leachate releases is also minimized.

Fig. 6.4.4

Remedial Action Alternative 4-RA-B

Operable Unit 4

Removal and Off-Site Disposal of Metal Oxides (Silo 3 only)

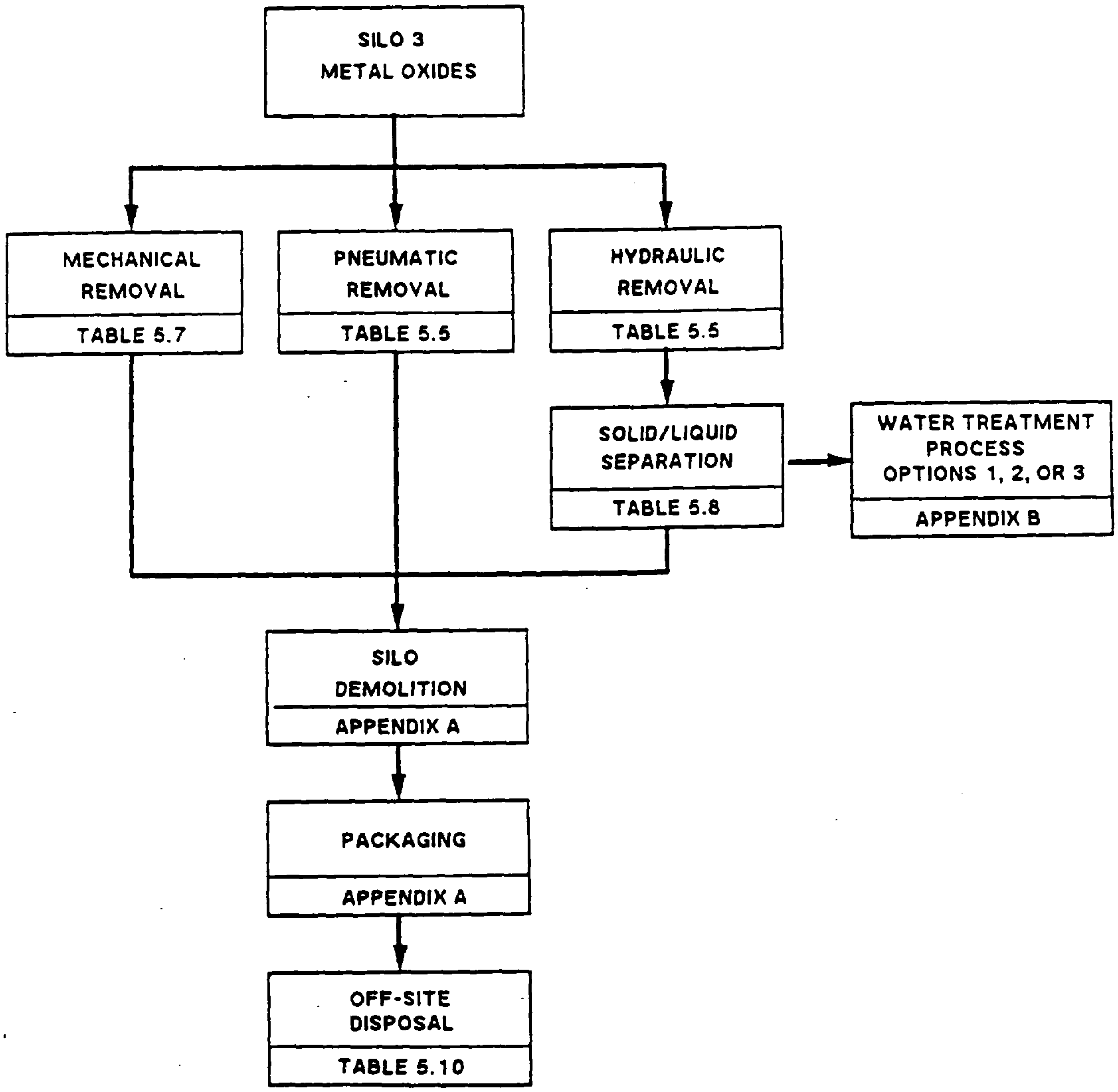
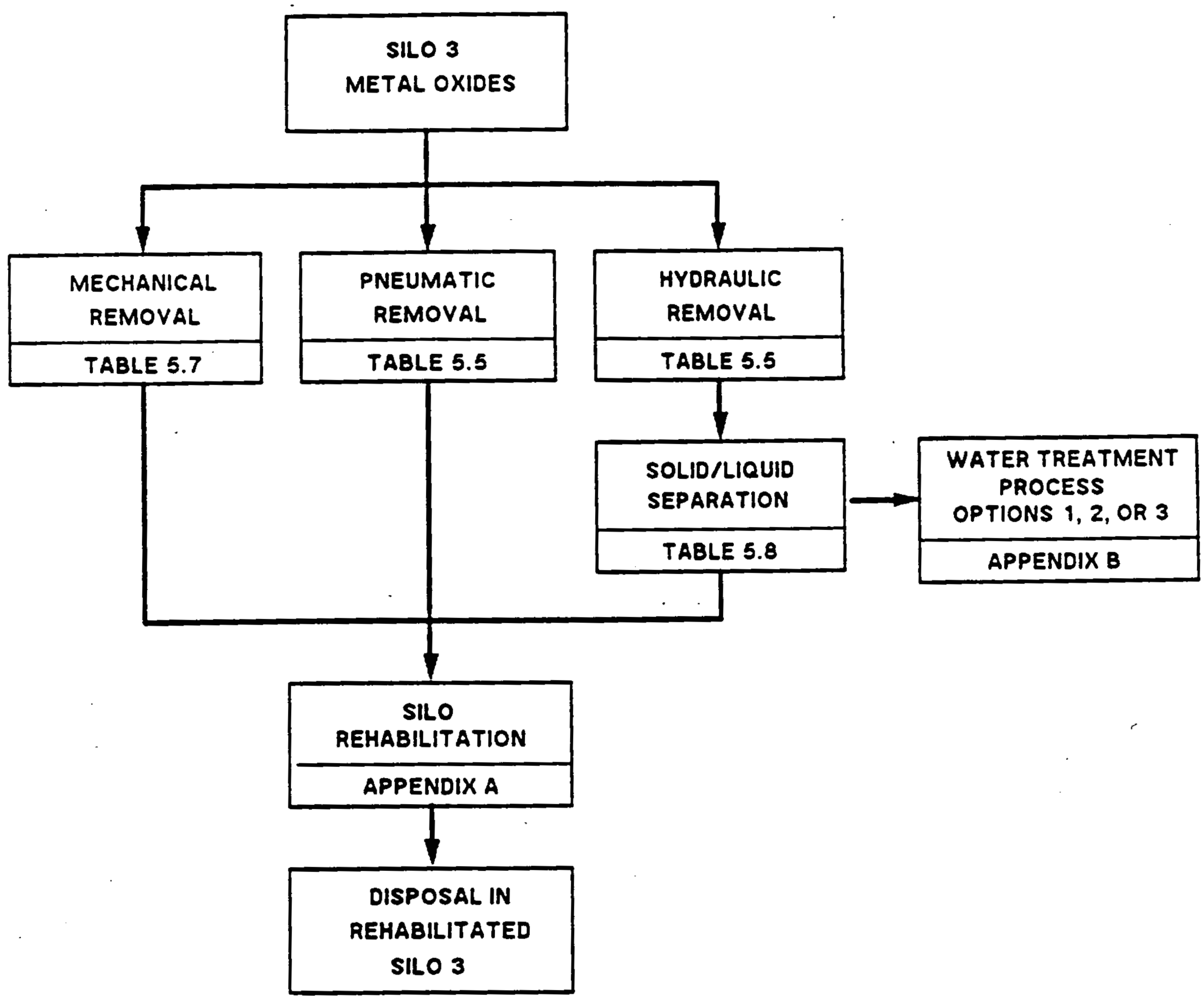


Fig. 6.4.5

Remedial Action Alternative 4-RA-C

Operable Unit 4

Removal and On-Site Disposal of Metal Oxides in Rehabilitated Silo (Silo 3 only)



As shown in Figure 6.4.6, various types of physical-chemical treatment technologies as well as vitrification are being considered as options for post-removal processing of the raffinate materials. These are described further in Section 6.4.2. It is also noteworthy that pneumatic removal has been deleted as a principal removal technology for the K-65 waste materials based on the current understanding of material properties. If subsequent sampling indicates the presence of layers of resin fines or other materials suitable for pneumatic removal, this technology will again be considered.

6.4.1.7 Removal of Waste (K-65 Silos), Treatment, and Off-Site Disposal (Alternative 4-RA-E)

This alternative represents the off-site disposal counterpart of Alternative 4-RA-D. As shown in Figure 6.4.7, all features of this alternative are the same as the previous alternative, except for the disposal option. As mentioned in a previous section, differences in waste packaging requirements could occur between on-site and off-site disposal alternatives. Such differences would, however, come into consideration only in a later task of the FS.

6.4.1.8 Removal of Waste (K-65 Silos), Contaminant Separation, Bulk Packaging, and On-Site Disposal (Alternative 4-RA-F)

This removal alternative, as shown in Figure 6.4.8, is similar to Alternative 4-RA-D in that it involves material removal, treatment, packaging, and on-site disposal. The key difference is that waste treatment in this case is not limited to physically or chemically stabilizing the waste through material addition. Rather, this alternative considers treatment processes to actually remove the radium (and possibly other radionuclides and metals) from the bulk waste, thereby minimizing the amount of radium-bearing waste for subsequent disposal. Processing of the waste could involve an existing facility (i.e., Plant 2/3) or a new process facility constructed specifically for purposes of K-65 silo remediation.

Fig. 6.4.6

Remedial Action Alternative 4-RA-D

Operable Unit 4

Removal, Treatment, and On-Site Disposal

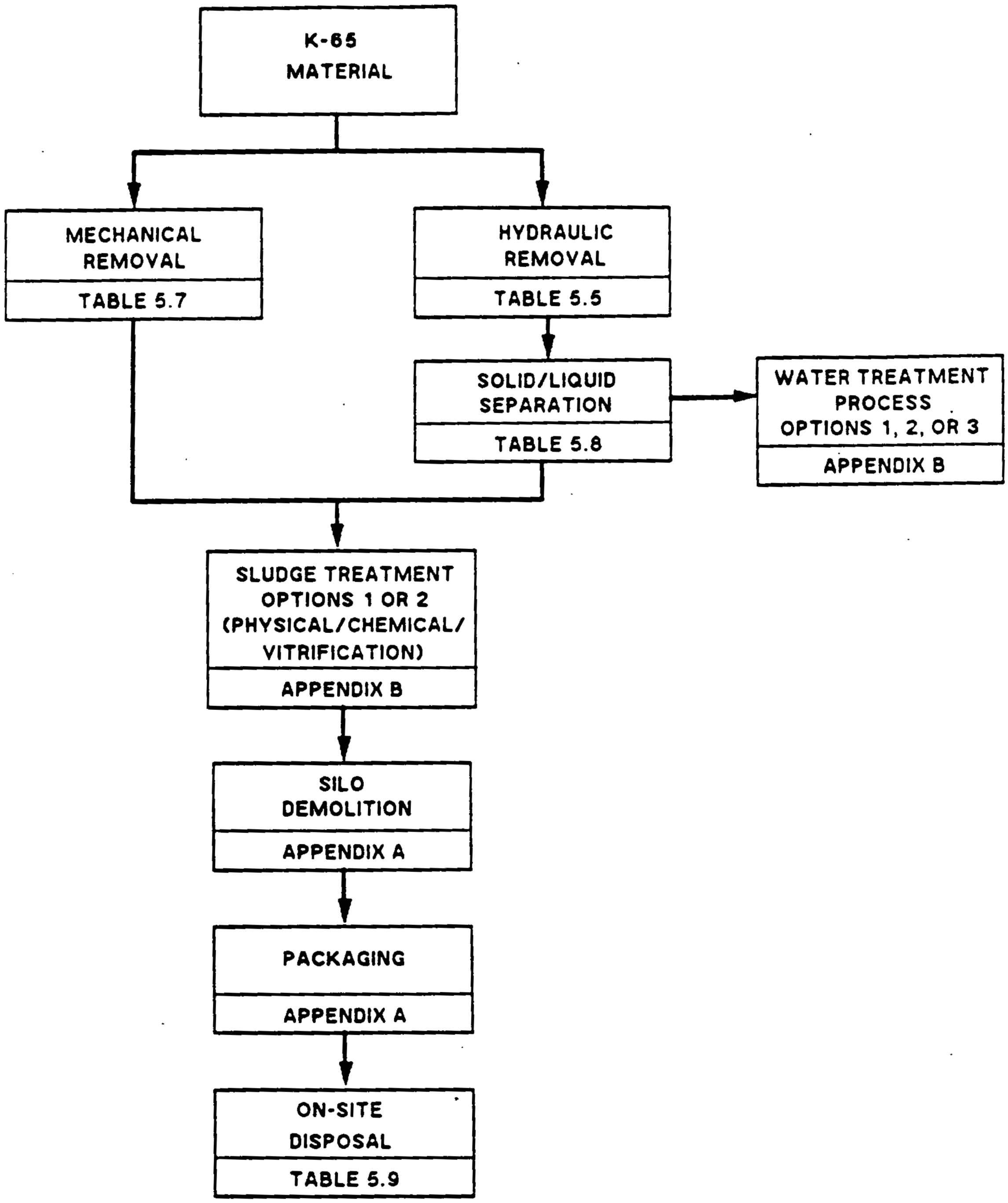


Fig. 6.4.7

Remedial Action Alternative 4-RA-E

Operable Unit 4

Removal, Treatment, and Off-Site Disposal

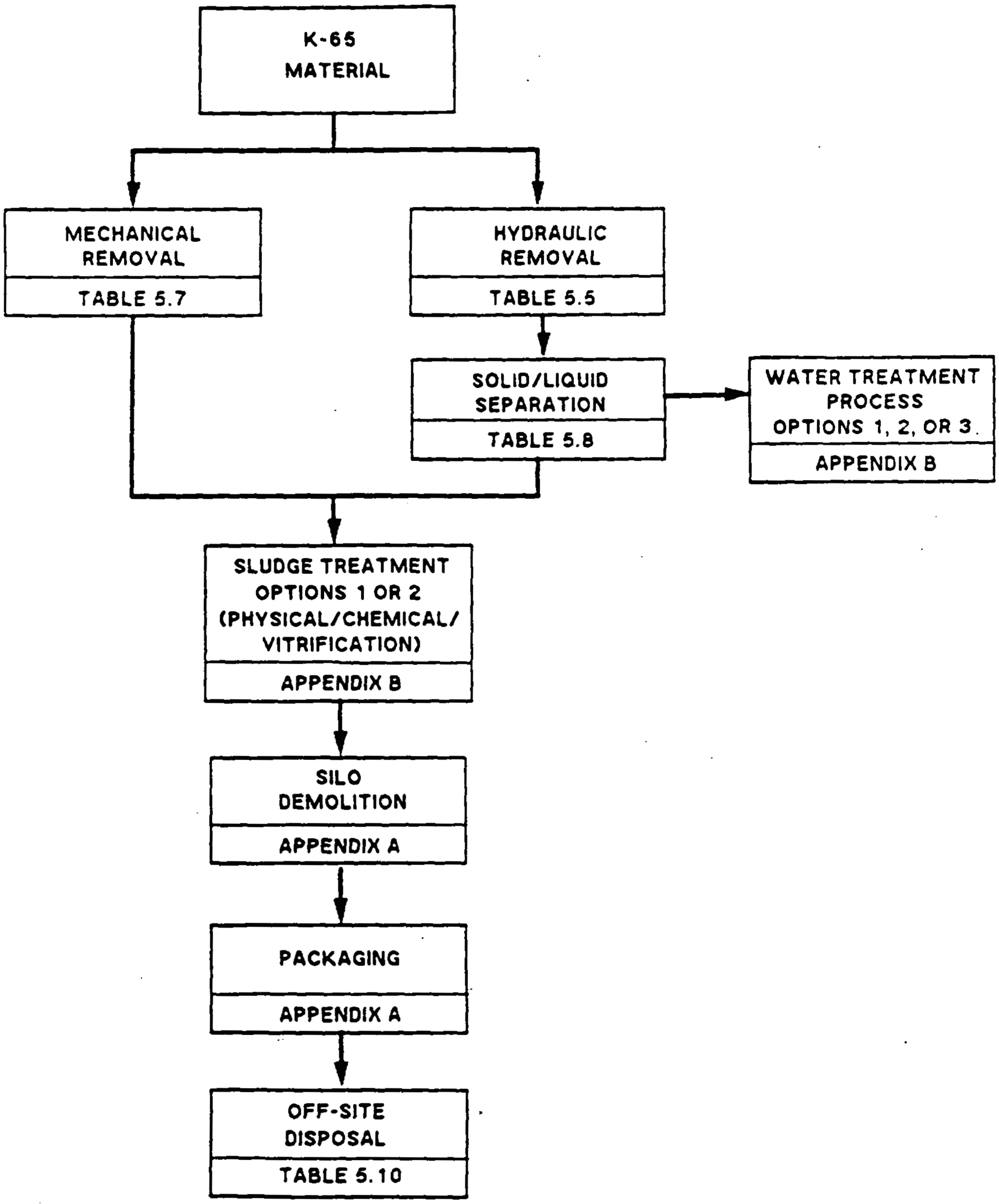
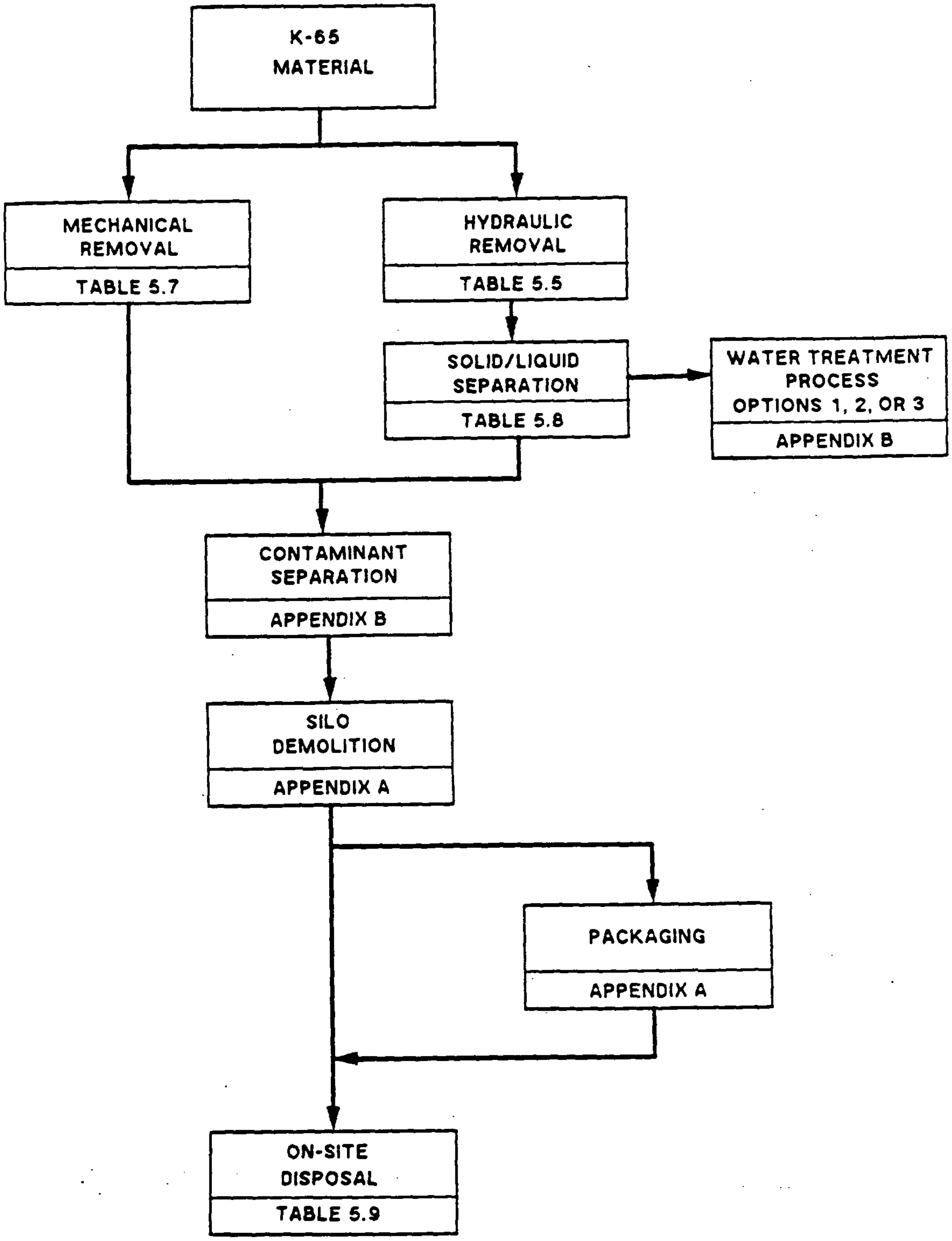


Fig. 6.4.8
Remedial Action Alternative 4-RA-F
Operable Unit 4
Removal, Contaminant Separation, and On-Site Disposal



6.4.1.9 Removal of Waste (K-65 Silos), Contaminant Separation, Bulk Packaging, and Off-Site Disposal (Alternative 4-RA-G)

This alternative is schematized in Figure 6.4.9. It is identical to Alternative 4-RA-F except for the substitution of off-site disposal. It should be noted that in the case of Alternatives 4-RA-F and 4-RA-G, two material waste streams will result: a high-concentration, high-activity radium residual and a bulk material containing inorganic metals and possibly radionuclides. The option is available to select different disposal options for the two waste streams.

6.4.1.10 Thorium Disposal On Site (Alternative 4-RA-H)

The final disposition of the packaged thorium stored at the FMPC could occur in a tumulus or similar on-site structure. This disposal option is considered as Alternative 4-RA-H and is depicted in Figure 6.4.10. Although it is being assumed that thorium repackaging has been completed as an interim protective measure, the final disposal of the thorium in an on-site structure could require additional stabilization or packaging steps to meet all disposal criteria. These potential technological needs have been included as options within Alternative 4-RA-H (Figure 6.4.10).

6.4.1.11 Thorium Disposal Off Site (Alternative 4-RA-I)

Alternative 4-RA-I considers the final disposition of the thorium to be at an off-site location such as the NTS facility. This alternative is shown in Figure 6.4.11.

6.4.2 Technology Descriptions

6.4.2.1 Silo Isolation

The actions described herein are for isolation and/or rehabilitation of the silos with the waste left in place. Options for silo isolation include providing an impermeable cap and improving silo integrity. Capping could be accomplished either by:

- Filling the entire void space inside the silo with sand or fly ash, and providing a multilayer cap

Fig. 6.4.9
Remedial Action Alternative 4-RA-G
Operable Unit 4
Removal, Contaminant Separation, and Off-Site Disposal

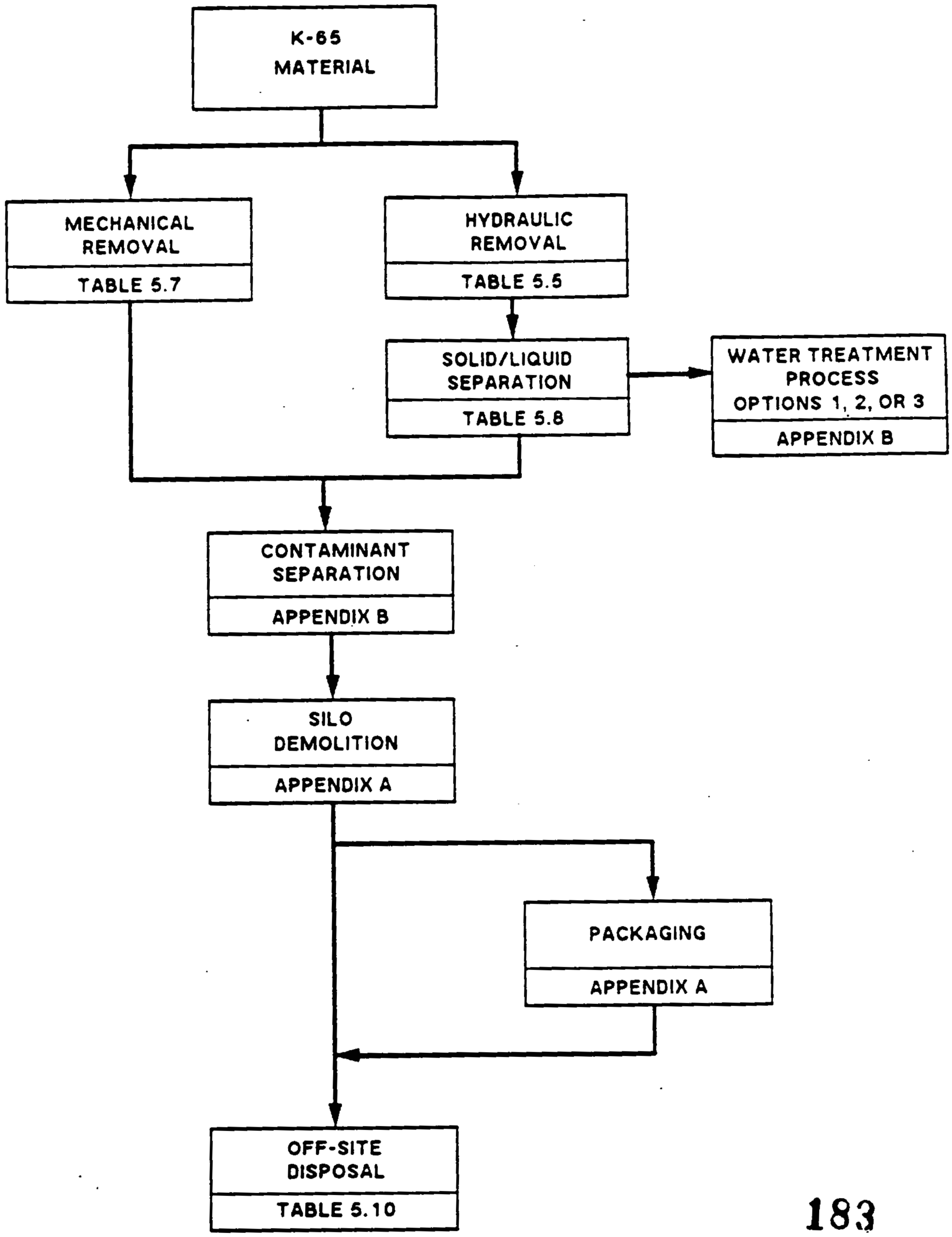


Fig. 6.4.10

Remedial Action Alternative 4-RA-H
Operable Unit 4
Thorium On-Site Disposal

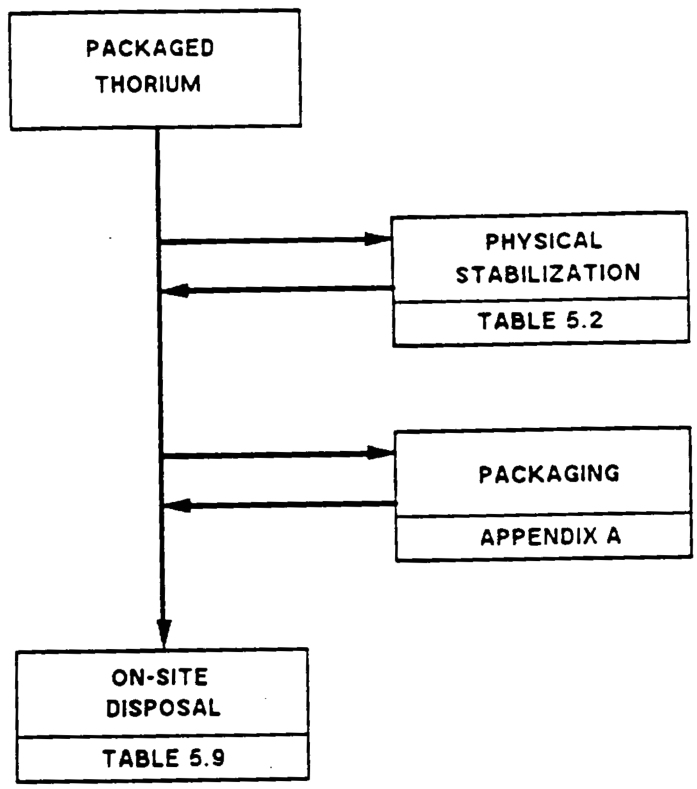
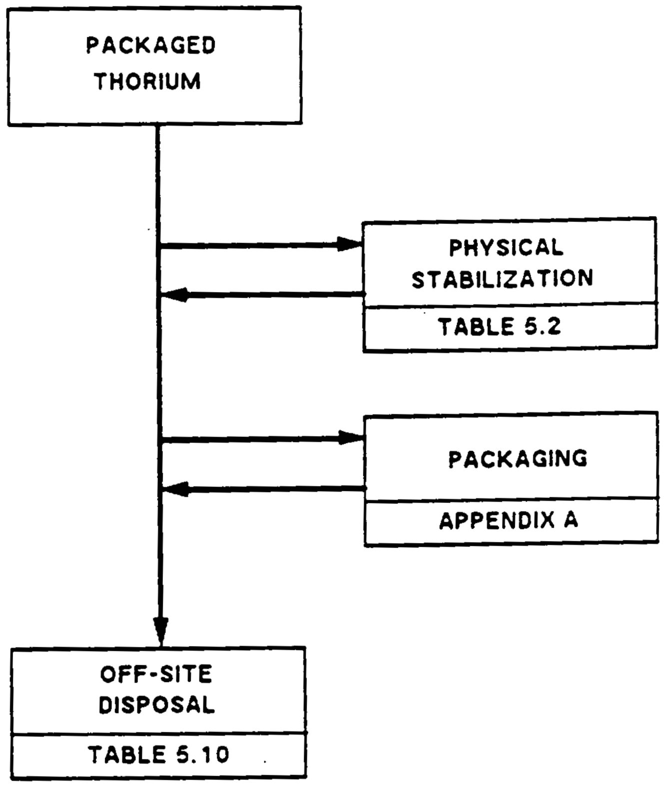


Fig. 6.4.11
Remedial Action Alternative 4-RA-I
Operable Unit 4
Thorium Off-Site Disposal



- Removing the concrete dome, adding fill material, and providing a multilayer cap

In addition to providing an impermeable cap, grout injection could be used around both the interior and exterior of the silo walls and underneath the silos to provide additional isolation of the waste. The need for additional isolation depends primarily on whether the results of the RI indicate that leachate is forming and being released. This is not expected, however, since past data indicates no contaminated ground water under the silos. The isolation system must be designed to incorporate any contaminated soil in the berms surrounding the K-65 silos. This could be accomplished by installing a slurry wall in the berm around the silo. Grout injection techniques could also be used. The cap for the K-65 silos would extend to the slurry wall or to the edge of the grouted area.

One option for Silo 3 rehabilitation is to provide protective coatings and/or membranes to the exterior concrete to extend the structural life of the silo. This could also be accomplished for the interior concrete if the wastes are first removed under Alternative 4-RA-C. Another option would be to cast additional concrete around the existing structure. The new concrete would require some type of bonding to the old concrete without affecting the posttensioning wires in the silo walls.

6.4.2.2 Vitrification

In order to use in situ vitrification techniques, the dome of the silo would likely have to be removed. Under such an event, interim measures would be required to ensure that radon emissions are maintained below the acceptable levels. A layer of sand placed on top of the waste materials will serve as a silica source for the vitrification process. The sand could also serve as primary or secondary radon emissions control measure. Electrodes will be placed through the sand and wastes in a predefined grid pattern almost to the bottom of the silo. A fume hood will then be constructed over the electrodes and connected to the air pollution control system. The system previously installed for the K-65 silos, which includes carbon beds for radon control, could be utilized. As explained in the technology description in Appendix B, power will be supplied to sequential squares of four electrodes, and blocks of the sand/wastes will be melted.

The melting process will be controlled so that all of the silo wastes as well as much of the silo walls are vitrified. Thermocouples will be placed in the silo walls to verify the extent of the vitrification. Thermocouples may also be placed in borings in the wastes along the slabs that form the bottom of the silos. Cores may also be drilled in the cooled glass block to confirm complete vitrification.

6.4.2.3 Capping

Depending on the stabilization technology selected and the associated performance criteria, the silos may be covered with a gently sloping synthetic membrane and/or clay cap. The impermeable cap will be covered with topsoil and planted with shallow rooted grasses. The berms around the K-65 silo will be enlarged and the slope decreased to reduce erosion.

6.4.2.4 Removal

Removal of the material from the silos can be conducted either by mechanical, pneumatic (Silo 3), or hydraulic means. In order to achieve a minimal impact on the workers, the public, or the environment, the operation must be conducted remotely and in a controlled environment. A negative pressure cover will be placed over the entire silo. The enclosed area will be equipped with appropriate safety and monitoring equipment and a radon removal system.

A remote controlled crane will be used for mechanical removal operations and would likely require removal of the dome roofs to achieve sufficient access. After the dome roof is removed, the mechanical crane equipped with a clamshell or bucket will be used to remove and transfer the silo contents into containers. The silo contents could also be transferred into a closed conveyor system for transport to a containerization facility. A pneumatic hammer attached to the crane would be used to dislodge the waste material if the clamshell or bucket are not adequate.

Pneumatic removal involves the use of an airlift to entrain the materials into an air stream. The discharge of the pneumatic system would be routed to a temporary storage area where the solids would be separated from the air stream. The air would be filtered and either recycled to the system or discharged. All operations would be conducted in closed vessels and all vents would be equipped with high efficiency particulate air (HEPA) filters for emission control.

Hydraulic removal provides an alternate method of removing the material from the silo. A cover similar to that used in the mechanical removal system would be placed over the silo area to control emissions. In addition, a system to ensure that the water used for "mining" the silo contents does not leak from the silos and contaminate surrounding aquifers and surface waters would be installed. As before, the roof of the silo would be removed before actual removal of the contents can begin. Water would be added as needed to maintain a proper slurry composition for the dredge, slurry pump, or similar piece of equipment. The slurry would be pumped to a solids/liquid separation area where the water would be removed to provide a dewatered sludge. This step could include filtration, centrifugation, sedimentation, drying, evaporation, or similar operations. The actual equipment will be determined by slurry composition and the water content requirements for final disposition of the sludge.

6.4.2.5 Silo Demolition

After a silo is emptied, the silo and surrounding berms will be demolished. This material, combined with the silo roof which was removed earlier, will be sent to an interim storage and repackaging area where it will be prepared for final disposal. Depending on the level of contamination, some decontamination activities may be required to facilitate the demolition effort.

6.4.2.6 Waste Treatment

Sludge from the silos will be removed using one of the techniques for sludge removal. These sludges may contain water that was added during the removal process or during contaminant separation that was performed before treatment.

The sludge will be converted into a form suitable for disposal using filtration, stabilization, drying, or a combination of these techniques. Vitrification will also be considered. The techniques and processing sequence used will depend on the physical and chemical characteristics of the sludge after its removal. Sequences that may be used are listed below:

- Filtration and stabilization
- Filtration and drying
- Filtration, drying, and stabilization
- Drying
- Drying and stabilization
- Stabilization

Filtration and drying operations could generate a wastewater requiring treatment. These operations and stabilization could also generate an off-gas contaminated with radon gas. One of the options described for water treatment will be used to treat any wastewaters generated. Off-gas contaminated with radon may be treated in the existing radon removal system.

If vitrification is necessary, the dried sludge would be placed in standard glass melting equipment or a reactor with sand and fluxing agents and heated with electrodes. The sludge would be melted and contaminants bound into a glass-like substance that prevents leaching ~~out of the material~~.

6.4.2.7 Contaminant Separation

Contaminant separation would first involve a leaching process to remove the contaminants (radium, lead, etc.) from the raffinate sludges. The optimum chemistry and equipment to use would be determined by lab and pilot-plant testing; consideration will be given to the use of existing processing operations and facilities. The leached raffinate sludges would go to physical/chemical treatment for dewatering, drying, or other operations.

The contaminants extracted from the ~~K-65 wastes~~ will next have to be recovered from the leachate. This could involve precipitation, ion exchange, liquid-liquid extraction, membrane separation, or evaporation. The products from this process would be a concentrated metals sludge and a wastewater stream.

These would be treated as described in the appropriate process options. The contaminant concentrate would be more difficult to treat, handle, and dispose than the original waste but its volume would be greatly reduced.

6.4.2.8 Packaging

The silo contents from the removal (Silo 3) or treatment (Silos 1 and 2) step will be containerized. Various packaging options for low-level waste are described in Appendix A. The type of container(s) will be dependent on the type of material, its radioactivity, the disposal option, and whether retrievable or permanent storage is being targeted. All of these operations must be conducted "remotely" since the silo contents have significant radiological exposure potential.

6.4.2.9 On-Site Tumulus Disposal

After packaging, the material could be placed into an on-site tumulus. The tumulus design has three slightly different variations. One design consists of a high-bermed perimeter with a RCRA type cap and leachate collection system underlain with liners. An alternate design would add a concrete pad on which to place the waste. Another alternate would use a gravel pad. Each of these options can accept the containerized waste. None of the waste can be accepted in a wet form containing any free liquids. The tumulus area will include regular monitoring and maintenance programs for a specified postclosure period.

6.4.2.10 On-Site, Above-Grade Structure Disposal

The material could also be placed into a different type of above-grade, on-site structure. This structure is designed from reinforced concrete for permanent waste disposal. It can accept unsorted radioactive or mixed waste. The structure is designed to withstand high-intensity earthquakes, tornados, and rainwater intrusion. This structure can accept bulk and containerized waste simultaneously. Two basic designs can be considered, each with or without a liner/leachate collection system. One design would be on grade while the other would be elevated on concrete piers providing complete inspection and monitoring capability. The size of each vault in the structure can be varied to fit removal rates from the silos and to minimize potential exposure pathways.

6.4.2.11 Off-Site Disposal

After packaging, the materials could also be transported to the NTS for final disposal. The current transportation network will only support trucks; however, as the volume of traffic increases, consideration should be given to installing a rail spur at NTS to provide access to a lower cost, lower risk mode of transportation.

6.4.2.12 Disposal in Rehabilitated Silo 3

Redisposal of the dry material back into Silo 3 would be accomplished in a free or containerized form. Pneumatic conveyance would be used if free material is to be redisposed. Containers would provide additional protection; however, the shape of the silo may make the use of containers inefficient. A concrete-type slurry could be pumped into the silo and allowed to solidify around containers to fill void space. The silo would be monitored according to required operating and maintenance plans.

6.4.3 Remedial Action Objectives

The ranking as to the relative degree to which each alternative would satisfy the remedial action objectives for Operable Unit 4 is provided in Table 6.4.1. With few exceptions, each of the alternatives would satisfy the five objectives. Preference would be given, however, to the removal scenarios with off-site disposal preferred over on-site disposal in terms of the long-term satisfaction of the objectives.

For the objective of preventing radon release, the alternatives that would remove and minimize the radium-bearing waste were given special preference since the bulk of the waste volume would have no residual radon release. The only major distinction between the alternatives is shown in Table 6.4.1 to be related to the future potential for direct contact with contaminated structures. Any option not involving silo demolition was assigned a lower ranking

TABLE 6.4.1

RANKING OF DEGREE OF SATISFYING REMEDIAL ACTION OBJECTIVES
OPERABLE UNIT 4

	ALTERNATIVE										
OBJECTIVE	4-NA-A	4-NA-B	4-RA-A	4-RA-B	4-RA-C	4-RA-D	4-RA-E	4-RA-F	4-RA-G	4-RA-H[a]	4-RA-H[a]
Prevent inhalation of air exceeding public health standards for carcinogens, radionuclides, and noncarcinogens	1-d	1-c	1-b	1-a	1-d	1-b	1-a	1-b	1-a	1-b	1-a
Prevent release of radon gas from wastes	1-e	1-d	1-d	1-c	1-e	1-d	1-c	1-b	1-a	N/A[b]	N/A
Prevent migration of contaminants to environmental media that would exceed public health or environmental standards	1-d	1-c	1-b	1-a	1-d	1-b	1-a	1-b	1-a	1-b	1-a
Prevent direct contact with contaminated structures	2-b	2-c	1-a	1-a	2-a	1-a	1-a	1-a	1-a	N/A	N/A
Correct structural conditions that could lead to sudden releases of chemicals or radionuclides	1-b	1-c	N/a	N/A	1-a	N/A	N/A	N/A	N/A	N/A	N/A

[a]Alternatives involving the thorium inventory are ranked separately.

[b]"N/A" = not available.

score, although direct contact with contaminated structures could be prohibited even under these alternatives by appropriate silo rehabilitation measures.

The aforementioned caveat that the ranking reflects only conditions anticipated upon the successful completion of a remedial action is of particular importance to Operable Unit 4. In this case, the most critical public health and environmental concerns may be associated with the period of implementation of the actions. This category of potential impacts will be addressed in the screening of alternatives in subsequent FS tasks.

6.5 OPERABLE UNIT 5

6.5.1 Alternative Descriptions

In addition to the no-action alternative, seven remedial action alternatives have been developed for further consideration for Operable Unit 5. Four of the alternatives apply to soils, while the remaining three apply to ground water. The three alternatives for ground water address different remedial action objectives. Consequently, the eventual remedial action response could include a combination of the three alternatives.

6.5.1.1 Soil: Nonremoval - Access/Use Controls (Alternative 5-NA-A)

The alternative of access/use controls represents a minimum action alternative intended only to limit human or animal contact with contaminated soil. As indicated in Figure 6.5.1, this alternative includes a single grouping of actions even though several control measures could be concurrently implemented. Methods selected for further consideration are physical barriers (e.g., walls or fences), security patrols or monitoring, and audio/visual warning devices.

6.5.1.2 Soil: Nonremoval - Cap (Alternative 5-NA-B)

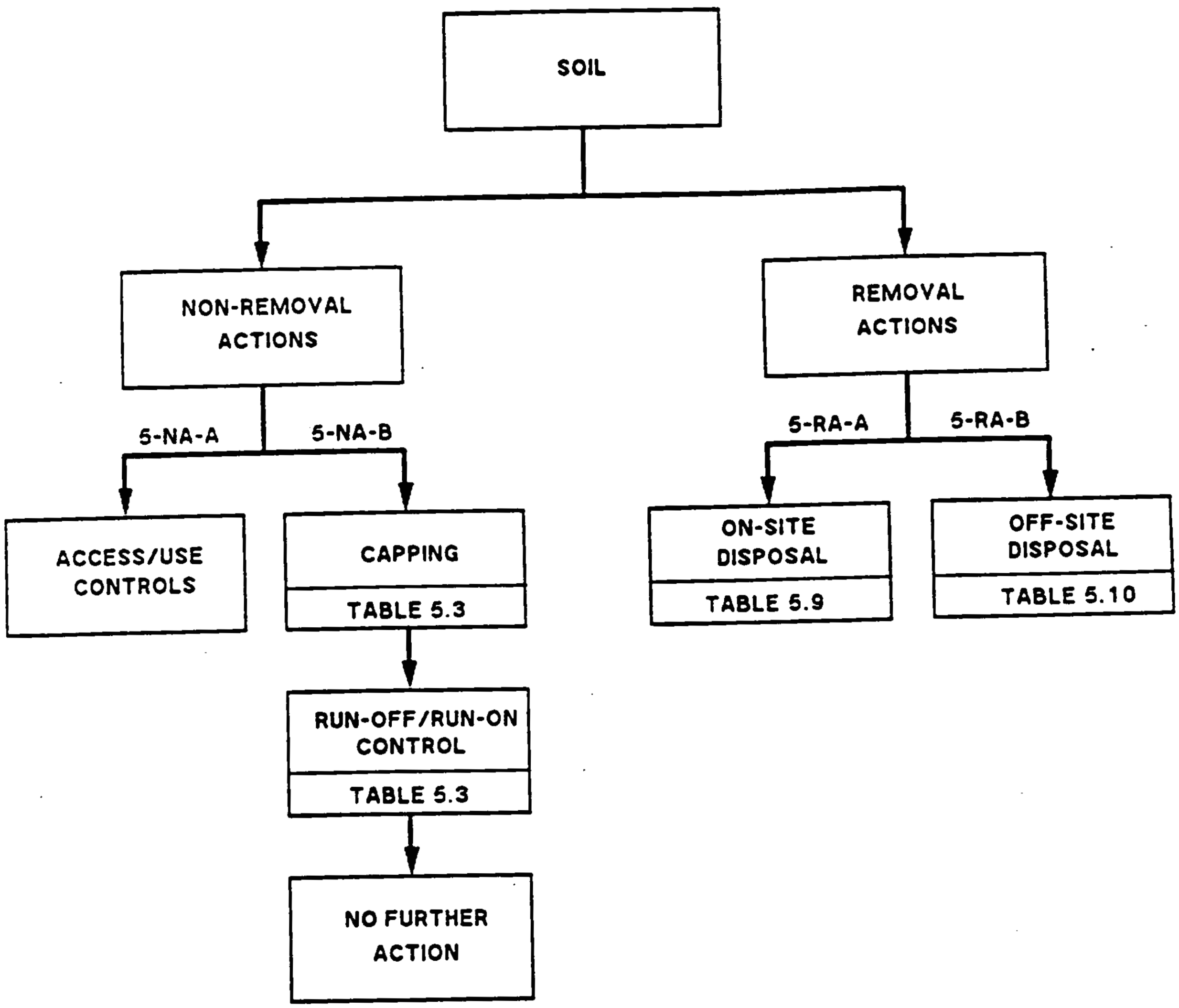
The second nonremoval alternative will provide for isolation of contaminated soil from the environment by construction of a closure cap with attendant storm water runoff and run-on control measures. This alternative is depicted

Fig. 6.5.1

Remedial Action Alternative 5-NA-A, 5-NA-B, 5-RA-A, and 5-RA-B

Operable Unit 5

Soil



in Figure 6.5.1. Descriptions of capping options and storm water control measures are provided in Section 6.5.2.

6.5.1.3 Soil: Removal and On-Site Disposal (Alternative 5-RA-A)

As indicated in Figure 6.5.1, the removal alternative developed for contaminated soils is straightforward. The technological groupings are limited to soil removal and direct on-site disposal. No postremoval stabilization or treatment processes are considered necessary for contaminated soil.

6.5.1.4 Soil: Removal and Off-Site Disposal (Alternative 5-RA-B)

The second soil removal alternative is identical to Alternative 5-RA-A except for the substitution of off-site disposal. This alternative is shown in Figure 6.5.1.

6.5.1.5 Ground Water: Gradient Control (Alternative 5-NA-C)

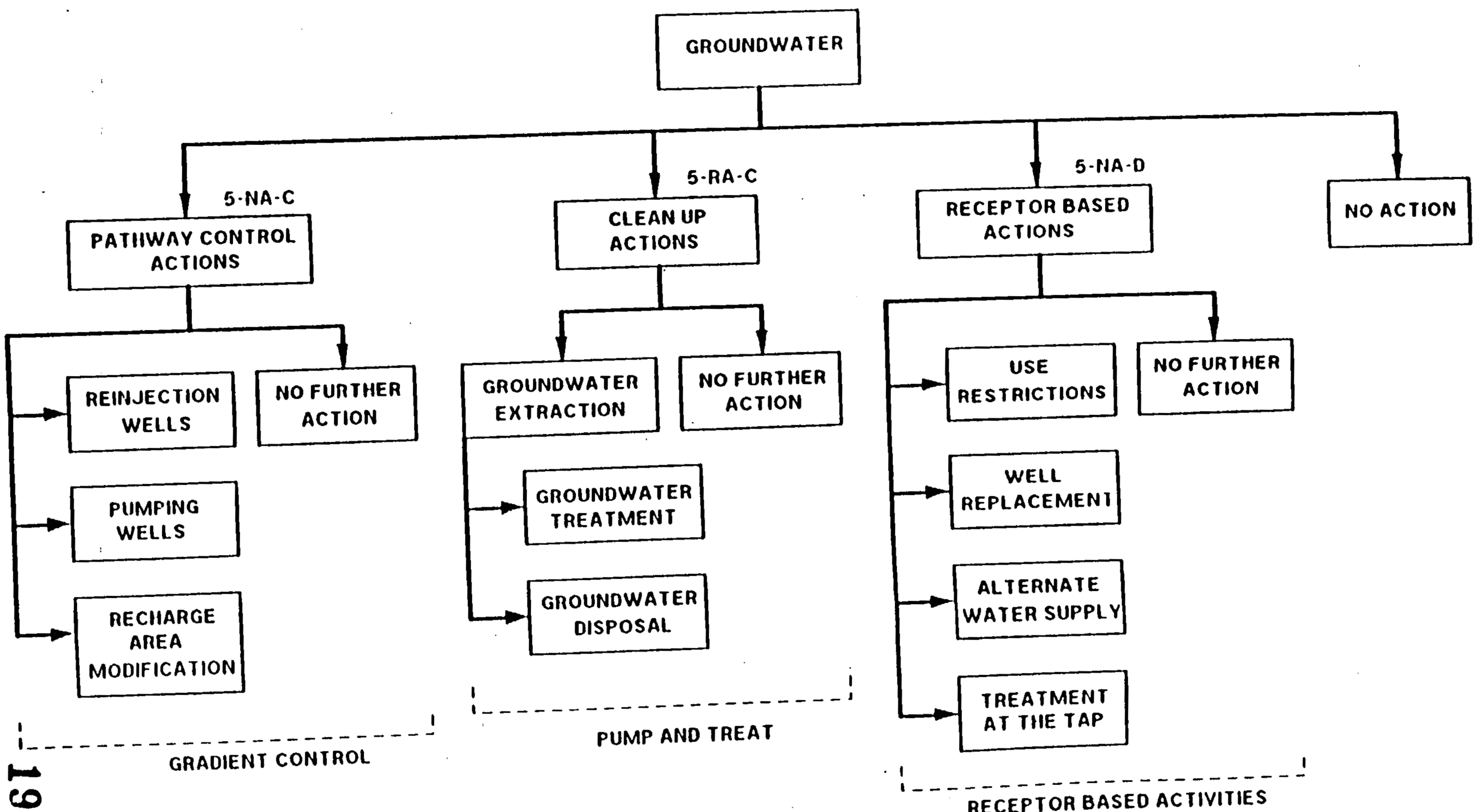
This alternative will utilize ground water gradient control to restrict or limit the spread of contamination and to attenuate contaminant concentration. Depending on the degree of contamination, contaminant type, location, and appropriate water quality standards, the following technology options, as presented in Figure 6.5.2, were selected for further consideration:

- Injection Wells - Water is injected into the ground water system to increase hydraulic pressure at a specific location or locations. This injection will change the hydraulic gradient and consequently alter and control ground water velocity and direction.

- Pumping Wells - Water is removed from the ground water system to decrease hydraulic pressure at a specific location or locations. This ground water removal will change the hydraulic gradient and consequently alter ground water velocity and direction. In particular, an inward hydraulic gradient is created within the zone of influence of the well, creating a hydraulic barrier and trapping contaminants from outward migration.

- Recharge Area Modification - Recharge area modification includes alteration of vegetative cover, alteration of surface material including installation of impervious surface layers, alteration of natural drainage systems, and installation of artificial drainage systems. These modifications of ground water recharge can change the ground water gradient and consequently affect flow velocity and direction.

Fig. 6.5.2
Remedial Action Alternative 5-NA-C, 5-RA-C, and 5-NA-D
Operable Unit 5
Groundwater



6.5.1.6 Ground Water: Pump and Treat (Alternative 5-RA-C)

This alternative will remove contaminated ground water and, when combined with source controls, will eventually reduce contaminant concentrations to acceptable levels at the points of concern. Depending on the degree of contamination, contaminant type, location, and appropriate water quality standards, the following ground water removal and treatment options, as presented in Figure 6.5.2, were selected for further consideration:

- Extraction and Disposal - Contaminated water will be pumped from the ground water system and disposed without treatment. Disposal methods include evaporation, reinjection into the ground water system, and release to a surface water course such as the Great Miami River or Paddy's Run. Oxidation reactions followed by precipitation can limit the concentration of certain contaminants in the ground water as equilibration with the atmosphere occurs.

- Extraction with Treatment and Disposal - Contaminated water will be pumped from the ground water system, treated, and disposed. Treatment technologies such as ion exchange or chemical treatment will remove the contaminants of concern. Disposal methods include evaporation, reinjection into the ground water system, and release to a surface water course.

6.5.1.7 Ground Water: Receptor-Based Activities (Alternative 5-NA-D)

The alternative involving receptor-based actions will eliminate or prevent the use of contaminated ground water at receptor locations of concern. One or a combination of the following receptor-based actions may be required:

- Use Restrictions - Water use would be restricted totally or to nonpotable use only. Pumping rate restrictions would prevent the spread of contaminants or, when combined with gradient control actions, would maintain a favorable ground water flow system.

- Well Replacement - Contaminated wells would be replaced by wells which are screened deeper or in another location. The new wells would supply water from a portion of the ground water system that meets the appropriate regulatory standards for water quality.

- Alternative Water Supply - Receptors with a contaminated ground water would be supplied with an alternative source of water. This alternative supply would meet appropriate water quality standards.

- Treatment at the Tap - Treatment technologies, such as deionization, ion exchange, and filtration, would remove contaminants when applied at user locations. The treated water would meet the appropriate regulatory standards.

6.5.2 Technology Descriptions

6.5.2.1 Closure Capping

Based on a determination of the extent of contamination in soils, selected areas will be contour graded to provide drainage and a closure cap will be placed. One of the following two types of caps will be constructed:

- Impermeable Cap - This cap will consist of concrete or bituminous asphalt providing a low-maintenance, nonerodable drainage surface. This type of cap would be most appropriate over small, high traffic areas such as within the Production Area.

- Soil Cap - Over most areas, clean soil will be used as a capping material with a vegetative cover added to reduce erosion. An option would be to utilize a low-permeability clay to minimize infiltration, with an overlying layer of clean soil that would better support a vegetative cover.

All cap elements will be contoured to grades which promote drainage while minimizing the effects of storm water erosion.

6.5.2.2 Runoff/Run-On Control

Runoff control features will safely remove storm water from the capped area while run-on control features will direct storm water away from the area. Runoff/run-on control would be accomplished using site contour grading, vegetation, or diversion and collection facilities (e.g., swales, lined ditches, berms, etc.).

6.5.2.3 Removal

This technology uses excavation equipment such as graders, scrapers, backhoes, loaders, or clamshells to remove contaminated soil. Upon completion of removal, the area would be restored to original grade and vegetated.

6.5.2.4 On-Site Disposal

As excavation progresses, the contaminated material would be transported and disposed on site. Disposal of contaminated soil could occur using a tumulus or other concrete structure if such a facility is constructed for other types of wastes and capacity is available. A separate disposal facility could also be developed for the contaminated soil since the design criteria may be less stringent than for other wastes.

6.5.2.5 Off-Site Disposal

After treatment, contaminated soils could be transported to the NTS for permanent disposal. Depending on the level of radionuclides in the removed soil and whether any organics are present, the soil could qualify for disposal at other low-level disposal facilities in closer proximity to the FMPC.

6.5.3 Remedial Action Objectives

Table 6.5.1 presents a ranking of the alternatives in terms of the relative degree to which each alternative would satisfy the remedial action objectives for the soil and ground water components of Operable Unit 5. In the case of alternatives for soil remediation, the implementation of access or use restrictions would satisfy only one objective, and then only to a secondary extent since restricted access could not be assured. The remaining alternatives would address all four of the objectives for soil, with off-site disposal given slight preference over long-term on-site storage. Both removal options are preferred over the soil capping alternative. A deficiency in the capping alternative is that total control of infiltrating water, and thus potential contaminant release, cannot be assured in the long term.

Each ground water alternative was developed with the intent of satisfying a specific remedial action objective. This condition is reflected in the ranking values for the ground water pump and treat alternative (Alternative 5-RA-C) and the receptor-based activities (Alternative 5-NA-D). The gradient control alternative would not directly satisfy either objective, but would provide a control mechanism that addresses each objective over a longer time frame.

TABLE 6.5.1

RANKING OF DEGREE OF SATISFYING REMEDIAL ACTION OBJECTIVES
OPERABLE UNIT 5

	ALTERNATIVE						
OBJECTIVE	5-NA-A	5-NA-B	5-RA-A	5-RA-B	5-RA-C[a]	5-RA-C[a]	5-NA-D[a]
Prevent ingestion of or direct contact with contaminated soils	2	1-c	1-b	1-a	-	-	-
Prevent release of airborne contaminants from soils	-	1-c	1-b	1-a	-	-	-
Prevent excessive leaching of contaminants from soils	-	2	1-b	1-a	-	-	-
Prevent excessive erosion of contaminated soils to surface water courses	-	1-c	1-b	1-a	-	-	-
Prevent ingestion of ground water exceeding public health standards for hazardous chemicals or radionuclides	-	-	-	-	2-b	2-a	1
Restore ground water to meet environmental standards	-	-	-	-	2	1	-

[a]Alternatives involving ground water are ranked separately.

6.6 OPERABLE UNIT 6

Five remedial action alternatives have been developed for Operable Unit 6, and in particular the sediment component of the three principal surface water courses (i.e., the Great Miami River, Paddy's Run, and the storm water outfall ditch). Three nonremoval alternatives and two removal alternatives are included. As discussed in the following sections, not all alternatives are applicable to each of the three surface water courses.

6.6.1 Alternative Descriptions

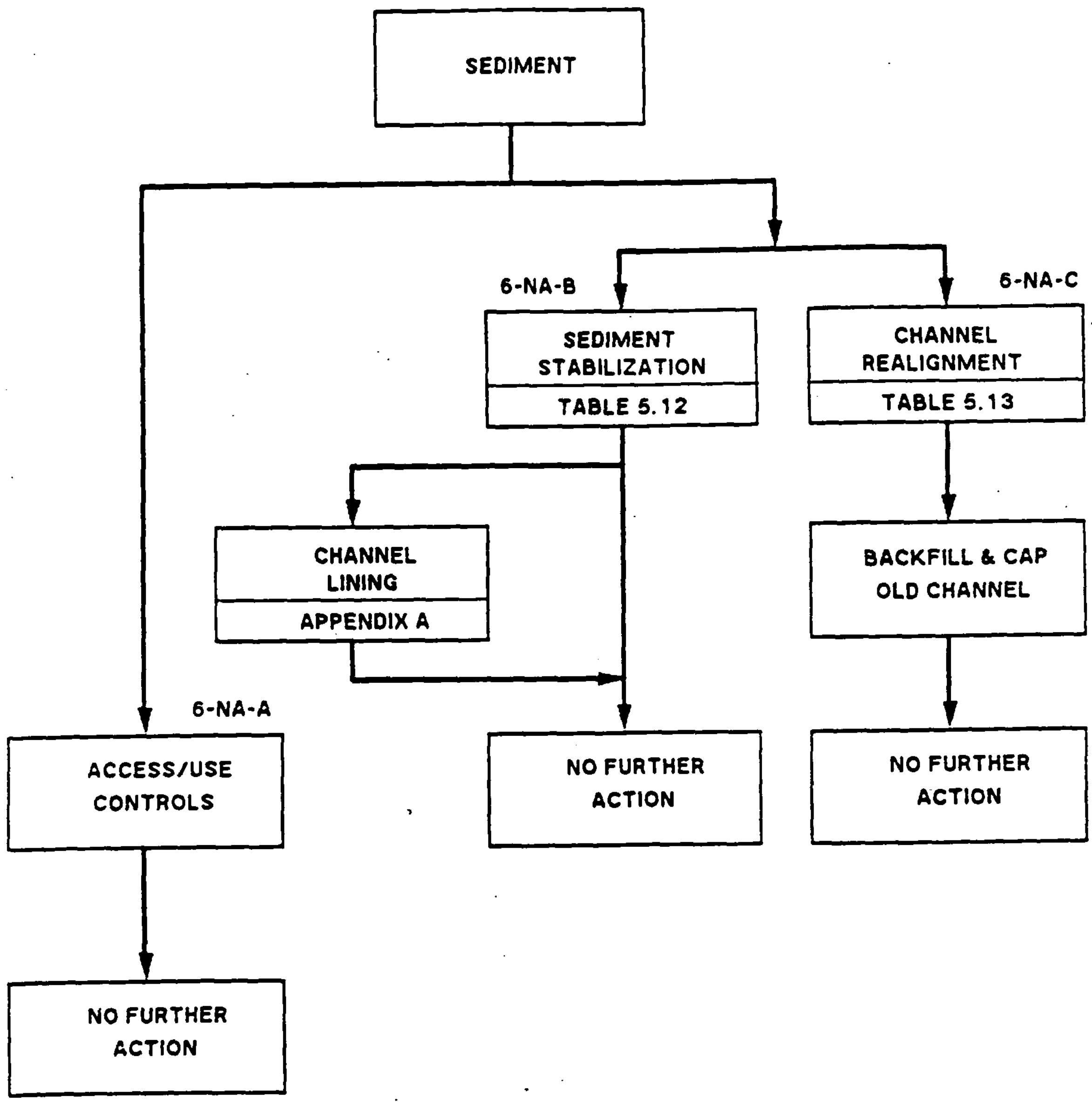
6.6.1.1 Nonremoval - Access/Use Controls (Alternative 6-NA-A)

The alternative of access/use controls represents a minimum action alternative intended to limit human contact with both contaminated sediments and surface waters. As indicated in Figure 6.6.1, this alternative includes a single grouping of actions even though control measures could be concurrently implemented. Methods selected for further consideration include fences, security patrols, and audio/visual warning devices for the drainage ditch and on-site portions of Paddy's Run. Access or use restrictions for the Great Miami River and off-site reaches of Paddy's Run would likely take the form of warning signs and/or enforceable closures, access prohibitions, or use restrictions.

6.6.1.2 Nonremoval - Sediment Stabilization (Alternative 6-NA-B)

The second nonremoval alternative is intended to isolate any contaminated sediments from the water column by stabilization technologies (Figure 6.1.1). Within this context, the term "isolation" refers either to the elimination of the sediment-water interface or to the elimination of sediment resuspension resulting from changes in the sediment properties. This alternative is applicable to each of the three surface water courses, with the limitation that only overbank and floodplain areas would be available for stabilization in the Great Miami River. Such restrictions would not apply for Paddy's Run due to the seasonal occurrence of no-flow conditions. Specific stabilization technologies under consideration are identified in Section 6.6.2.

Fig. 6.6.1
Remedial Action Alternative 6-NA-A, 6-NA-B, and 6-NA-C
Operable Unit 6
Nonremoval of Sediment



The reference to run-on control measures in Figure 6.6.1 is applicable only to the storm water outfall ditch. The intent of such controls would be to minimize any damage to the stabilized sediments caused by peak flows.

6.6.1.3 Nonremoval - Realignment and Cap (Alternative 6-NA-C)

The final nonremoval alternative is also directed toward sediment isolation, in this case being achieved by realigning the surface water course away from any contaminated reaches. The contaminated sediments would be covered to grade and closed with an engineered cap and supporting runoff/run-on control measures. This alternative, which is illustrated in Figure 6.6.1, is primarily applicable to the storm water outfall ditch and, to a lesser extent, Paddy's Run. Realignment of the Great Miami River is not being considered.

6.6.1.4 Removal and On-Site Disposal (Alternative 6-RA-A)

The first alternative involving sediment removal is depicted in Figure 6.6.2, and includes technology groupings for sediment removal, sediment dewatering, and on-site disposal. Two removal options are indicated to account for differences in the physical characteristics of the three surface water courses. Although temporary stream diversion is shown to be a prerequisite to mechanical excavation, this step may not be necessary if sediment removal can be scheduled around extended no-flow or low-flow conditions in Paddy's Run and the storm water outfall ditch.

6.6.1.5 Removal and Off-Site Disposal (Alternative 6-RA-B)

The second removal alternative differs from Alternative 6-RA-A only in the method of disposal. In particular, this alternative involves off-site disposal options (Figure 6.6.2) that could range from disposal in an engineered near-shore containment facility to transport to the NTS facility.

6.6.2 Technology Descriptions

6.6.2.1 Sediment Stabilization

The purpose of sediment stabilization is to prevent the contaminants in sediments from being released either to the overlying water column or to the

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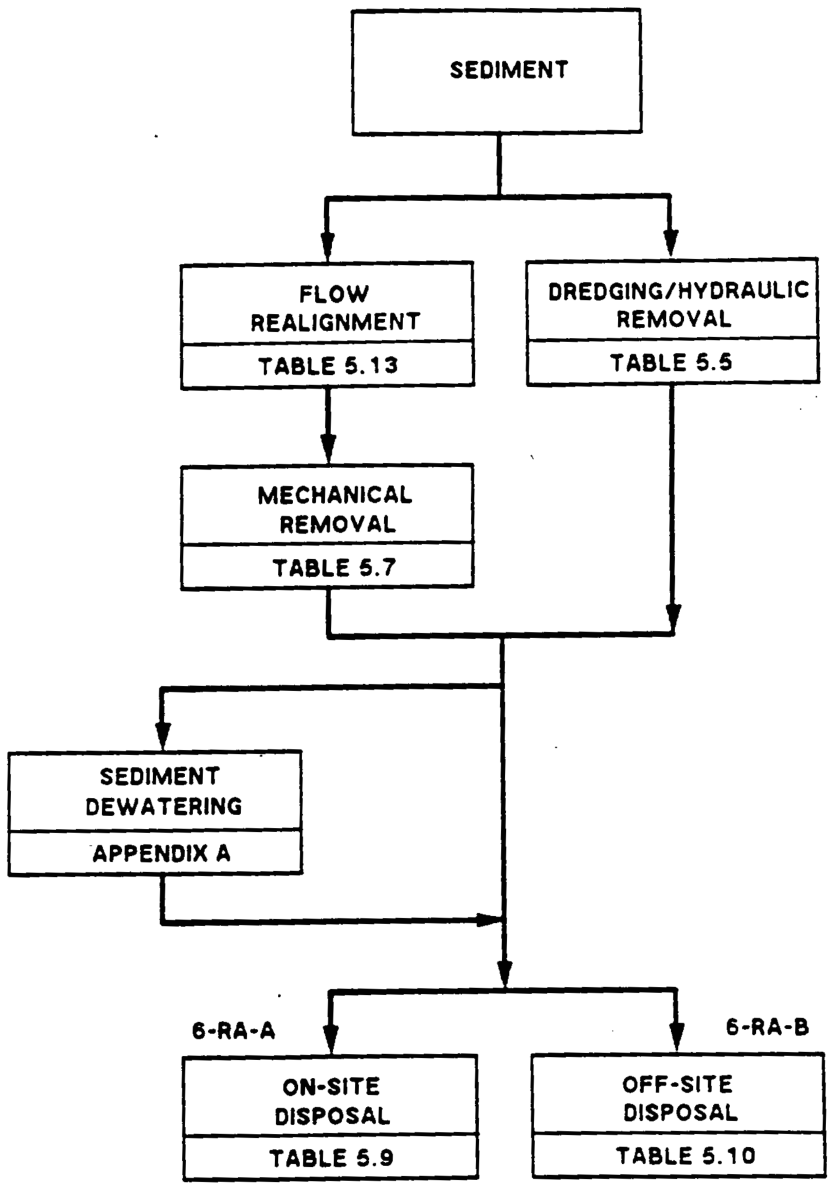
Fig. 6.6.2

Remedial Action Alternative 6-RA-A and 6-RA-B

Operable Unit 6

Removal of Sediment



underlying aquifer. Two general types of sediment stabilization technologies could be implemented depending on contaminant levels, physical properties of the sediments, and flow velocities and channel profiles.

The first class of technologies would involve lining the channel bottom to preclude contact between the sediment and surface waters and to prevent leakage through the channel bottom. Concrete or asphalt liners would be appropriate, as would in situ methods such as grouting. Such technologies would be limited to the storm water outfall ditch and possibly selected reaches of Paddy's Run.

The second type of action would physically stabilize the sediments without excluding water exchange. Examples of appropriate technologies include riprap, vegetative methods, and synthetic stabilization mats. These methods could be applied to the storm water outfall ditch, Paddy's Run, and selected areas of the Great Miami River, such as overbank and floodplain areas.

6.6.2.2 Run-On Control

Dependent on site topography, run-on control measures can be used to redirect storm water away from any stabilized, but contaminated, sediments in the storm water outfall ditch. Run-on control would be accomplished using site contour grading, vegetation, or diversion and collection facilities (swales and ditches). Similar measures would also be used to protect any old channels that were backfilled and capped as part of a stream diversion action.

6.6.2.3 Flow Realignment

The purpose of flow realignment is to permanently redirect flow away from a zone of contaminated sediments. The most common practice to achieve flow realignment is the excavation of a new channel and the diversion of flow using dams, sheet piling, berms, or similar structures. The latter methods can also be utilized to direct flow around critical problem areas without realigning the existing channel. Pipeline diversion could also be utilized in the case of the storm water outfall ditch and possibly Paddy's Run, although the need to collect local drainage limits the feasibility of this technology. Another option for the storm water outfall ditch would be to collect water in an upstream basin and pump it past any contaminated area; this is essentially the purpose of the existing storm water retention basin.

6.6.2.4 Closure Capping

As part of a channel realignment action, the old channel will be backfilled with clean compacted soils, contour graded for surface drainage, and capped. One of the following two types of caps would be used:

- Impermeable Cap - This cap would consist of concrete or bituminous asphalt providing a low-maintenance, nonerodable drainage surface.
- Soil Cap - This cap would utilize clean soil as the cover material with a vegetative cover to reduce erosion. An option would be to install a layer of low-permeability clay beneath the soil cover to reduce infiltration through the underlying contaminated material.

All cap elements will be contoured to grades which promote drainage while minimizing the effects of storm water erosion.

6.6.2.5 Sediment Removal

Dependent on the physical nature, location, and water content of the sediments, hydraulic dredging and/or mechanical removal technologies can be employed as follows:

- Hydraulic Dredging/Removal - This technology, using vacuuming and pumping, dislodges, captures, and transports the sediment to a central collection/processing point. If the hydraulic dredging methods cannot be utilized due to specific area conditions, mechanical removal methods would be employed.
- Mechanical Removal - This technology uses excavation equipment such as backhoes, draglines, graders, scrapers, loaders, or clamshells for contaminated sediment removal. The excavated waste is then moved to the treatment area by truck or conveyor system. To facilitate mechanical operations, temporary flow realignment may be required to redirect water away from the active operations. This will also minimize the potential for contaminant sediment resuspension.

6.6.2.6 Sediment Dewatering

As sediment removal progresses, the contaminated material is transported to a central processing area for dewatering prior to disposal. Dewatering would only be required for dredged material; mechanically removed sediments would likely have sufficiently low water content for direct disposal. Dewatering technologies could include air drying, gravity settling in constructed basins (with collection and possible treatment of the decanted water), or induced dewatering through vacuum extraction.

6.6.2.7 On-Site Disposal

Under this option, the dewatered sediments would be transported and disposed on site. Disposal could occur using a tumulus or other concrete structure if such a facility is constructed for other types of wastes and capacity is available. A separate disposal facility could also be developed for the contaminated sediments since the design criteria may be less stringent than for other wastes.

6.6.2.8 Off-Site Disposal

After dewatering and packaging, the contaminated sediment could be transported to the NTS for permanent disposal. Depending on the level of radionuclides in the removed sediment and whether any organics are present, the sediment could qualify for disposal at other low-level disposal facilities in closer proximity to the FMPC.

A third off-site disposal option, which would apply only to sediments removed from the Great Miami River, would be the construction of a near-shore containment area. This would be an engineered disposal facility constructed within or alongside the flood plain of the river, and would incorporate design features to protect against flood flows.

6.6.3 Remedial Action Objectives

The relative ranking of the five alternatives in terms of the degree to which each would satisfy the remedial action objectives is given in Table 6.6.1. As indicated, none of the alternatives would fully satisfy any objective related

TABLE 6.6.1

**RANKING OF DEGREE OF SATISFYING REMEDIAL ACTION OBJECTIVES
OPERABLE UNIT 6**

OBJECTIVE	ALTERNATIVE				
	6-NA-A	6-NA-B	6-NA-C	6-RA-A	6-RA-B
Prevent ingestion of surface water exceeding public health standards for hazardous chemicals and radionuclides	2-a	2-e	2-b	2-d	2-c
Restore surface water quality to meet environmental standards	-	2-d	2-a	2-c	2-b
Restore surface water quality to avoid adverse environmental impacts	-	2-d	2-a	2-c	2-b
Prevent ingestion of contaminated sediment	2-a	2-b	1-c	1-b	1-a
Prevent excessive releases of contaminants from sediment	-	2-b	2-a	1-b	1-a

to surface water quality. The reason is that sediment remediation may not alone lead to acceptable water quality if other sources of contamination to the surface waters are not concurrently eliminated. The objective of preventing ingestion of surface waters exceeding public health standards is related to the surface water quality issue, and again sediment remediation may not alone account for acceptable water quality. The two objectives dealing directly with sediments are more completely addressed by the alternatives, although the nonremoval alternatives do not provide full assurance of a long-term remedy.

6.7 SCREENING OF ALTERNATIVES IN TASK 13

The remedial action alternatives developed in Chapter 6.0 will be comparatively screened in Task 13 of the FS. Task 13 will follow the acceptance of this report on the development of alternatives. The initial screening of alternatives in Task 13 will be a comparison of the evaluation data among the alternatives and the identification, for further consideration, of those alternatives with the most favorable composite evaluations. The goal of the screening will be to reduce the number of alternative actions to two to five for each operable unit and will also be targeted to the final selection of one or two process options for each technology type.

The screening in Task 13 will be a three-step process in which:

- Alternatives will be further refined
- Alternatives will be evaluated on a general basis to determine their relative effectiveness, implementability, and cost
- Decisions will be made as to which alternatives should be retained for more detailed screening in Task 14.

LIST OF TECHNOLOGIES

Air Flotation
Asphalt/Soil Mixing
Biological Denitrification
Capping (Infiltration Capping)
Cement-Bentonite Slurry Wall (Vertical Containment Barrier)
Centrifugation
Channel Realignment by Excavation (Temporary or Permanent)
Chemical Dust Suppressants
Chemical Reduction
Clarification
Dewatering
Diversion and Collection
Drying/Calcination
Dynamic Compaction
Evaporation
Filtration
Flocculation
Grading (Surface Water Management System)
Ground Water Pumping
Grout Injection Techniques
Hydraulic Removal/Dredging
Ion Exchange
Liquid/Liquid Extraction
Mechanical Removal By Backhoe
Mechanical Removal by Dragline
Mechanical Remoival by Front-End Loader
Neutralization
Off-Site Waste Disposal
On-Site Greater Confinement Disposal (GCD) Vaults
On-Site Tumulus Waste Disposal
On-Site Waste Disposal/Rehabilitated Silos
Packaging/Containerization
Pozzolanic/Soil Mixing
Precipitation

AIR FLOTATION

Air flotation is a clarification process for removing fine solids from wastewater.

Overall Assessment

Air flotation involves injecting air into water and skimming the resulting foam/froth off the surface of the water. Air is added by a compressor through a series of injectors that are designed to generate very fine bubbles which attach to the solids to make them buoyant. Sometimes a frothing agent is added to improve the flotation process. Air flotation only works on low-density solids that are small enough to be floated.

Screening Factor Summary

Although air flotation has limited applicability in wastewater treatment, it can be used for removal of fine particulates from the wastewater. The foam layer would have to be treated further to separate the solids from the foam prior to disposal. The aeration process may result in emissions to the atmosphere and does not reduce the hazards associated with the solids. The process requires more costly equipment than other clarification processes. Air flotation can be effective for removing fine particulates from the wastewater.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	Moderate
Cost	Moderate

Conclusions

Air flotation is retained for further consideration.

ASPHALT/SOIL MIXING

This technology provides sediment stabilization by the mixing or spraying of surficial soil with emulsified asphalt or tar, followed by roller compaction. The bitumen to soil ratio of the mixture is soil dependent. The finished surface after treatment and rolling becomes durable and water resistant.

Overall Assessment

Asphalt/soil mixing techniques have been applied successfully to reduce soil erodability at numerous sites. The finished compacted surface is highly resistant to erosion and low-velocity stream scouring but is more subject to weathering and environmental degradation than pozzolanic/soil mixtures. This technology may not be suitable for high-silt or clay-content soils.

Screening Factor Summary

Soil mixing is an effective and easy way to stabilize soils and sediments subject to erosion. With minimal maintenance, this technology will limit the transport of surficial site sediments to downstream locations.

Screening Factor Ranking

All operable units receive the same ranking.

Effectiveness: High
Implementability: High
Cost: Medium

Conclusion

Asphalt/soil mixing is an acceptable, safe, and proven stabilization method for general erosion control applications. This method would not be suitable for high-velocity discharge stream applications (e.g., large drainage water courses). This technology is a viable treatment method and should be retained for further consideration.

BIOLOGICAL DENITRIFICATION

Biological denitrification is a microbial wastewater process by which nitrates and nitrites are reduced to molecular nitrogen. Denitrification is a respiratory mechanism in which the nitrate/nitrite replaces molecular oxygen in bio-assimilation. Denitrification requires the availability of a carbon source that is usually satisfied by the addition of methanol to the wastewater.

Overall Assessment

Denitrification takes place in an anoxic environment. In the absence of molecular oxygen, facultative bacteria use the nitrates or nitrites as a source of molecular oxygen for metabolizing organic matter for the energy. The addition of organic material is critical in effective nitrogen removal. A ratio of organic carbon to nitrogen is normally set at 1.3 to 1 (C to N). Carbon required for treatment can be supplied by organics already in the waste or by the addition of methanol or acetic acid.

The level of dissolved solids is also a determinate factor in nitrate removal. High levels of dissolved solids are inhibitory to denitrification. High nitrate/nitrite levels (greater than 0.1 percent) will also slow down the rate of denitrification.

Screening Factor Summary

Denitrification should reduce the nitrate level in the FMPC wastewaters from 1,000 to 2,000 milligrams per liter (mg/ℓ) to less than 5 mg/ℓ. This level should be acceptable for discharge to the Miami River. Denitrification should have no adverse environmental effects and is a low cost, easily implemented, reliable technology for wastewater treatment. This technology is currently being used at the FMPC.

Screening Factor Ranking

Effectiveness:	High
Implementability:	High
Cost:	Low

<u>Conclusion</u>

Biodenitrification can be used to remove nitrates from FMPC wastewaters before they are discharged.

CAPPING (INFILTRATION CAPPING)

Capping involves the installation of a barrier over the surface of the contaminated area. Capping is designed to control erosion and prevent the generation of leachate caused by surface water infiltration. Capping can also alleviate possible direct and/or indirect exposures. Capping is applicable for source control and containment. Capping is generally used in combination with other technologies.

Cap design must be in accordance with applicable regulations, including 40CFR264. Some of the considerations are:

- Minimum liquid migration through the wastes
- Low cover maintenance requirements
- High resistance to damage by settling or subsidence
- Lower than or equal permeability to the underlying liner system

Caps can be of single or multiple layers and can consist of asphalt, chemical sealant/stabilizer, clay, concrete, or multimedia. Chemical sealants and stabilizers require a homogeneous soil base, are typically feasible for small areas, and can be susceptible to cracking and weathering.

Single-Layer Caps

Single-layer caps are constructed of any low permeability materials mentioned above. Natural soil and admixes are not recommended because they are susceptible to freeze/thaw cycles and because exposure to drying can cause shrinkage and cracking. The most effective single-layered caps are composed of concrete and/or bituminous asphalt.

Multiple-Layer Caps

Multiple-layer caps are generally designed in accordance with U.S. EPA guidelines under RCRA. The guidelines recommend a three-layer system which consists of:

- An upper vegetative layer
- A drainage layer
- A lower permeability bottom layer (synthetic liner and/or impermeable material)

The vegetative layer is supported by the topsoil/cover. The drainage layer consists of sand, and the low permeability layer consists of a synthetic liner and low permeability soil liner. This design diverts infiltrating liquids away from the enclosed waste materials.

Overall Assessments

Capping isolates contamination from the aboveground environment and significantly reduces underground migration of wastes. Capping is applicable to Unit 1 but it would require removal and treatment of the surface water (Pits 5 and 6) and removal of excessive moisture and stabilization of contents. Capping is also applicable to Unit 2 (except for the scrap metal piles).

A properly designed and installed multiple layer cap with a synthetic liner is capable of providing trouble-free service for 20 years. After this period, the integrity of the synthetic liner becomes uncertain, and it should be inspected regularly. A multilayer cap without a synthetic layer would have an adequate lifespan to meet all regulatory requirements. Additionally, consideration should be given to possible problems caused by burrowing animals and deep-rooted plants. Also, ground water monitoring wells unusually form a part of the system and must by periodically sampled and monitored.

In spite of the long-term maintenance requirements, capping may still be a more economical and environmentally acceptable alternative than excavation and removal.

Screening Factor Summary

Capping is used for in situ wastes and those that are to be buried. Capping lends itself to applications where potential hazards and excessive costs make excavation and removal unsuitable. To detect any possible ground water contamination, properly located monitoring wells must either exist or be installed. A gas collection systems must also be included if the wastes generate gases.

A properly designed capping system confines the materials in place, thereby eliminating handling and possible exposure problems encountered in alternatives where combinations of excavation and removal are used. Capping can be used for controlling contamination of both surface and ground water. Capping does need long-term maintenance, including periodic inspections for settlement, ponding of liquids, and erosion. Furthermore, it is necessary to install and/or sample ground water monitoring wells. Capping, with ground water monitoring, may still be considered an unacceptable risk if the source of contamination is in close proximity to drinking water supplies.

Screening Factor Ranking

Effectiveness:	High/Low
Implementability:	High
Cost:	Moderate[a]

[a]If long-term monitoring is included.

Conclusion

Capping, in combination with other surface and ground water controls, is a viable technology.

CEMENT-BENTONITE SLURRY WALL (VERTICAL CONTAINMENT BARRIER)

Portland cement, bentonite, and water are used to construct a cement bentonite slurry wall. The slurry is placed in a trench where it forms a complete barrier to water intrusion. For very deep installations, normal bentonite slurry is used for excavation and then replaced by cement bentonite.

Overall Assessment

The primary differences between the cement-bentonite and the soil-bentonite slurry wall are the strength and permeability. Cement-bentonite slurry sets up faster and with more stringent than soil-bentonite slurry but may not have a higher permeability than soil-bentonite.

Screening Factor Summary

Cement-bentonite slurry is more versatile than a soil-bentonite slurry because:

- The cement-bentonite slurry sets up into a semirigid solid and is therefore usable in areas where the topography varies
- It can be used in restricted areas where there is less room to mix soil-bentonite and in areas adjacent to buildings and roads because of its higher strength
- Cement-bentonite slurry walls are also more susceptible to chemical attack by sulfates, strong acids and bases, than soil-bentonite slurry walls

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	High
Cost:	High

Conclusion

Same as soil-bentonite slurry walls.

CENTRIFUGATION

Centrifugation is a solid/liquid separation process where the solid and liquid components of a mixture are separated by the application of centrifugal force. The process of centrifugation is analogous to sedimentation (settling) in which solids are separated from liquids as a result of gravitational force; however, the centrifuge increases the applied force by several times the force of gravity. Centrifuges are used in wastewater treatment processes for "dewatering" sludges.

Overall Assessment

Centrifugation is a well established process and is a widely used technology. Basically, industrial centrifuges are grouped into two categories: (1) sedimentation centrifuges and (2) filtering centrifuges. Sedimentation centrifuges are used to further dewater material produced by sedimentation processes. Filtering centrifuges are used to separate suspended particles from a liquid solution. Sedimentation centrifuges are typically used to process dilute sludge (2 to 5 percent) into a more concentrated or dewatered sludge with solids concentration greater than 15 percent depending on the specific materials. Pretreatment of the feed sludge with a polymer to aid in dewatering is frequently used to increase solid/liquid separation efficiency.

Capital costs associated with centrifuges are relatively high, whereas rental of portable units is considerably lower and more feasible for limited duration remediation activities involving sludge dewatering. Daily monitoring of the system is critical to proper operation.

Screening Factor Summary

Centrifuges, though relatively expensive, could be a part of the treatment system. Centrifuges can offer an advantage over filtration or clarification for solids removal from the wastewater in that centrifuges can thicken sludges and handle some solids at a relatively high throughput. They only separate the suspended solids and do not reduce their hazard expect by reducing their volume. Decontamination of a centrifuge at the end of the the remediation activities could pose a problem due to the complexity of the equipment.

<u>Screening Factor Ranking</u>

Effectiveness:	Moderate
Implementability:	Moderate
Cost:	High

<u>Conclusion</u>

Centrifugation can be a viable treatment process for removing solids from the wastewater.

CHANNEL REALIGNMENT BY EXCAVATION (TEMPORARY OR PERMANENT)

In addition to flow diversion excavation and material removal techniques described in Appendix A, this technology is used extensively for construction work in rivers, canals, channels, and other waterways. For rivers or larger waterways, it may be necessary to use a combination of excavation material removal including dewatering, mechanical/hydraulic dredging, and flow diversion.

Overall Assessment

Channel realignment for temporary and permanent purposes is used routinely in irrigation and other construction projects worldwide. It does require a site-specific environmental/other impact analysis prior to implementation.

Screening Factor Summary

Prior to using this technology environmental and other impacts on the area would have to be fully evaluated and documented. The relative costs of implementing this technology could be high for rivers/major waterways even though it does offer the potential of diverting clean water from contaminated sediments. The sediment contamination levels have to be high enough to justify the extensive work and high cost of this technology.

Screening Factor Ranking

Effectiveness:	High
Implementability:	High
Cost:	High

Conclusion

Channel realignment is retained for further consideration.

CHEMICAL DUST SUPPRESSANTS

This technology controls the release of surficial soil particles into the air by spraying a natural or synthetic material which strengthens the bonds between soil particles. A wide variety of resins, bituminous materials, and polymers are marketed as dust suppressants. The suppressant is typically applied with water wagons equipped with two to five nozzles that shoot a flat spray behind the vehicle. If the application rate becomes critical, more sophisticated spray delivery systems are available.

Overall Assignment

This technology is commonly applied to construction sites for dust control during hauling operations and stabilizing inactive waste piles. The 100 percent effectiveness of a dust suppressant ranges from one to four weeks, depending on the suppressant used, degree of traffic disturbance, and weed emergence. There is the potential for secondary environmental impact due to soil and ground water contamination from the use of certain chemical suppressants which contain toxic substances.

Screening Factor Summary

The application of dust suppressants is an effective and easy way to stabilize soils and sediments against airborne release, as well as environmentally safe if the proper suppressant is chosen. Due to the temporary effectiveness, reapplication is required on a regular basis for achieving long-term dust control.

Screening Factor Summary

Effectiveness:	High
Implementability:	High
Cost:	Low to medium (suppressant dependent)

Conclusion

Dust-suppressant technology is an accepted, safe, and proven stabilization method for general wind-induced erosion control applications, including earth moving operations and stabilizing inactive waste piles against airborne contaminant (dust) release. This technology is a viable treatment method and should be retained for further consideration.

CHEMICAL REDUCTION

Chemical reduction is the addition of a compound to reduce the ionic state of a specific compound to make it easier to treat or remove. Reduction can also include the addition of hydrogen to an organic compound.

Overall Assessment

Reduction is commonly used on streams containing hexavalent chromium. The hexavalent chrome is reduced to trivalent chrome by the addition of sulfite, thiosulfate, or a similar reducing agent. The trivalent chrome can then be removed with standard precipitation methods. Hydrogenation of organic compounds is a common chemical processing procedure.

Screening Factor Summary

Reduction could be used in the treatment system if reducible compounds are present. Current data does not indicate the presence of any reducible compounds; however, the process will be retained until the final data indicate the lack of reducible compounds. After reduction, the compounds would be removed by the usual methods, including precipitation, flocculation, and solid/liquid separation.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	Moderate
Cost:	Moderate

Conclusions

Although the current data do not indicate the presence of reducible compounds, the technology will be retained until more complete data are obtained.

CLARIFICATION

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

Overall Assessment

Clarification can either be used as a pretreatment technique to remove organic or inorganic contaminants prior to 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.

Screening Factor Summary

Clarification can remove the suspended solids from wastewater. In fact, some clarification of the wastewater in pits and lagoons has probably already occurred. Clarification will not reduce the hazards associated with the solids, but it will reduce their volume. The sludge will probably have to be treated further. The water may also 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.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	Moderate
Cost:	Low

Conclusions

Clarification can remove the solids from wastewater and may be a part of the treatment process. It would not be useful to the solids in Units 2, 4, and 6, but if wastewater is created during the processing of these units then clarification may be useful.

DEWATERING

Dewatering or water/fluid removal techniques are used extensively in excavation work. Dewatering includes:

- Pumping and fluid transport systems
- Wellpoint and ejector well systems
- Deep wells with submersible pump systems

Pumping and fluid transport systems are used either directly or with a sump where the water is collected by gravity or intermediate pumping (water transfer stations). Wellpoint and ejector well systems generally involve installing a series of in-line, small-diameter wells around the periphery of the area from which the water needs to be extracted or shielded. A pumping system is used to remove the water from the wells. The spacing and number of wells is based upon the anticipated flow rate of water through the material. Deep wells with submersible pump systems are used for larger flow rates and removal of deeper water.

Overall Assessment

Dewatering is a proven technology which is used routinely in construction. Site-specific suitable dewatering equipment is readily available and could involve one or more of the techniques mentioned above.

Screening Factor Summary

Dewatering can be used for removing standing water as well as lowering the water table.

Screening Factor Ranking

Effectiveness:	High
Implementability:	High
Cost:	Low/medium

Conclusion

Dewatering is a useful technology and is retained for further consideration.

DIVERSION AND COLLECTION

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

Overall Assessment

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

Screening Factor Summary

Surface water controls play a significant role in directing and diverting surface runoff to reduce flooding, control erosion, and increase the stability of sloped surfaces.

Screening Factor Ranking

Effectiveness:	Medium
Implementability:	Medium
Cost:	Low/medium

Conclusion

Surface water diversion and collection are viable technologies when used in conjunction with other remedial action technologies and are therefore retained for further consideration.

DRYING/CALCINATION

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.

Overall Assessment

Drying can remove bound water but not combined water (water of hydration) from sludges. The higher temperatures involved in calcination will remove water of hydration. Drying performance will depend on the sludge composition. Drying can be accomplished in indirect heat transfer equipment, through direct contact with hot gas, or in equipment that combines both methods of heat input. The water produced by the drying or calcining processes may have to be condensed and may require treatment for entrained particulate or volatilized organics. Drying temperatures are unlikely to be high enough to volatilize any metals.

Screening Factor Summary

Drying and calcination are weight/volume reduction techniques; they have no effect on the hazards associated with any organics, metals, or radioactive compounds in the sludge. Drying will reduce the amount of energy required for vitrifying the sludge and the amount of Portland cement or other additives required for solidification. This may reduce the total cost of these options. Drying will also reduce the weight and volume of the sludge and will reduce the cost of packaging and off-site transportation and disposal. Drying the sludge will likely produce a dusty product and increase the possibility of fugitive emissions of dusts containing any of the hazardous components of the sludge, including uranium, thorium, and other metals. Any drying system would require ventilation and dust control equipment. Drying is a commercial technology in the nuclear power industry for volume reduction of radioactive wastes. Raffinate sludges are currently being dried at the Fernald Feed Materials Production Center (FMPC) in a rotary kiln. This equipment might be used to dry some sludges. There would be no major difficulties in implementing this technology. Drying is a moderately expensive technology.

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.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	High
Cost:	Moderate

Conclusions

Drying may be a cost-effective pretreatment for many of the high moisture sludges in the waste pits. Drying could be employed prior to solidification, vitrification, or packaging these wastes. Drying may be applicable to river bottom sediments, lime pond and pit sludges or potassium-65 residues.

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 in a predetermined pattern over a surface area one location before moving on to the next location.

Overall Assessment

This technology has 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 prior to the start of any compaction effort:

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

After treatment, the soil blanket will be contoured and a RCRA-type cap constructed. Ground water control measures will be installed to provide an environmentally secure permanent waste disposal unit.

Screening Factory Summary

Dynamic compaction is fairly inexpensive and effective for subsurface compaction. This method has been used to compact radioactive, low-level and mixed waste trenches at various disposal facilities as well as sanitary landfills. Since the water content in the pits may cause excessive scatter, a field test program should be instituted to verify applicability and worker safety parameters.

Screening Factor Ranking

Effectiveness:	High
Implementability:	High[a]
Cost:	Low

[a]Used after removal of excess waste/soil pore water.

Conclusion

While this technology is a proven and accepted method for in situ stabilization (force subsidence) at hazardous and mixed waste sites, it may release water to the pit surface.

Dynamic compaction is not a recommended treatment option prior to removal of excess pit water. After water removal, dynamic compaction can provide excellent deep consolidation.

This technology is a viable treatment after removal of excess water and should be retained.

EVAPORATION

Evaporation is the process of separating a solvent from a solute by vaporizing or evaporating the solvent.

Overall Assessment

Evaporation is a common volume reduction technique; it will concentrate solids, salts, and other nonvolatile soluble contaminants in a wastewater. Evaporation can produce either a waste brine or a "salt cake" for disposal. The condensate generated may require treatment before discharge. Evaporation requires the addition of energy in the form of solar input, steam, electric power, or direct fuel combustion. Many types of evaporators are available and selection of the appropriate type will depend on site-specific variables and utility costs.

Screening Factor Summary

Evaporation could be used to concentrate the salts in wastewater; however, evaporation will not reduce the hazards associated with these wastes but will facilitate their subsequent treatment and disposal. Condensate treatment may be required. The brine concentrate can probably be treated with the sludge. Significant adverse environmental impacts should not result from this process. Evaporation has a moderate cost compared to other wastewater treatment processes and is very energy intensive. Evaporator design will have to be reviewed for critical geometric considerations. Evaporation may be considered as a pretreatment step for wastewater treatment or treatment of liquids generated from any solid/liquid separation step.

Screening Factor Ranking

Effectiveness: Moderate
Implementability: High
Cost: Moderate

Conclusion

Evaporation can concentrate the salts and solids in a wastewater and could be a component of a wastewater treatment system. Evaporation is therefore retained for further consideration.

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.

Overall Assessment

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 polish the treated water effluent prior to final discharge. Filtration typically produces filter cakes that contain 20 to 50 percent solids.

Screening Factor Summary

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 water 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.

Screening Factor Summary

Effectiveness:	High
Implementability:	High
Cost:	Low

Conclusions

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.

FLOCCULATION

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

Overall Assessment

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, or high molecular weight polymeric compounds are added to help agglomerate the particles. More than one flocculant is normally used for removing inorganics in conjunction with neutralization/precipitation and clarification/filtration.

Screening Factor Summary

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 flocculant is properly handled and stored. Flocculation costs are usually relatively low. However, in some cases, the costs can be high depending on the type and dosage of flocculant used.

Screening Factor Ranking

Effectiveness: Moderate
Implementability: High
Cost: Low

Conclusion

Flocculation could be a component of the wastewater treatment system. Typically, laboratory-scale bench settling tests would be required to select type and dosage of flocculant.

GRADING (SURFACE WATER MANAGEMENT SYSTEM)

Grading is a general term for techniques used for managing surface water runoff and for controlling infiltration and erosion. Soil spreading and compaction, which are essential components of grading, are used extensively in land development and at sanitary landfills. Grading modifies the topography and the runoff characteristics thereby accomplishing infiltration and erosion control. One of the steps in grading is to establish continuous surface grades to eliminate possible ponding of surface runoff. This technology is often used in combination with surface sealing and revegetation.

Overall Assessment

For covered disposal sites, a properly designed and constructed grading program can be an economical method of controlling infiltration, diverting runoff, and minimizing erosion. An adequately graded surface, coupled with surface sealing, aids in reducing possible leachate formation by minimizing infiltration and promoting erosion-free drainage of surface runoff. Grading assists in preparing a suitable soil cover that can support beneficial plant species. It is also an important factor in proper cap design, performance, and reliability. Revegetation plays a key role in grading and is easy to implement.

Screening Factor Summary

Grading/regrading is inexpensive if suitable cover materials are available on site or close to the disposal site. The techniques and equipment used in grading operations are well established and are widely used. It is usually possible to find contractors and equipment locally.

Grading is useful in ponding, runoff velocities/soil erosion, differential settlement infiltration, and leaching of wastes; it also roughens and loosens soils, thereby preparing them for revegetation. For grading to be effective, it is essential to remove depressions and to repair slumped or badly eroded slopes.

Screening Factor Ranking

Effectiveness: High
Implementability: High
Cost: Low

Conclusion

Grading, in combination with capping, surface sealing, and revegetation, is a viable technology for containment of materials in a suitably designed and constructed facility. It is, however, a support technology.

GROUND WATER PUMPING

Ground water pumping includes the extraction of water from or the injection of water into wells to capture a plume or alter the direction of ground water movement.

Using techniques of actively modifying and managing the ground water system, a contaminated plume can be contained or removed. To accomplish this, well-points, suction wells, ejector wells, and deep wells are used. Selecting suitable well types, locations, and arrangement depends upon the depth of contamination and the hydrologic and geologic characteristics of the aquifer.

Overall Assessment

Well systems are used to contain, remove, divert, or prevent development of plumes under a variety of site conditions. Pumping has been found to be effective where underlying aquifers have high permeability/hydraulic conductivity. For plume containment or removal, either extraction wells or a combination of extraction and injection wells can be used. Extraction wells alone can be useful where contaminants are miscible and move readily with water; hydraulic conductivity is high and quick removal is not a requirement. Extraction wells are frequently used with slurry walls to prevent ground water from overtopping the wall and to minimize any possible wall degradation caused by leachate contact with the wall.

A combination of extraction and injection wells is used in containment or removal where the hydraulic gradient is relatively flat and hydraulic conductivities are only moderate. Although not widely used, sometimes extraction and injection wells can help in adjusting ground water levels.

Screening Factor Summary

The above techniques, together with a barrier wall and a cap, can be used for complete hydrologic isolation. Ground water pumping systems are site specific, and performance and applicability have to be evaluated for each site (e.g., performance is poor in low transmissivity aquifers). Costs of these systems can be quite high.

Screening Factor Ranking

Effectiveness:	High
Implementability:	Medium
Cost:	High

Conclusion

Ground water pumping is a viable technology an is therefore retained for further consideration.

GROUT INJECTION TECHNIQUES

Compaction Grouting (Displacement)

Compaction grouting is the injection of a low slump mortar-type grout under relatively high pressure to displace and compress the surrounding soil particles. The grout pipes are installed in a predetermined design pattern to the required depth and grout is pumped until a refusal criterion is met or until ground heave is observed.

Overall Assessment

This grouting technique is most suitable for densification of cohesionless soils. At each injection location, a homogeneous grout bulb is produced. As the grout pipe tip is extracted in increments, a linked series of bulbs is formed to provide a denser, less permeable soil column.

The effectiveness of this technique in reducing horizontal permeability is dependent upon the degree of continuity achieved in the grout curtain formed by columns of grout bulbs. Achieving effective continuity of the grout curtain is a function of many variables, including homogeneity of soil properties. Use of this grouting technique will require thorough knowledge of the soil profile to be grouted.

Chemical Grouting (Permeation)

Chemical grouting is the permeation of a soils mass to increase the geotechnical/mechanical soil properties and completely fill voids to stop water flow. Grout pipes are installed in a predetermined pattern and encased in a continuous brittle mortar sheath. Grout is then injected and exits through ports in the pipe at specific intervals and flow rates.

The chemical grouts can be defined as follows:

- Suspension types consisting of microfine cement, cement, bentonite, and sodium silicate
- Solution types consisting of lignin group, urea resin group, and acrylate

Of these numerous grouts, microfine cement and acrylate will be considered for primary usage due to low or no toxicity concerns and good soil permeation ability.

Overall Assessment

The permeation capabilities of acrylate and microfine cement are as follows:

- Acrylate grout has the ability to permeate coarse silts
- Microfine cement has the ability to permeate fine sands down to a grain size of 74 micrometers

This restriction, however, does not exclude the injection of two-component grout mixes, such as sodium silicate added to microfine cement. This mixture is used for gel time management (affecting the extent of permeation through the soil) in controlling ground water and grout strength requirements.

Effectiveness of chemical grouting is dependent to a large extent on permeation of the grout throughout the soil fabric.

Jet Grouting (Replacement)

While there are numerous variations based on this technology, generically, jet grouting utilizes the jetting action of high-pressure water sheathed in a core of air to breakdown soil structure. The loosened soil is partially removed to the surface by airlift pressure while the remaining soil is simultaneously mixed with grout.

Overall Assessment

This procedure will allow in situ construction of solidified ground to any predetermined shape, size, and depth as well as a design characteristic, including strength and permeability. Advantages of the jet grouting technique are:

- Jet grouting can be used in a wide variety of soil types and has achieved permeabilities of 10^{-6} to 10^{-9} centimeter per second (cm/s) in cohesive soils.

- Slurries are almost exclusively cement based and relatively inexpensive.

The major disadvantage of jet grouting for this application is the required handling and disposal of the contaminated soils brought to the surface. The technique has the advantage, however, of ensuring completeness of a grout curtain to full depth.

Screening Factor Summary (Grouting Injection Techniques)

Grouting may be considered for three purposes. First, grouts may be used to add strength to materials in the pits, thereby reducing the amount of soil/waste consolidation and the resulting settlement of a cap covering the pit. Second, grouts may be used outside the pit borders as an alternative to slurry walls to provide a curtain against horizontal migration of contaminants. Third, grouts may be used for structural purposes to improve the geotechnical properties of specific soils.

A general concern in assessing the feasibility of grouts and grouting techniques is the effectiveness of the grout curtain against radionuclide migration through the processes of diffusion and dispersion. Consideration must be given to including in the grout curtain materials which adsorb radionuclides and hence retard migration.

Screening Factor Ranking

INJECTION METHOD	EFFECTIVENESS[a]	IMPLEMENTABILITY[a]	COST
Displacement	Low	Low	High
Permeation	Low (medium)	Low (medium)	High
Replacement	Low (medium)	Low (medium)	High

[a]Ranking denoted "(medium)" are for K-65 silo insitu isolation applications.

Conclusion

These technologies should be retained only for operable unit subunit (except K-65 silos) due to the following:

- None of the injection technologies will effectively stabilize or remove the soil/waste pore or excess matrix water due to the waste character, grain size, and chemicals.
- Closely spaced grout holes must be drilled three to five feet, on center, thereby greatly increasing worker and environmental risks.
- Grouting will not stabilize the 55-gallon drums and/or other buried objects.
- Grout injection technologies are extremely expensive and, in this application, offer no significant benefits.

Permeation and replacement are viable technologies for Operable Unit 4 (K-65 silos).

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-supporting package.

Hydraulic removal/dredging is generally limited to excavating slurries with low percentages of solids and is normally used for 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.

Overall Assessment

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 capability of 10 to 50 feet.

Screening Factor Summary

Hydraulic removal/dredging including slurry pumping is a proven technology. Its design can be optimized for pumping greater quantities of solids. The significant advantage of a hydraulic removal/dredging and pumping system is reduced exposure because of the remote handling and transport of the materials being removed.

Screening Factor Ranking

Operable Unit/Subunit:	North Lime Sludge Pond
Effectiveness:	High
Implementability:	High
Cost:	Medium
Operable Unit/Subunit:	South Lime Sludge Pond Fly Ash Piles, Southfield Sanitary Landfill, and Metal Scrap Piles
Effectiveness:	Low
Implementability:	Low
Cost:	Low

Conclusion

Hydraulic removal/dredging is the most suitable technique for removing sediments from the wet areas or removing contaminated material in high water table areas. It offers the least potential of environmental and worker exposure to the contaminated material.

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 electrostatic forces to charged groups on the surface of an insoluble solid (resin) with which the solution is contacted. 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.

Overall Assessment

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 the 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.

Screening Factor Summary

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 regenerant can 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.

Screening Factor Ranking

Effectiveness: High
Implementability: Moderate
Cost: Moderate

Conclusion

Ion exchange can remove specific inorganic ionic materials and may be a component of the overall wastewater treatment system.

LIQUID/LIQUID EXTRACTION

In the liquid/liquid extraction process one or more impurities are removed from the wastewater by intimate contact with a second liquid having low aqueous solubility and for which the impurities have a high affinity. The separation can be based either on physical differences that affect differential solubility between the solvents or on a definite chemical reaction.

Overall Assessment

Liquid/liquid extraction usually is used to remove organics from water. In this process, the water is contacted with a solvent that has a greater affinity for the organic contaminant. The organic is extracted into the solvent, typically in a countercurrent column. Liquid/liquid extraction can sometimes be used to extract inorganics (e.g., uranium) from water by adding chelates to the solvent. These chelates are organic compounds (insoluble or slightly soluble in water) with functional groups that attract inorganic ions. In liquid/liquid extraction, the water usually is contaminated by the solvent and must be treated. The extracted contaminant must also be removed from the solvent so that it can be recycled. Removal of the contaminant can be achieved by distillation, crystallization, acid/base washing, or reaction. In liquid/liquid extraction, it is difficult to achieve very low levels of residual contaminant in the water. Liquid/liquid extraction is usually used to recover high value chemicals from aqueous process effluents; it is not a typical waste treatment process.

Screening Factor Summary

Liquid/liquid extraction could be used to remove some of the inorganic salts, including uranium and thorium from the wastewater. It is not likely that the extraction will yield effluent suitable for discharge. This process would produce spent solvent that would require treatment. It is also an undemonstrated technology for this application and would require significant development work. Liquid/liquid extraction is an expensive process and is practical only when the value of the recovered product is very high.

Screening Factor Ranking

Effectiveness: Low
Implementability: Low
Cost: High

Conclusion

Liquid/liquid extraction is usually a recovery process for high value components and will not be a practical treatment technology for wastewater at Fernald.

MECHANICAL REMOVAL BY 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 about 40 feet. Deeper digging depths (up to 80 feet) are achievable by using modified backhoes with extended booms, modified engines, and counterweights.

Overall Assessment

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

Screening Factor Ranking

Operable Unit/Subunit:	North Lime Sludge Pond
Effectiveness:	Low
Implementability:	Low
Cost:	Low
Operable Unit/Subunit:	South Lime Sludge Pond Fly Ash Piles, Southfield, and Sanitary Landfill
Effectiveness:	Medium
Implementability:	Medium
Cost:	Low

Conclusion

A backhoe with extended reach/depth capability is a versatile piece of equipment and can yield higher production rates as compared to the clamshell and dragline. Also, with the use of a grappler attachment, it can be used for drum removal.

MECHANICAL REMOVAL BY 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.

Overall Assessment

The dragline has a longer reach than a clamshell and better horizontal control. It has a greater potential of losing material in hoisting and may require a specially designed bucket.

Screening Factor Summary

A dragline uses the same basic equipment as the clamshell. Its advantages over the clamshell are longer reach and better horizontal control.

Screening Factor Ranking

Operable Units/Subunits:	Operable Unit 2
Effectiveness:	Low
Implementability:	Low
Cost:	Low

Conclusion

Since the dragline uses the same equipment as the clamshell it needs to be retained for possible site specific use.

MECHANICAL REMOVAL BY FRONT-END LOADERS

Front-end loaders are tractors with buckets 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. Crawler machines are equipped with self-laying tracks of variable cleat design and width, which provide ground contact and flotation/traction capabilities.

Overall Assessment

Front-end loaders equipped with large rubber-tired wheels are faster and more responsive on level terrain. Their ability to manuever on rough, muddy, and sloping terrain depends somewhat on the type of tires.

Screening Factor Summary

The crawler loader can be a good excavator and can be used to carry material up to 300 feet. The front-end loader's buckets vary in capacity and design. Medium-sized crawler loaders typically have maximum bucket capacities of 5 to 6 cubic yards. Wheel-mounted bucket loaders for high production operations on stable surfaces such as paved areas have bucket capacities up to 20 cubic yards. Usually front-end loaders are used in combination with the excavation equipment like dozers and backhoes.

Screening Factor Ranking

Effectiveness: Moderate
Implementability: Moderate
Cost: Low

Conclusion

Front-end loader is retained for further consideration.

NEUTRALIZATION

Neutralization is the addition of an acid or a base to a waste for pH adjustment prior to subsequent treatment or final discharge.

Overall Assessment

Neutralization can be used either to change the solubility of ionic species in wastewater (as in chemical precipitation) or to satisfy a final pH discharge standard. The acid or base added can either be a dry solid, a slurry, or a solution. Lime and caustic soda are the most common bases; hydrochloric and sulfuric acid are the most common acids.

Screening Factor Summary

Neutralization can reduce the corrosivity of a waste by bringing its pH into an acceptable range. Neutralization of some of the wastewater or sludges might result in the evolution of a gas such as carbon dioxide, thereby requiring emission controls. Neutralization is a common, low-cost, reliable process that is easily implemented. Proper storage and handling of acids/bases and the use of appropriate personnel protective gear is necessary to avoid adverse environmental and health effects.

Screening Factor Ranking

Effectiveness:	High
Implementability:	High
Cost:	Low

Conclusion

Neutralization may be a component of the waste treatment process.

OFF-SITE WASTE DISPOSAL

After treatment, the FMPC waste can be transported to the DOE Nevada Test Site (NTS) for permanent disposal. As a condition of NTS disposal, no untreated wet, raw waste or free liquids will be accepted for transport. Bulk and/or containerized wastes may be transported to NTS 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 NTS requirement is 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 NTS, 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.

Overall Assessment

The FMPC can readily accommodate rail transport by use of existing on-site 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

Unfortunately, NTS does not have an available rail spur. Therefore, either a spur could be built or a combination of rail/truck transport be investigated.

Truck transport can provide portal-to-portal service with the road system available at NTS and FMPC. Dependent upon if the waste is containerized, bulk/dry cake, or solidified, the number of run trips (each 20 tons one way) could range from 2,000 to 7,000. 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.

Screening Factor Summary

NTS has been previously identified as the off-site waste disposal facility of choice. The major consideration is the transport method, which may utilize truck, railroad, or a combination. While long-haul truck transport is the easiest transportation method to implement, this method could be totally unacceptable from a safety standpoint. Rail transport offers many advantages over trucking, except that a NTS spur is not available. This suggests an engineering cost study be initiated to identify the most preferable method of transportation prior to final technology screening.

This should include the following determinations, at a minimum:

- Budgetary costs associated with rail transport:
  - Loading and unloading waste handling methods unique to various waste forms
  - Placement and construction of a new NTS rail spur
  - Existing mainline tracks at NTS and/or FMPC may need upgrading
  - Direct carrier transport charges
- Budgetary costs associated with a combination of rail/truck transport:
  - Landing and unloading waste handling methods unique to various waste forms
  - Rail-to-truck transfer station at NTS
  - Existing mainline tracks at NTS and/or FMPC may need upgrading
  - Direct rail carrier transport charges

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.

Screening Factor Ranking

TRANSPORT	EFFECTIVENESS	IMPLEMENTABILITY	COST
Rail	High	Medium	Low
Truck	Medium	Low	High
Rail with truck transfer station at NTS	High	Medium	Low

Conclusion

While truck transport is not the technology of choice, all transport methods should be retained for further consideration until the safest public access route(s) can be selected.

ON-SITE, GREATER CONFINEMENT DISPOSAL (GCD) VAULTS

The GCD vault is an above-grade structure (AGS) of reinforced concrete construction designed for permanent waste disposal. This vault derives its name from the ability to accept unsorted, highly hazardous/ radioactive (mixed) waste forms and provide unlimited duration disposal due to the extremely conservative design criteria applied. The GCD vault will be designed as a maximum resistance structure with the ability to withstand high-intensity earthquakes, tornado-generated missile impacts, and rainwater intrusion.

The vault can functionally accept bulk and containerized waste simultaneously, if required.

The GCD vault has two slightly different variations or designs, each with and without a liner system:

- Design 1 - The GCD vault is constructed directly on grade (Figure 4)
  - Design 1A with a liner system including leachate collection/ detection system (LCDS)
  - Design 1B without the Design 1A systems (only primary leachate collection system)
- Design 2 - The GCD vault is constructed with the structural support slab placed six feet over grade, using an extended height reinforced concrete foundation (Figure 5)
  - Design 2A with a liner system including LCDS
  - Design 2B without Design 2A systems (only primary leachate collection system)

As a condition of placement, no untreated (wet, raw) waste or free liquids will be accepted for disposal in any AGS. Bulk and/or containerized wastes may be placed in the vault 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"

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

A preliminary geological evaluation has identified host areas suitable for on-site disposal structure placement with 30- to 40-foot surficial till thicknesses and depths to water table greater than 20 feet.

Overall Assessment

All the GCD vault designs offer the following:

- Advantages
  - Isolates waste forms from the ground water regime
  - Isolates the waste forms from the surface environment and human contact
  - The conservative design criteria will provide an extremely high level of disposal and isolation confidence
  - Used as an AGS at other DOE facilities
  - Will accept any type and shape of mixed waste forms, except wet, raw waste or free-standing liquids
  - Design flexibility allows many different waste placement methods to be utilized:

    a. Waste placement by conveyor systems
    b. Waste placement by forklift or crane
    c. Waste-crete pumped directly into cells

    All placement methods, except by crane, would allow the permanent reinforced concrete roof to be installed during initial vault construction
  - During lulls in waste form placement activities, the vault interior is not exposed to rainfall; therefore, no leachate will be generated for testing and treatment

- The GCD vault's structural integrity is not vulnerable to attack by deep-rooted vegetation or burrowing insects and animals

- Unique Design Advantages

  - Design 2 allows all exterior surfaces, including the structural slab underside, to be visually inspected for any indication of leachate penetration; this allows immediate remediation response and minimizes the potential for environmental contamination

- Disadvantages

  - The structure exterior must be inspected for leaks and cracking on a regular basis

  - The exposed exterior surfaces must have a waterproofing agent reapplied every five to ten years as protection against possible storm water permeation through the concrete

  - The waste forms are not easily retrievable

  - The construct design costs are high

- Unique Design Disadvantages

  - Design 1B and 2B does not utilize liner systems with complete liners, leachate collection/detection systems (LCDS); this could potentially impact environmental safety as well as being politically unacceptable

Screening Factor Summary

The GCD vaults provide safe and permanent isolation of waste from both the surface and subsurface environment. The vaults would be designed to withstand the most severe surface conditions and would provide the ability to accommodate almost any waste placement method and form. Although the initial construction costs will be high, the long-term maintenance should be less than other AGS technologies. Designs 1B and 2B offer major disadvantages by not providing liner systems with LCDS. Therefore, these two designs may have limitations placed on their usage.

A major consideration for any on-site disposal technology may be the resistance from local groups. While considerable local opposition should be expected, the off-site disposal could also be challenged in numerous local political jurisdictions along the transport route, creating unacceptable site cleanup delays.

Screening Factor Ranking

DESIGN	EFFECTIVENESS	IMPLEMENTABILITY	COST
1A	High	High	High
2B	High	Medium	Medium
2A	High	High	High
2B	High	Medium	High

Conclusion

All designs of this technology are viable disposal methods and should be retained. Designs 1B and 2B, without liners and LCDS, may not be appropriate for "dry cake" waste form placement, while Designs 1A and 2A can accept any waste forms. All designs are structured to withstand environmental stresses including earthquakes, tornados, and temperature extremes. All designs will provide long-term waste immobilization and environmental protection.

ON-SITE TUMULUS WASTE DISPOSAL

The tumulus disposal concept basically consists of mounding over waste which has been placed on a stable structural pad. For definition purposes, a tumulus is an above-grade structure (AGS) and can function as a permanent or temporary disposal unit.

The tumulus design has three slightly different variations or designs:

- Design 1 - High-bermed perimeter incorporating the following (Figure 1)
  - RCRA-type closure cap with leachate collection/detection systems (LCDS)
  - All waste shall be underlaid with liners and LCDS
  - The tumulus can accept both bulk and containerized waste
- Design 2 - On-grade reinforced concrete structural pad (Figure 2), incorporating the elements listed under Design 1, except for the following:
  - The tumulus can only accept containerized and highly solidified waste forms
- Design 3 - Compacted gravel structural pad (Figure 3), incorporating the elements listed under design 2, except for the concrete pad

As a condition of placement, no untreated (wet, raw) waste or free liquids will be accepted for disposal in any AGS. Bulk and/or containerized wastes may be placed in the tumulus 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"

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

A preliminary geological evaluation has identified host areas suitable for on-site disposal structure placement with 30- to 40-foot surficial till thicknesses and depths to water table greater than 20 feet.

Overall Assessment

All three tumulus designs offer the following:

- Advantages
  - Ease and low cost to construct
  - Features RCRA-type covers and underliners complete with LCDS
  - Isolates waste forms from the ground water regime
  - Isolates the waste from the surface environment and human contact
  - Soil provides shielding from radionuclide emissions
  - Waste may be retrieved after closure (except for in place pumped waste-crete)
- Disadvantages
  - Long-term cap maintenance and monitoring costs (e.g., primary and secondary LCDS sumps)
  - Integrity of tumulus may be compromised by the effects of weather, deep-rooted vegetation, and burrowing insects or animals
  - During lulls in waste from placement activities, the open tumuli will be exposed directly to rainfall; this will generate leachate requiring additional testing and treatment
- Unique Design Disadvantages
  - Design 1 does not readily allow waste retrieval if placed in bulk form
  - Designs 2 and 3 cannot accommodate bulk waste form placement; therefore, the waste placement costs are greater than Design 1

Screening Factor Summary

A properly designed tumulus will dispose waste as effectively as a RCRA-designed landfill while providing superior isolation qualities from the ground water regime.

The tumuli offer easy construction, low cost, and the ability to retrieve waste forms with some exceptions.

A major consideration for any on-site disposal technology may be the resistance from local groups. While considerable local opposition should be expected, off-site disposal could be challenged in numerous local political jurisdictions along the transport route, creating unacceptable site cleanup delays.

Screening Factor Ranking

DESIGN[a]	EFFECTIVENESS	IMPLEMENTABILITY	COST
1	Low[b]	Low[b]	Low
	High[c]	High[c]	Low
2	High	High	Low
3	High	High	Low

[a]All waste is retrievable after closure.
[b]If dry cake placed.
[c]If solidified or containerized.

Conclusion

All designs of this technology are viable disposal methods for treated waste in a solidified or containerized form. These designs are not recommended for "dry cake" waste form disposal due to weather exposure and lack of vector control during placement operations.

ON-SITE WASTE DISPOSAL/REHABILITATED SILOS

The placement of treated waste into rehabilitated silos can be defined as above-grade structure (AGS) waste disposal. All presented silo rehabilitation methods should be considered as nonretrievable containment. A structural evaluation of Silos 1 and 2, designated K-65 (Camargo, 1985), indicate severely worn out (overstressed) structures with a predicted short life expectancy and the centermost 20-foot-diameter portion of each silo dome in danger of collapsing. While Silos 3 and 4, metal oxide and an empty silo respectively, appear to be in satisfactory condition, they will require a structural evaluation prior to rehabilitation efforts.

As a condition of placement, no untreated wet, raw waste or free liquids will be accepted for disposal in any AGS. After treatment, if required, the resulting waste form may be placed bulk and/or containerized 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"

As with all on-site disposal systems, regularly scheduled monitoring and facility maintenance programs will be required throughout some specified postclosure period.

<u>Overall Assessment</u>

The K-65 silo rehabilitation would require the following:

- A full stress analysis to determine if the raw waste can be removed without structural damage due to exterior earthen-berm pressure and develop a plan for implementation. This brief summary of K-65 rehabilitation does not address the potential of berm contamination.
- Empty and thoroughly clean the interior with high-pressure water and/or vacuum. This may require the use of special equipment (e.g., robotics) due to safety concerns.

- Based on geotechnical/structural considerations, core drill through base slab and chemically grout subsurface soils to improve the foundation.

- Form and pour a reinforced concrete inner silo surface, except dome, monolithic with the existing surface. A flexible membrane liner (FML) can be incorporated directly with the concrete formwork prior to the pour.

- Core drill through the existing silo walls at selected locations to provide leachate collection capabilities.

- An additional FML and leachate system may be placed, if desired.

- Place the treated silo waste.

- After water placement is two feet below the top of liner(s), install gas collection in two-foot-minimum layer of coarse sand. Sand contour should be as domes.

- Place FML over sand and attach to structural surface.

- Using high strength grout, fill voids between FML and silo dome interior.

- Connect LCDS to new high-density polyethylene lined sumps. All lines leading to sump will need gas-tight valves with sampling ports.

- Grout full or remove all silo perimeter drainage lines.

- Cover dome with RCRA-type closure cap extending to preberm placement surface grade.

The rehabilitated K-65 silos with closure caps would resemble a tumulus while providing effective environmental isolation and radionuclide shielding with any generated radon gas vented in a controlled manner at selected locations.

The Silo 3 rehabilitation would require the following, assuming structural integrity:

- For more specifics, refer to K-65 silo rehabilitation items

- Thoroughly clean the interior

- Provide leachate collection capabilities by core drilling through the existing walls

- Based on geotechnical/structural considerations, a foundation grouting program may be instituted
- Place FML system
- Place the treated waste
- Install gas collection system with sand layer
- Place FML over sand and attach to structural surface
- Using high-strength grouts, fill voids between the FML and silo dome
- Connect LCDS to new lined sumps
- Grout full or remove any existing silo perimeter drainage lines
- Coat exterior silo surface with waterproofing compounds

Silo 4, listed as empty, can be lined similar to Silo 3 and used for permanent waste disposal.

Screening Factor Summary

Any program to rehabilitate the silos (except Silo 4) will be time consuming, costly, and dangerous to remediation/construction personnel due to required cleanup efforts in a confined space and silo structural concerns prior to new concrete placement (K-65 silos only). Once the silos are cleaned and relined, the rehabilitated silos will perform in an environmentally acceptable manner.

If the silos are not rehabilitated, they will require closure. This may include demolition and disposal as waste, decontamination to some DOE or U.S. EPA acceptable level, or a combination of both. Therefore, the cost incurred to fully rehabilitate Silos 1, 2, and 3 becomes more attractive and are in line with other above-grade structures. All silos will require a full structural assessment. For retrievable waste disposal, the use of tumulus and temporary storage structure technologies[1] should be assessed.

Screening Factor Ranking

SILO	EFFECTIVENESS	IMPLEMENTABILITY	COST
K-65	High	Medium	High
3	High	Medium	Medium
4	High	Medium	Medium

Conclusion

Rehabilitation technology is a viable possibility and should be retained. The K-65 silo restorations may represent the most costly of any disposal technology and present the highest worker exposure risks. A RCRA-type closure cap should be considered for all silos (Silos 1 through 4) after waste replacement.

PACKAGING/CONTAINERIZATION

Packaging/containerization techniques are used primarily for the transportation of radioactive materials and for which principal federal regulatory responsibility lies with DOT (49CFR). In addition, NRC (10CFR) and DOE have specific responsibilities. Under a memorandum of understanding NRC and DOT cooperate closely to regulate containers for radioactive materials. NRC, under its own legislative authority, is responsible for regulating reviewing, and certifying the packaging and transportation operations for shipments of fissile and highly radioactive materials that must be packaged very securely in Type B containers (described below), when such shipments involve NRC licensees (10CFR71.4). DOE also has authority granted by DOT regulations (49CFR173.7) to approve the packaging and certain operational aspects of its research, defense, and contractor-related transportation of fissile and highly radioactive materials. DOE is required to use standards and procedures equivalent to those of NRC in the certification process. Guidelines for public radiation protection are established by the U.S. EPA and follow the international criteria established by the International Commission on Radiological Protection (ICRP) and the National Commission on Radiological Protection (NCRP). DOT and NRC regulations are based upon these guidelines, which establish upper limits on radiation levels around containers.

Overall Assessment

Regulations and standards divide transportation of radioactive materials into three categories based on their radioactivity levels:

- Low hazard or very low levels of radioactivity requiring "strong tight" containers.
- Somewhat higher levels of radioactivity requiring secure containers called "Type A" packages.
- Fissile materials and those very high levels of radioactivity requiring exceptionally durable containers called "Type B" packages

Procedures to ensure safe packaging for transport of radioactive materials include:

- Categorizing the materials according to their levels of radioactivity and form
- Requiring the preparation and use of packaging appropriate for the type and quantity of material

Screening Factor Summary

The choice of packages is based upon form and quantity of material shipped. The two forms are:

- Normal-Form
- Special-Form

Most materials are classified normal-form. They are not highly radioactive. Special-form materials are generally encapsulated solids that present a hazard due to direct external radiation if they escape from the package. The quantity of radioactivity in the material is indicated by four subdivisions, namely, excepted or limited quantity, low-specific activity, Type A, and Type B, in accordance with 10CFR and 49CFR.

It is necessary to categorize the waste materials in accordance with established criteria and applicable regulations mentioned above. The categorization and retrievable/nonretrievable nature of the materials would determine the type of containerization/packaging and its justification.

Screening Factor Ranking

	EFFECTIVENESS	IMPLEMENTABILITY	COST
Off-Site Transportation/Disposal	High	High	High
On-Site Disposal	Medium	Medium	High

Conclusion

Off-site transportation/disposal requires containerization/packaging. It may not be justified for on-site disposal due to high cost and double handling, except if the material has to be retrieved. Therefore, containerization/ packaging is retained for further consideration.

POZZOLANIC/SOIL MIXING

This technology provides sediment stabilization by the intimate mixing of surficial soils with cement, fly ash, lime, blast furnace slag, or any other readily available pozzolanic materials. Typically, 5 to 10 percent by weight of portland cement is mixed into the soil by an agricultural disc or Rototiller prior to using a light to medium static roller. The finished rolled layer becomes extremely hard and durable.

Overall Assessment

Soil mixing has been applied successfully to control surface water induced erosion at numerous sites. The finished, compacted surface is highly resistant to erosion and very low velocity stream scouring but is subject to weathering and must be periodically maintained. As with all admixtures, treatment or chemical process discharges may severely limit this technology's useful service life.

During mixing operations, minor amounts of contaminated dust may become air-borne. Worker health protection and operation procedures can readily minimize site and personnel safety concerns.

Screening Factor Summary

Soil mixing is an effective and easy way to stabilize soils and sediments subject to erosion. With minimal maintenance, this technology will limit the transport of surficial site sediments to downstream locations.

Screening Factor Ranking

All operable subunits received the same ranking.

Effectiveness: High
Implementability: High
Cost: Medium

Conclusion

Pozzolanic/soil mixing is an acceptable, safe, and proven stabilization method for general erosion control applications. This method would not be suitable for high-velocity discharge stream applications (e.g., large drainage water courses). This technology is a viable treatment method and should be retained for further consideration.

PRECIPITATION

Precipitation is the removal of metals and other components from a wastewater by chemical addition and adjustment of pH to a point where the various species exhibit minimum solubilities.

Overall Assessment

The most commonly used precipitation technique is pH adjustment with alkaline materials (e.g., caustic soda, soda ash, lime) or sulfides. Sulfide precipitation must be used with caution so as to not convert the waste to a RCRA reactive waste. 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 wastewater may require additional treatment to meet discharge criteria. Problems are encountered when ammonia levels are high or chelating and complexing agents are present in the wastewater.

Screening Factor Summary

Wastewater in the pits and ponds is the supernatant from lime precipitation. 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 is 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 has to be disposed of appropriately. Precipitation is a proven commercial technology, and the costs for this technique are low.

Screening Factor Summary

Effectiveness: Moderate
Implementability: Moderate
Cost: Low

Conclusion

Precipitation may be an option for metals removal in the wastewater treatment process. However, bench-scale tests would be necessary to confirm this option.

REVEGETATION (SURFACE WATER MANAGEMENT SYSTEM)

Revegetation (providing a vegetative cover) assists in stabilizing the surface and is generally used in conjunction with capping and/or grading. It reduces erosion by wind and water and helps in developing a stable and naturally fertile surface environment. Revegetation can be useful for upgrading the appearance of a possible disposal site. Planning involves the selection of suitable plant species, seed bed preparation, seeding/planting, mulching and/or chemical stabilization, and fertilization and maintenance. Revegetation has application for both short-term stabilization, including intermediate covers at waste disposal sites and long-term site reclamation.

Overall Assessment

The selection of suitable grasses, legumes, shrubs, and possibly trees is a very important aspect of successful revegetation. Additional factors include the use of mulches and stabilizers, the application of required doses of lime/fertilizers and optimum timing in seeding. Revegetation should be incorporated in design/construction of any disposal facility considered for short or long term storage of materials. It can stabilize the surface of the disposal facility and prevent erosion and thus contribute to the effectiveness and reliability of a cap.

Screening Factor Summary

With proper planning, design, and implementation, a revegetation plan can reduce erosion and stabilize the surface of a covered disposal site.

A multilayered capping system with properly graded slopes, in combination with suitable vegetative cover (i.e., grasses, legumes, and shrubs), is capable of isolating buried wastes from surface water input.

Vegetative covers require frequent maintenance, but may prevent more costly maintenance from erosion of surface soils. Revegetation is also important to the integrity and performance of dikes, waterways, and sedimentation basins.

Screening Factor Ranking

Effectiveness: Moderate
Implementability: High
Cost: Low

Conclusion

Revegetation is a viable component of a surface water management system.

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.

Overall Assessment

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 and membranes employed. One of the significant limitations of RO is related to the tendency of membranes to foul and reduce the flux or product flow. This happens if the solubility limit of any of the salt species in wastewater is exceeded; sequestrants can be added to reduce this effect.

Screening Factor Summary

RO might be used to concentrate the salts in the wastewater. Calcium sulfate fouling can be a problem in treating most of the 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 is a commercial process that can be reliably implemented; costs are moderate compared to other wastewater treatment processes.

Screening Factor Ranking

Effectiveness:	High
Implementability:	Low
Cost:	Moderate

Conclusions

RO can concentrate the salts and solids in a wastewater and may be part of the wastewater treatment process. Some pretreatment of the water to the RO units may be required.

SEDIMENTATION BASIN

This is a method of containing site surface water and runoff for a specific period of time to allow the settlement of suspended soil sediments prior to off-site discharge. The basin is generally preengineered and constructed by erecting suitable earthen dams, by using a natural depression, by excavation, or by a combination of these.

Overall Assessment

Implementing impoundment can be useful because it will assist in:

- Controlling diverted uncontaminated surface runoff prior to discharge
- Controlling suspended solids entrained in surface flow; surface impoundments are an essential part of a surface water management system

A preengineered impoundment should be sized for worst-case conditions. The general trend is to require both temporary and permanent sedimentation basins.

Screening Factor Summary

Surface impoundments can be used for the redirected uncontaminated surface runoff from waste storage areas.

Proper design and construction procedure, including clearing, grubbing, and stripping are required. Any fill material used must be clean, and good compaction techniques must be employed.

Screening Factor Ranking

Effectiveness:	High
Implementability:	High
Cost:	Moderate

Conclusion

This technology is a general requirement for all sites and should be retained.

SELECTIVE ION REMOVAL

This process removes dissolved materials by passing an aqueous stream over a fixed bed of insoluble beads. Selective ion removal operates in a manner very similar to ion exchange. The difference is that ion exchange is reversible, while selective ion removal is difficult or impossible to reverse because of the stability of the chemical bonds that are formed within the resin. The selective ion removal materials are very ion specific (e.g., they may remove only one material such as radium, or a group of materials such as all heavy metals).

Overall Assessment

Selective ion removal is most useful for separating small quantities of unwanted materials from otherwise innocuous aqueous discharges. The applicability at Fernald thus depend on (1) if any free liquids are left after sludge disposal or solidification, and (2) if the remaining constituents are of low enough concentration and innocuous character to allow disposal.

Screening Factor Summary

Selective ion removal can be uniquely applied to the wastewater problem if the two factors mentioned above are present during the processing of the pond contents. Because well known and controlled unit operations from regular ion-exchange technology are employed, the process could be carried out with a minimum of environmental risk. After exhaustion, the resin must be handled in accordance with the environmental protection standards for the unwanted metals that it has scavenged. The spent resins can be volume-reduced by compaction and/or incineration. In any event, a radioactive mixed waste will probably be produced, which may require subsequent treatment or stabilization.

Costs for selective ion materials are high, as they are specialty, low-volume items. On the other hand, they do not spend themselves with the uptake of alkali or alkaline earth metals so that large volumes of water can be treated without unnecessarily depleting the resin. Laboratory testing will be needed before quantitative evaluation of resin capacity can be made.

Screening Factor Ranking

Effectiveness: Moderate
Implementability: Moderate
Cost: High

Conclusion

Selective ion removal is very effective for heavy metals and/or high atomic number radionuclides in aqueous streams. Other dissolved materials are not removed by this process. Therefore, the only applicability would be to treat an effluent that was otherwise sufficiently innocuous for more routine processing or discharge.

SOIL-BENTONITE 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, result in this type of slurry wall. There is a work area requirement for on-site slurry preparation to be effective; this work area should be located adjacent to the slurry wall installation site.

Overall Assessment

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 ground water. 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 function to divert ground water away from waste thus minimizing leachate migration.

Screening Factor Summary

Soil-bentonite slurry walls can be designed and constructed to isolate waste materials. A well designed cap, in conjunction with other suitable support technologies, would be required for remediation. The effectiveness of the remedial action depends on the relative impermeability of the subsurface materials.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	High
Cost:	Moderate

Conclusion

Soil-bentonite slurry wall applicability is dependent on subsurface data. When used in conjunction with suitable capping and other support measures, a soil-bentonite slurry wall is a viable technology.

SILO REHABILITATION (IN SITU)

The silos at Fernald are located south of the waste pits, and consist of four silos. Silos 1 and 2 contain by products of uranium ore processing (K-65 material). Silo 3 contains metal oxides while Silo 4 is presently empty.

The K-65 material in silos 1 and 2 contains approximately 4,600 curies (ci) of radium, and therefore continuously generate radon gas which can be potentially released to the environment. Remedial actions have been performed in the past to maintain the integrity of the K-65 Silos. These include repairing the walls and constructing a berm on a 1-1/2 to 1 slope (mid 1960s) and enlarging the berm to a 3 to 1 slope in the early 1980's. In 1985 a structural assessment was performed. This assessment revealed that the walls and base slab are structurally stable and can function as a containment of dry solids for a period of 10 to 15 years. However, the center 20-foot section of the dome was determined to be structurally unsound for a load greater than the existing static load. Remedial actions taken since 1985 include placement of protective covers constructed of steel and plywood over the center portion of each dome.
Three inches of rigid polyethylene foam topped by a 45-mil waterproof, ultraviolet-resistant, urethane-finish coating was placed in 1987 in order to provide weather protection and insulation to the domes. A radon treatment system was implemented for this project to reduce radiation exposure to the workers during the installation process.

Silo 3 contains waste raffinate which was dewatered and calcined prior to being blown in the silo under pressure. To date, no additional remedial actions have been taken. The radium content of the material in Silo 3 is approximately 15 ci, and presently radon emissions from Silo 3 are negligible compared to Silos 1 and 2.

Overall Assessment

Currently, additional remedial actions are being proposed for the K-65 silos. A study was undertaken in 1988 to determine the most feasible method of attenuating the radon gas. The results of this study are contained in the report "Quantitative Analysis Report of Alternatives for Interim Remediation of K-65 Silos" (Draft), and indicated that addition of sand or fly ash is the most feasible interim method for remediation. This preferred method is contingent upon favorable results regarding the impact of load increase due to the addition of sand or fly ash. A structural assessment is currently being performed by Camargo Associates.

Implementation of the proposed remedial action for the K-65 silos would provide short term benefits while long term solutions are developed. The structural assessment performed in 1985 confirmed that the waste and berm would require simultaneous removal, since the walls would collapse if either the berm or contents were removed by themselves. This fact limits the options available for rehabilitation of the K-65 silos. Possible options for long term remediating (assuming the proposed remedial action is implemented) are listed below for the K-65 silos.

Option 1

Remove the domes and provide an impermeable cap. Other technologies can be integrated such as grout injection or other below surface controls. Capping would prevent moisture infiltration and eliminate the environmental release of radon gas. Radiation exposures would be reduced to within acceptable levels.

Option 2

Add posttensioning rings (compression rings) to the wall as the berm is removed. The feasibility of this option would require further investigation. If this option were feasible there would be an increase in radiation exposure to workers, as well as the likelihood of radon releases to the environment through cracks in the walls. Removal of the berm would allow for the possibility of casting additional concrete around the silo.

Silo 3 has more options available for in situ silo rehabilitation. Foremost is the addition of protective membranes to the concrete to reduce waste filtration, insulation to reduce thermal movement of the dome or casting additional concrete around the existing structure.

For any in situ alternative the air and underlying ground would require monitoring. Ground water controls may be necessary depending on information gathered during the remedial investigation currently underway at the site.

Screening Factor Summary

Possibilities for in situ rehabilitation of the K-65 silos is limited since removal of the berm would probably constitute removal of the contents (except for Option 2). Leaving the contents in place and capping are implementable from a construction standpoint, but regulatory requirements would need to be addressed. At this time it is not certain if secondary containment requirements would apply to this waste. Therefore, more investigation is needed.

Silo rehabilitation is a more likely alternative for Silo 3 since it presently appears to be more structurally sound and the radiation hazard is less than that of the K-65 silos.

Screening Factor Ranking

Effectiveness:

Option 1: Moderate
Option 2: Low (K-65 silos)/medium (Silo 3)

Implementability:

Option 1: Moderate
Option 2: Low (K-65 silos)/medium (Silo 3)

Cost:

Option 1: Low/Moderate
Option 2: High

Conclusion

Rehabilitation of Silo 3 using Option 1 or 2 is a viable alternative. Rehabilitation of the K-65 silos by option 1 may be viable; option 2 is not viable.

SOLIDIFICATION AND STABILIZATION

Solidification and stabilization are processes applicable to Class A and Class B/Class C waste, respectively. The waste forms (A, B, and C) are defined in 10CFR61.55. 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 of Testing Materials (ASTM) standards for compressive strength, exposure to radiation fields, biodegradation, and leaching as stated in the NRC Technical Position Paper on Waste Form.

Overall Assessment

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 of other failure when disposed. A number of different solidification agents are available including portland cement, limestone, fly ash, clay (extrusion and firing into bricks), gypsum, adsorbents, resins, and polymers. Laboratory testing will be required to determine the proper solidification formula.

Screening Factor Summary

The solidification medium selected and, therefore, the cost of solidification, is very dependent on the pretreatment selected and the amount of liquid remaining in the waste. The solidification of the waste should reduce its potential for adversely affecting the environment by reducing leachability and other properties.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	Moderate
Gost:	Moderate (Class A - NRC)

Conclusions

Solidification is a viable alternative along with other treatment for the ultimate disposal of the wastes.

STRUCTURAL COVERAGE

This technology provides channel or watercourse soil and sediment stabilization against large-velocity stream flow erosion by lining the waterway. The lining may consist of traditional materials emplaced by standard construction methods, including:

- Concrete
- Gunite (sprayed-on cement mortar)
- Asphalt
- Riprap (graded stone)

The liner may also consist of newer materials and techniques, such as:

- Gabion construction (wire baskets field with rock)
- "Fabriform" mats (cement-filled fabric forms)
- Synthetic fiber matting (e.g., "Enkamat" and "Miramat")

Each of these methods/materials within specific design limitations provides a durable, low or nonerodable surface.

Overall Assignment

This technology is commonly applied to all aspects of erosion control and sediment stabilization. The various methods of lining are specifically useful for eliminating or limiting the effects of high-velocity water discharges and have been used to isolate contaminant bottom sediments in large river channels (e.g., concrete slurries and Gunite applications). The construction techniques of this technology are simple and environmentally safe but costs are high.

Screening Factor Summary

The application of structural coverage technology is an easy and effective way to stabilize soils and sediments against erosion. The liners are durable and require only minor maintenance for achieving a long service life.

Screening Factor Ranking

All operable subunits receive the same ranking.

Effectiveness: High
Implementability: High
Cost: High

Conclusion

This technology is a viable treatment method and should be retained for further consideration.

SUBSURFACE DRAINS (GROUND WATER COLLECTION SYSTEM)/INTERCEPTING TRENCHES

Subsurface drains consist of a gravity collection system designed to intercept ground water. They include any type of buried conduit to collect/transport aqueous discharge by gravity flow. Subsurface drains function like an infinite line of extraction wells. Their essential components are:

- Drainpipe or gravel bed (for directing flow to a storage tank, sump, or wet well); pipe drains are used more frequently than gravel beds or french drains and tile drains
- Envelope (for directing flow from the aquifer to the drain pipe or gravel bed/drain)
- Filter (to prevent clogging of the system by fine particles)
- Backfill (to bring drain to grade and prevent ponding)
- Manholes or wet wells (to collect flow and pump discharge to a treatment plant)

Overall Assessment

Drains are generally applicable to shallow contamination problems. They are also useful in diverting water to prevent contamination as well as intercepting a plume downgradient from its source. Interceptor drains are generally used in combination with a barrier wall and this can be accomplished in the following ways:

- A subsurface drain can be placed just upgradient of a stream. In this case, the drainage system would reverse the flow direction of the stream and cause a prohibitively large volume of clear water to be collected. The barrier wall would prevent infiltration of clean water from the stream, thereby reducing treatment costs.
- For a downgradient barrier wall installation to contain wastes, an interceptor drain can be installed just upgradient of the barrier wall.
- An interceptor drain can be placed along the circumference of a waste site. This drain could also be a part of a total containment system, including a barrier wall and a cap.

For a hazardous waste sites, mostly pipe drains are used. French or gravel drains can be used if a small amount of water is to be drained and velocities are small.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	Moderate
Cost:	High

Conclusion

Subsurface drains may be a viable technology when applied to shallow contamination problems.

SURCHARGING (OVERBURDENING)

This technology typically induces consolidation of soils by covering the area with a soil mound for a long period of time. After the consolidation goal is achieved, the soil overburden may be removed and discarded or utilized for surcharging another area (termed "rotating surcharge technique").

Overall Assessment

This technology is one of the simplest and least expensive methods for large area treatment. This method can be utilized most effectively in free-draining soils but can be readily applied to fine-grained and cohesive soils by installation of sand 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 and would require collection and treatment.

If the drains are not utilized, the surcharge would force the contaminated pore water into the surrounding fill and confining basin subsoils. This may cause a 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 bearing purposes.

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

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

After treatment, the surcharge could be removed and a RCRA-type cap constructed. Ground water control measures will also be implemented to provide an environmentally secure permanent waste disposal unit.

Screening Factor Summary

This inexpensive and simple stabilization technique will achieve long-term soil/waste stability and adequate cap-bearing capacity.

If drains are used, there can be a ten-fold decrease in settlement time but contaminated water will raise to the surface requiring treatment.

If drains are not used, the contaminated pore water will exit into the surrounding confining pit soils, a minor short-term environmental event.

Screening Factor Summary

Effectiveness:	High
Implementability:	High (if internal drainage established)
Cost:	Low

Conclusion

Surcharging is an accepted, safe, and proven method for in situ stabilization at hazardous and mixed waste sites. If internal drainage (wells or wick drains) is provided, the material will consolidate more rapidly. The drained wastewater can be treated and safely removed. This technology is a viable treatment method and should be retained.

THERMAL DESORPTION

Also known as Thermal Separation.

Thermal desorption is the heating of a solid to volatilize or drive off organic contaminants.

Overall Assessment

Thermal desorption is a new technology for treating soils or sludges that are contaminated by organics. In this process, the contaminated solid is heated to a temperature (typically 300 to 1000 degrees Fahrenheit) sufficient to volatilize the hazardous organics adsorbed on the material. These temperatures are not high enough to destroy most organic compounds; they must be destroyed by further treatment of the vapor driven off the solids. These vapors can be treated by fume incineration or by condensation followed by off-site disposal, incineration, or chemical treatment. It is frequently cost-effective to dry the solids before thermal desorption.

Thermal desorption has been demonstrated on soils contaminated with volatile organic compounds (VOCs), with 2,4-D/2,4,5-T herbicides (including dioxins), and on sediments that contain polychlorinated biphenyls (PCBs). Some highly volatile inorganics, such as mercury, might be partially volatilized, but thermal desorption is not a practical metals removal technology.

Screening Factor Summary

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

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	Moderate
Cost:	Moderate

Conclusions

Thermal desorption is effective only for organics in solid or semisolid waste materials. It might be used on soils or sludges contaminated by PCBs or solvents. Thermal desorption could remove hazardous organics from a mixed waste to allow for delisting and subsequent disposal as a low level rad waste.

VACUUM EXTRACTION

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 and inordinately large number of mechanical dewatering units such as filters and centrifuges.

This technology's essential features are:

- Wellpoints - 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 (gpm) 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 ground water so that different pressures are developed. Return pipe flow is a mixture of supply water and ground water which recharges the system water tank. Excess tank water is removed for treatment, while the balance of the water is recycled for ground water withdrawal.

Overall Assessment

Vacuum extraction has been applied to large-scale dewatering operations, with each method having certain restraints:

- General Disadvantages

  - Maintenance requirements are higher and more costly than nonmechanical drainage systems

  - Screens and filters subject to clogging in more fine-grained soils if water is "pumped" too rapidly

- Wellpoint Disadvantages

  - Restricted to granular soils, certain coarse silts, and stratified soils

  - Limited to approximately 18 feet of drawdown

  - Requires close spacing between wellpoints

  - Low ground water withdrawal rates

- Suction Well Disadvantages

  - Restricted to clean sands and gravel (some special exceptions)

  - Limited to approximately 18 feet of drawdown

- Ejector Wells

  - Lower efficiency than other types of pumping
  - More costly to operate than other types of pumping

The vacuum extraction methods have the following advantages:

- Wellpoint Advantages

  - Flexible and reliable method
  - Efficient
  - Inexpensive

- Suction Well Advantages

  - Normal spacing between wells can be four times greater than wellpoints and two times that of ejector wells

  - Can be used more readily than other methods to apply a vacuum to sludges for dewatering

  - Large withdrawal rates

- Ejector Well Advantages

  - More economical and effective in low permeability soils
  - Can be used in stratified and granular soils
  - Can be used at depths greater than 18 feet

After dewatering is complete, the wells are removed and filled with dry packed bentonite. The dewatered area may have to be treated by forced subsidence methods (e.g., dynamic compaction) to reduce the potential of liquefaction and improve long-term bearing capacity.

Screening Factor Ranking

All operable subunits received the same ranking.

Effectiveness:	Moderate
Implementability:	Moderate
Cost:	Moderate (Does not include operating costs)

Conclusion

This technology includes wellpoints, suction wells, and ejector wells and should be retained as a potential in situ treatment method.

This method has various drawbacks but may be required to aid in pit dewatering and/or temporary ground water control during remediation construction.

Screening Factor Ranking (Unit 2)

OPERABLE SUBUNIT[a]	EFFECTIVENESS	IMPLEMENTABILITY	COST
Lime Sludge Ponds	High	High	Medium
Fly Ash Piles	Low	Low	Medium
Southfield[b]	Low	Low	Medium
Sanitary Landfill	Low	Low	Medium
Metal Scrap Piles	(Delete: In Situ Treatment Not Applicable)		

Conclusion

This technology includes wellpoints, suction wells, and ejector wells and should be retained as a potential in situ treatment method.

This method has various drawbacks but will be required to aid in pit dewatering and/or temporary ground water control during remediation construction.

The lime sludge pits may benefit from the placement of suction wells into sludge. The vacuum-induced consolidation will be maintained by placement of plastic sheeting over the pit surface.

VACUUM REMOVAL (INDUSTRIAL VACUUM LOADERS)

Industrial vacuum loaders such as "Supersucker" (Super Products), "Vactor" (Peabody Myers), and "Guzzler" (Guzzler Manufacturing, Inc.) can be used for removing any soily type material including pools of liquid waste. The vacuum loaders can be truck or trailer mounted with up to a 30 cubic yard capacity. These units employ high strength vacuums that can carry solids, liquids, shredded metal and plastic scrap and almost any other material that can be transported through an eight-inch diameter hose. They are equipped with a boom with up to 500 feet of hose. Average available capacities are from 1,250 to 6,000 gallons. Portable skid mounted vacuum units are also available generally in capacities ranging from 500 to 1,500 gallons but special ones with up to 3,000 gallon capacity are manufactured.

Overall Assessment

The techniques with appropriate site specific modifications can eliminate double handling prior to hauling for disposal or treatment. Vacuum loaders can operate in either a solids or liquids handling mode. Changing modes can be accommodated quickly with external adjustment and without emptying loads, thereby, allowing the unit to convey both soils and pools of liquid waste without dumping the load.

Screening Factor Summary

The size of the site, quantity of materials and the disposal or treatment of the materials determines the applicability of this technique. Special units can be manufactured with vapor recovery and or HEPA filter systems. The cost of decontamination is another important factor but, it can be controlled with good management practice. The units would have to be specially sized for the job. It may be necessary to have separate dedicated units for the highly contaminated materials. The 500 feet of hose (range) may be a limiting factor in some cases.

Screening Factor Ranking

Operable Unit/Subunit:	North Lime Sludge Pond
Effectiveness:	Medium
Implementability:	Low
Cost:	Medium
Operable Unit/Subunit:	Fly Ash Piles
Effectiveness:	Medium
Implementability:	Medium
Cost:	Medium
Operable Unit/Subunit:	South Lime Sludge Pond Sanitary Landfill
Effectiveness:	Low
Implementability:	Low
Cost:	Medium

Conclusion

This technology has been effectively used in conditions similar to that prevalent in the north lime sludge pond and in the fly ash areas and is consequently a viable technology for those areas.

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 which are each 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 ten years, wick drains have become the technology of choice in lieu of sand drains. Therefore only wick drains will be assessed.

Overall Assessment

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.

Vertical drains can be utilized more effectively if incorporated into other consolidation technologies.

Wick drains are inexpensive to install and have been used on projects in all parts of the world.

Due to the method of installation and collection of free pore water, there may be a potential of environmental and worker contamination. Prior to 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 ground water control measures

After treatment, wick drains can be left in place. A RCRA-type cap will be constructed in conjunction with ground water control measures to provide an environmentally secure permanent disposal unit.

Screening Factor Summary

Wick drains are inexpensive, simple, and effective.

When wick drains are used in conjunction with a designed surcharge fill, there can be a ten-fold decrease in consolidation (settlement) time. Water collected through the wicking action will have to be collected and treated.

Screening Factor Ranking

All operable subunits received the same ranking.

EFFECTIVENESS	IMPLEMENTABILITY	COST
Medium[a]	Medium[a]	Low
High[b]	High[b]	Low

[a]Ranking when not utilized in combination with surcharging technology.
[b]Ranking when utilized with surcharging.

Conclusion

This technology, when used in combination with surcharging, will provide a safe and effective method of stabilization. Wick drains should be retained as an in situ treatment method for all operable subunits.

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 nonleachable 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.

Overall Assessment

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 also 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 that would be "pulled" off. This melt could be cast as blocks or frit and would probably resemble a bottle glass. This product could be entombed or buried as required for final disposal.

For in situ vitrification (ISV) 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 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 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 particulate. 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.

Screening Factor Summary

Vitrification of FMPC sludges, soils, and other solid wastes would significantly reduce the hazards associated with these materials. The radionuclides and metals would be fixed in a glass/crystalline matrix that has extremely high resistance to leaching and good mechanical integrity. The vitrified product should, in most situations, be stable for several hundred years (which far exceeds the service life of other solidified waste forms). Some of the sludges in the waste pits are not good candidates for ISV because of their high water and lime content. The sludges would need to be mixed with material high in silica and/or alumina compounds. This material could include fly ash, contaminated soil, or even clean soil or sand. The mix can then be vitrified in a drop tube or cold cap melter, or placed in an engineered pit or mound and vitrified by ISV techniques. Drying the sludges before vitrification may reduce overall costs.

Vitrification of these sludges produces an off-gas, thereby requiring an air pollution control system including HEPA filters. Vitrification of radioactive wastes has been proven in various pilot and demonstration projects and is an emerging commercial technology; it should be a reliable treatment option. However, some degree of development work would be needed. Vitrification costs are moderate.

Screening Factor Summary

Effectiveness:	High
Implementability:	Moderate
Cost:	Moderate

Conclusion

Vitrification is an appropriate technology for many of the FMPC solid or semisolid waste materials. Vitrification forms a high strength leach-resistant solid that does not rely on a container, an engineered facility, or institutional control for long-term stability.

VOLUME REDUCTION

Volume reduction technologies are used to reduce the weight/volume of waste material. Volume reduction is only part of a remedial action alternative that involves treatment and/or disposal of the wastes. Reducing the weight/volume of waste may reduce costs associated with containerization, transportation, and disposal.

Available volume reduction technologies include:

- Compaction
- Shredding
- Drying/Calcination

Overall Assessment

Volume reduction technologies have no effect upon the hazards associated with metals, organic compounds, or radioactive substances in the waste.

Compaction - Compaction is a commonly used technology for reducing the volume of a wide variety of wastes. Compaction technologies could be applied to both contaminated and decontaminated wastes prior to disposal or reutilization. Compaction of the waste facilitates handling and optimizes the use of space in a disposal facility. Compacting equipment is readily available.

Shredding - Shredding is another frequently used and widely available technology for reducing the volume of waste before disposal or reutilization. Shredding technologies are generally applicable to the same types of wastes as compaction technologies.

Drying/Calcination - 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 can be accomplished in indirect heat transfer equipment, through direct contact with hot gas, or in equipment that combines both methods of heat input. The steam produced by the drying or calcining processes may have to be condensed and may require further treatment. Drying may also produce a dusty product and increase the possibility of fugitive emissions of dust containing hazardous materials or radionuclides.

Screening Factor Summary

Volume reduction technologies could be used in Operable Unit 2 as part of a removal action alternative to reduce the volume of waste disposed. If some of the wastes stored in Operable Unit 2 could be reutilized (e.g., metal scrap), volume reduction would facilitate handling of the materials. Volume reduction could be used in conjunction with waste segregation technologies as an intermediate step between removal of the wastes and their ultimate disposal or reutilization.

The volume reduction technologies described could be implemented with no major difficulties. A rotary kiln currently used at the FMPC for drying raffinate sludges might be used to dry sludges from Operable Unit 2. The compactor/baler and mobile high force compactor currently used to compact process waste and trash might be utilized for compacting wastes in Operable Unit 2. The overall costs of the volume reduction technologies will be dependent upon the extent to which existing equipment can be used.

Screening Factor Ranking

Effectiveness:	Moderate
Implementability:	High
Cost:	Moderate

Conclusion

Volume reduction technologies may be cost-effective pretreatments for many of the wastes.

WASTE SEGREGATION

(Waste Pits, Clear Well, Burn Pit)

Waste segregation is a process that separates and isolates the different components making up a waste stream. Waste segregation can be accomplished by using the physical or characteristic differences within the waste stream.

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. Support data indicate 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, manual sorting, and screening/sizing:

- MAGNETIC

  Overall Assessment - This method would 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.

  Screening Factor Summary - This method was used in locating borings and proved to be effective. This method could only be used to locate metallic objects. Some method of manual or mechanical sorting would be utilized after the material had been uncovered. The materials would have to be classified and isolated for final disposal. The cost of this method would be low relative to the cost of the removal of materials.

- MANUAL SORTING

  Overall Assessment - 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.

Screening Factor Summary - This method is to be used in conjunction with one of the other methods of locating objects to be separated. Care and protection would have to be used when handling these materials to protect the workers and the surrounding environment. The cost of this procedure would be low relative to the cost of segregation and removal processes.

- SCREENING/SIZING

Overall Assessment - 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 gyratory with vibrating being the most common and most efficient. Fixed screens are usually inclined and used for separating larger materials.

Screening Factor Summary - This method is effective in separating materials by size and separation is dependent on screen sizes. Materials which cannot be passed through the screens will require other means of separation. Large bulky items will require manual sorting.

Implementation of this method could be difficult due to the mechanical equipment required.

Due to the volume of material to be screened the time factor would be dependent on the size of the screening equipment.

The cost of this method would be moderate relative to the other methods of separation.

Screening Factor Rankings

Magnetic

Effectiveness:	High
Implementability:	High
Cost:	Low

Manual Sorting

Effectiveness:	High
Implementability:	Moderate
Cost:	Moderate

Screening/Sizing

Effectiveness:	Moderate
Implementability:	Moderate
Cost:	High

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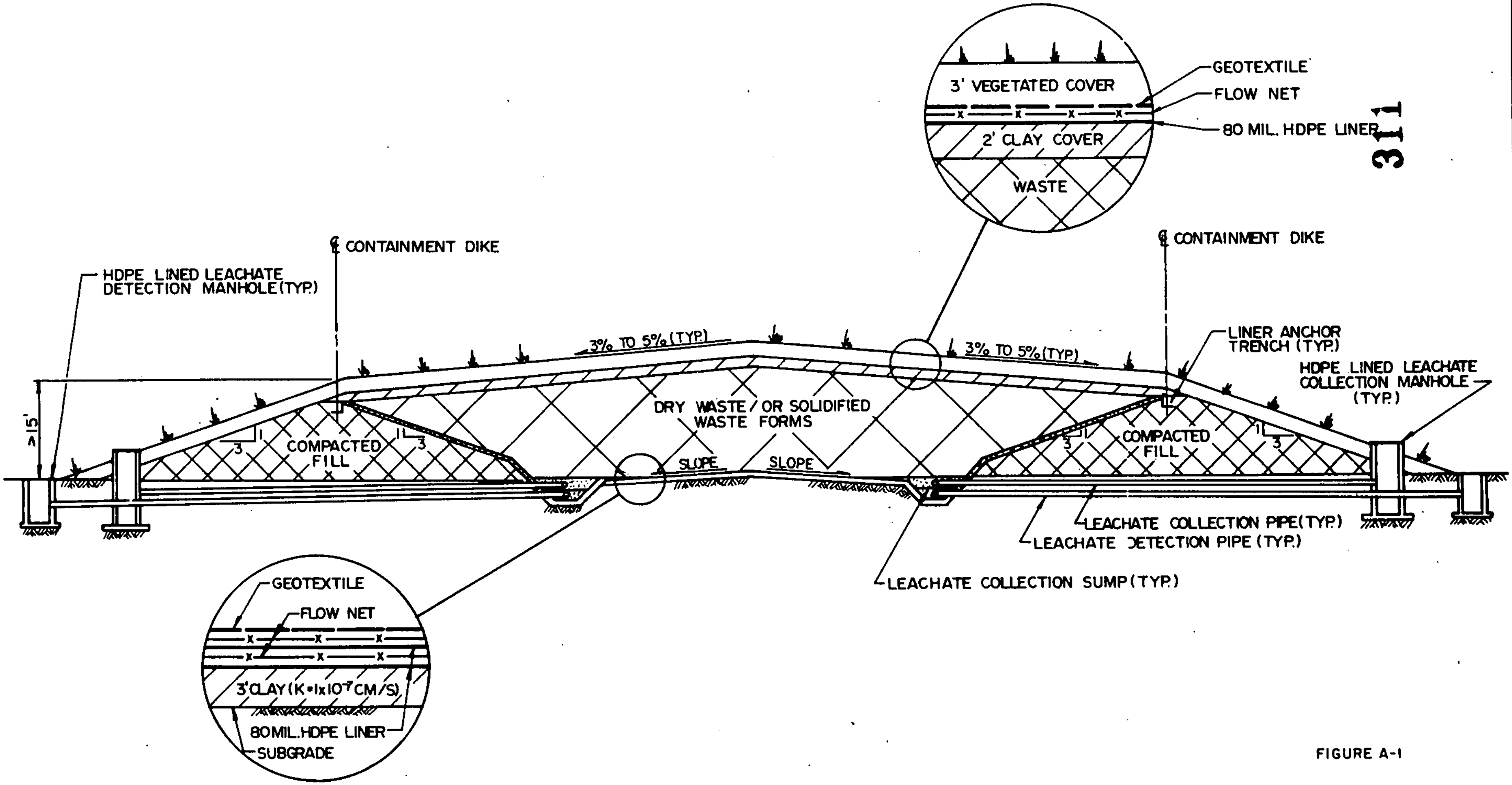

FIGURE A-1

TUMULUS - HIGH BERMED PERIMETER

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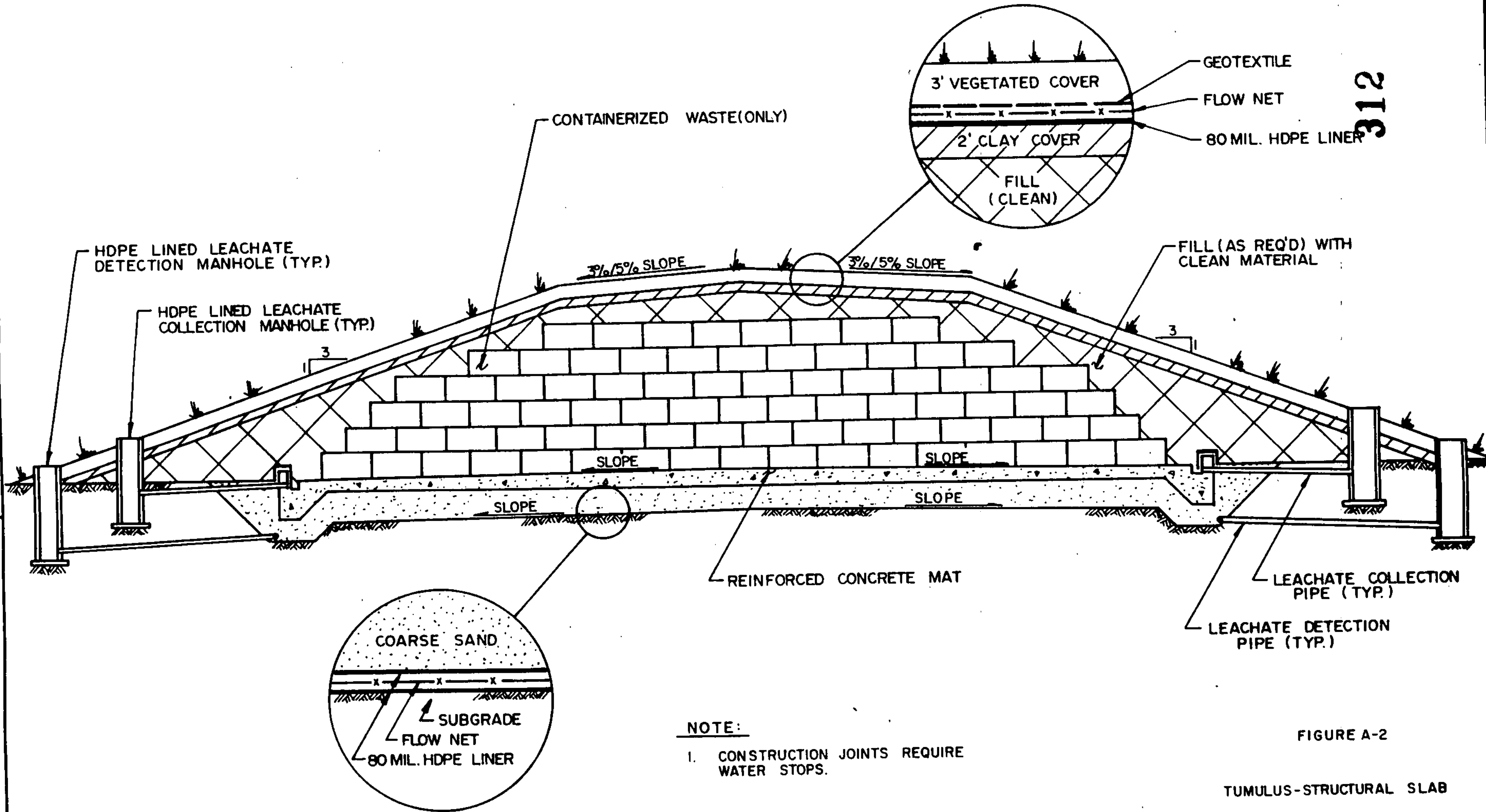

NOTE:

1. CONSTRUCTION JOINTS REQUIRE WATER STOPS.

FIGURE A-2

TUMULUS-STRUCTURAL SLAB

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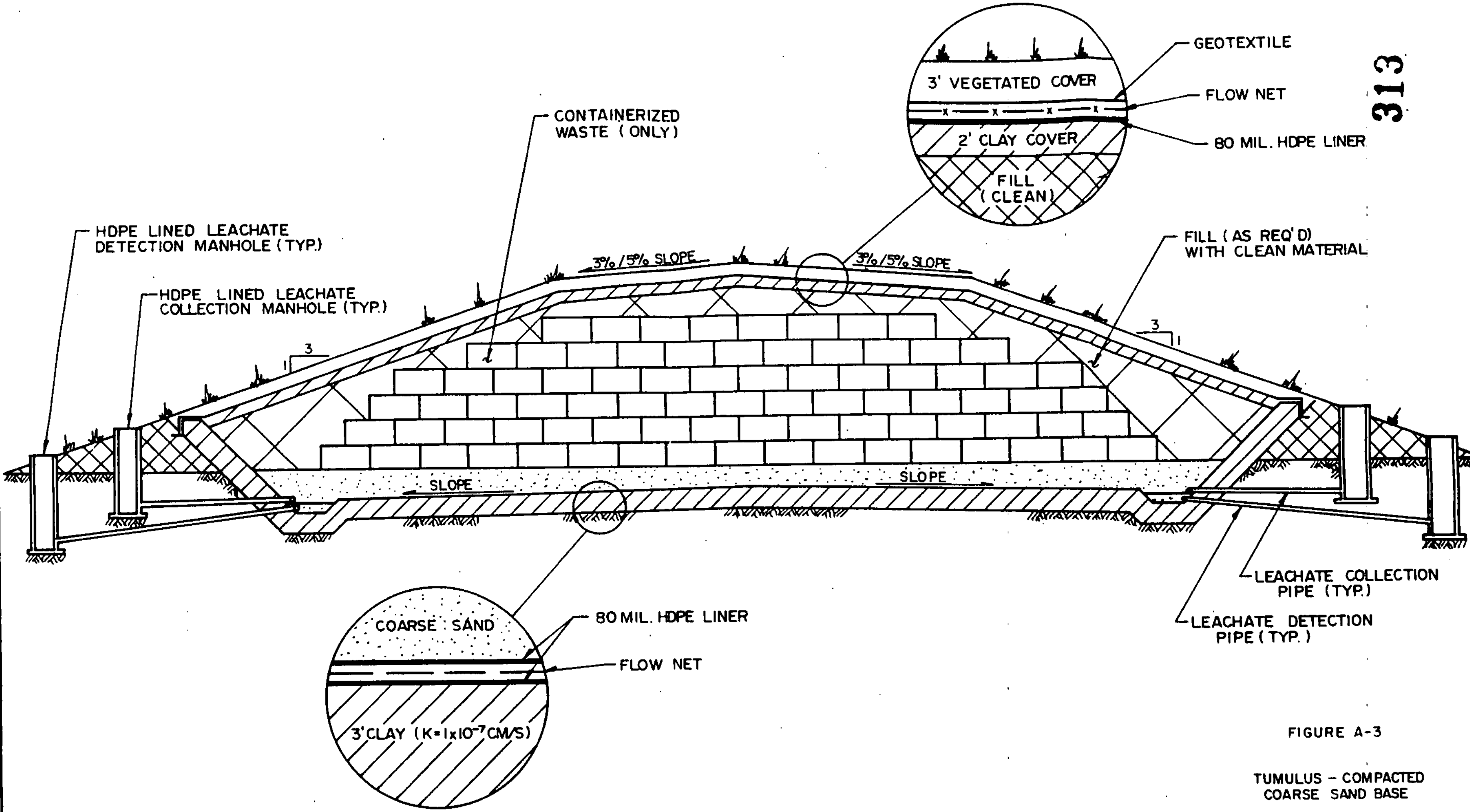

FIGURE A-3

TUMULUS – COMPACTED COARSE SAND BASE

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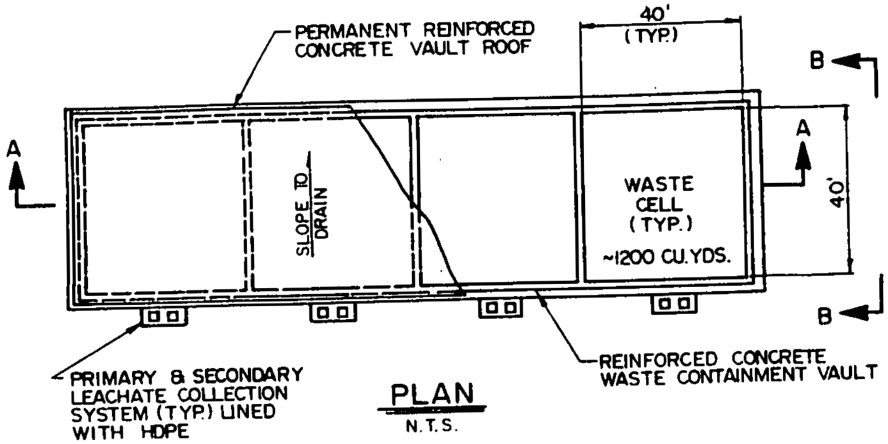
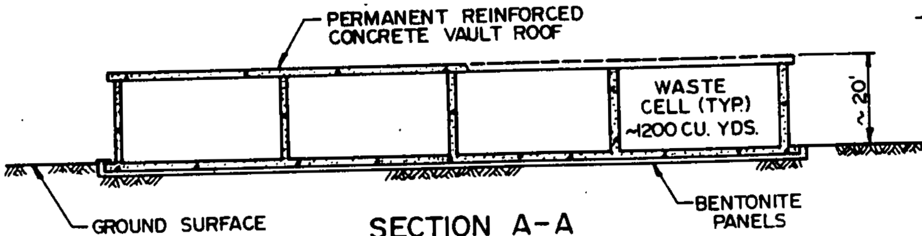
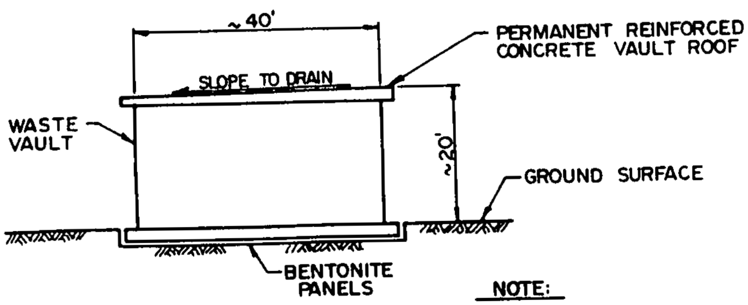


PLAN
N.T.S.

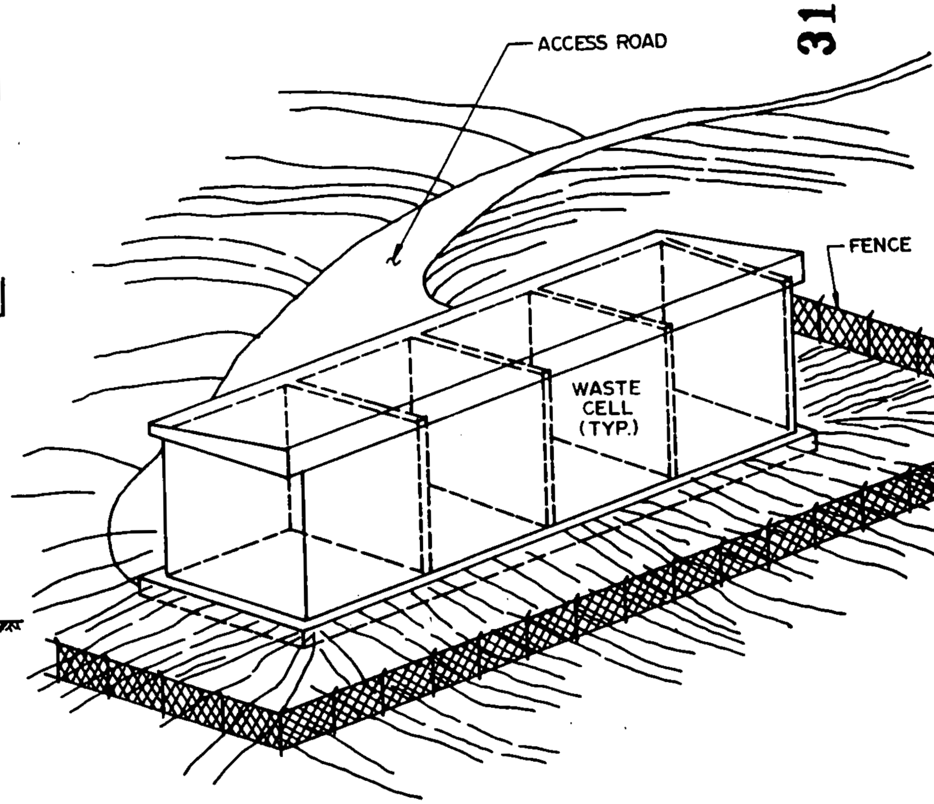


SECTION A-A
N.T.S.



ELEVATION 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 IS 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.

FIGURE A-4

GREATER CONFINEMENT DISPOSAL VAULT FACILITY (GCD)

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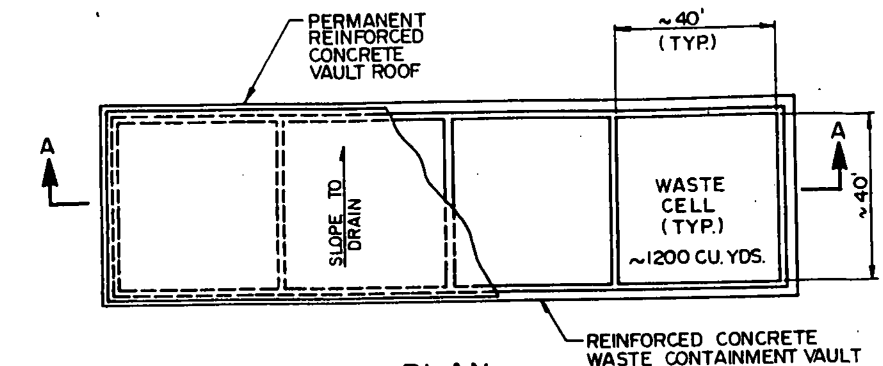
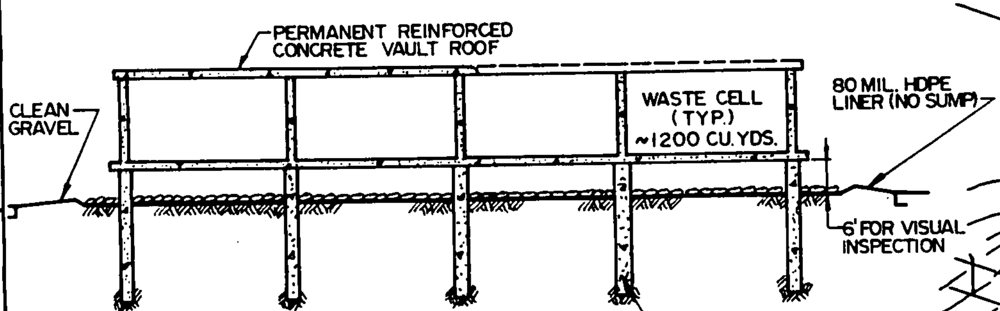
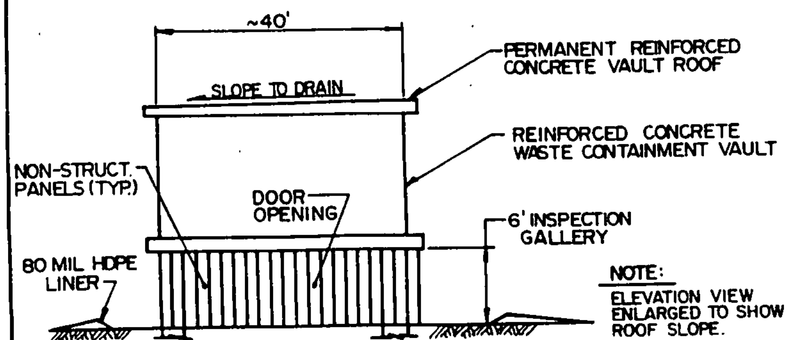


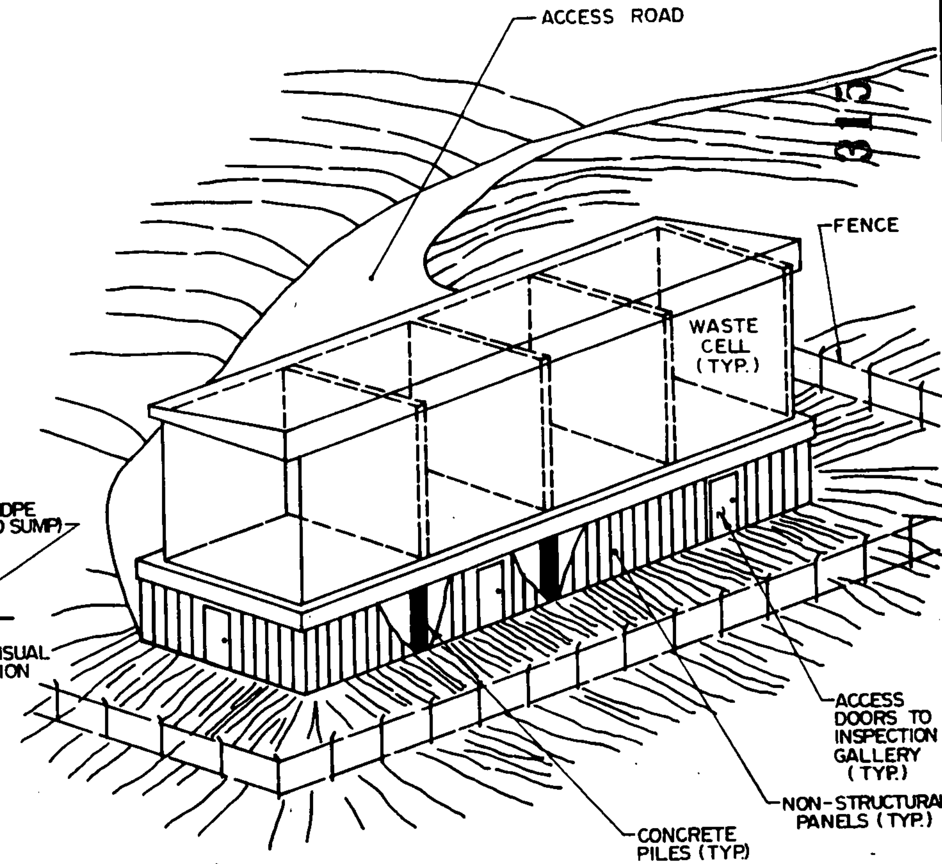
PLAN
N.T.S.



SECTION A-A
N.T.S.



NOTE:
ELEVATION VIEW ENLARGED TO SHOW ROOF SLOPE.



NOTES:

1. PROVIDE FRAMING & NON-STRUCTURAL TRANSLUSENT PANELS FOR WEATHER ENCLOSURE.
2. PROVIDE ACCESS DOORS IN ENCLOSED AREA EVERY 40 LINEAL FT. OF EACH FACE.
3. ALL EXPOSED EXTERIOR SURFACES RECEIVE WATERPROOF COATING.

FIGURE A-5

GCD WITH STRUCTURAL SLAB AND VAULT PLACED ABOVE GRADE

PREPARED FOR

FERNALD RI/FS
U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS

INTERNATIONAL TECHNOLOGY CORPORATION

LIST OF PROCESS OPTIONS

WATER TREATMENT OPTION 1
OPERABLE UNITS 1 AND 2
(EVAPORATION AND ION EXCHANGING PROCESS OPTIONS)

WATER TREATMENT OPTION 2
OPERABLE UNITS 1 AND 2
(ION EXCHANGE AND DENITRIFICATION)

WATER TREATMENT OPTION 3
OPERABLE UNITS 1 AND 2
(METALS REMOVAL, ION EXCHANGE, AND DENITRIFICATION)

SLUDGE TREATMENT OPTIONS
OPERABLE UNIT 1
(SLUDGE REMOVAL, DRYING, AND/OR VITRIFICATION)

SLUDGE TREATMENT OPTIONS
OPERABLE UNIT 1
(SOLID/LIQUID SEPARATION, STABILIZATION, AND/OR DRYING)

SLUDGE TREATMENT OPTIONS FOR ORGANIC CONTAMINATION
OPERABLE UNIT 1
(SOLID/LIQUID SEPARATION, THERMAL DESORPTION, AND STABILIZATION)

SLUDGE TREATMENT OPTIONS FOR K-65 MATERIALS
OPERABLE UNIT 4
(IN SITU VITRIFICATION)

SLUDGE TREATMENT OPTIONS FOR K-65 MATERIALS
OPERABLE UNIT 4
(SLUDGE REMOVAL, DRY, AND/OR VITRIFICATION)

SLUDGE TREATMENT OPTIONS FOR K-65 MATERIALS
OPOERABLE UNIT 4
(FILTRATION/STABILIZATION/DRYING)

SLUDGE TREATMENT OPTION FOR K-65 MATERIALS
OPERABLE UNIT 4
(CONTAMINANT SEPARATION)

SILO ISOLATION OPTIONS FOR K-65 AND METAL OXIDE WASTES
(SILO ISOLATION/SILO 3 REHABILITATION)

WATER TREATMENT OPTION 1
OPERABLE UNITS 1 AND 2
(EVAPORATION AND ION EXCHANGING PROCESS OPTIONS)

Reverse osmosis (RO) can remove metals and other ions from contaminated water. The water must first be pretreated by filtration to remove particulates that can foul the sensitive RO membranes. The RO unit works by forcing water molecules through a membrane with high pressure. Most contaminant molecules are too large to pass through the membrane and will remain in reject water.

The treated water or permeate may meet standards for discharge or may require polishing by an ion exchange resin. This resin will remove residual ions from the water to meet discharge requirements. Carbon treatment might conceptually be required to remove any trace organics.

Reject water from the RO unit containing the contaminants can be further concentrated in an evaporator. Water condensed from the evaporator may meet discharge requirements or may require polishing using ion exchange. The concentrated brine (from the evaporator) may be then sent directly to sludge treatment for solidification/stabilization or sent through another separation step to provide a filter cake and filtrate. The separation step could include filtration, centrifugation, clarification, and/or precipitation. Filtrate from the separation step would be recycled to the evaporator for further concentration.

Water Treatment Option 1 is shown in Figure B.1.

WATER TREATMENT OPTION 2
OPERABLE UNITS 1 AND 2
(ION EXCHANGE AND DENITRIFICATION)

Waters that contain relatively low levels of metal contaminants can be treated by ion exchange without pretreatment by precipitation of the metals. In this scenario, water is first filtered to remove any solids that could foul the ion exchange resins. Filtration may be accomplished using a belt filter, filter press, cartridge filter, or sand filter. Filtered water is then treated by ion exchange. Various ion exchange resins may be used that have differing selectivity, depending on the mixture of metals and other ions present in the water.

Ion exchange resins are regenerated using an acid solution that removes metals from the resin in a concentrated form. The regenerant is then treated using neutralization and metals precipitation to remove the metal as a hydroxide sludge. Sludge from this treatment is then sent to sludge processing, and clear water is recycled to the filtration step.

If needed, clean water from ion exchange will be treated in a biological denitrification system. The existing system available at the facility can be used or a new unit, such as a sequencing batch reactor, can be installed for this service. Disposal of a biological sludge in a sanitary landfill should be acceptable because low levels of metals and/or radioactive materials would be removed in the ion exchange system prior to biodenitrification.

A schematic drawing of Water Treatment Option 2 is shown in Figure B.2.

WATER TREATMENT OPTION 3
OPERABLE UNITS 1 AND 2
(METALS REMOVAL, ION EXCHANGE, AND DENITRIFICATION)

Water treatment will be required for a wide variety of types, concentrations, and flows of wastewaters. Many of the waters have metals contamination, low-level radioactivity, some organics, and high nitrate. To treat the relatively concentrated streams, bulk removal methods for metals can be utilized followed by polishing with ion exchange and denitrification.

Concentrated waters will be pH adjusted and treated with chemicals to encourage precipitation of insoluble metal compounds. Flocculation then allows particle agglomeration to occur. Solids will then be separated from the water using one or a combination of methods, depending on the size and concentration of the particles. Clarification, filtration, centrifugation, and flotation can all be considered. Sludges from these operations will then be sent to sludge treatment.

Treated water may be polished using ion exchange to remove residual contaminants. Typically, this will be necessary to treat water with low levels of radioactive metals and should allow direct discharge of the water. Various ion exchange resins can be used that have differing selectivity, depending on the mixture of metals and other ions present in the water. Some resins are regenerated using an acid solution that removes the metals from the resin. This solution is neutralized and then recycled back to the precipitation unit. Other resins are used one time and then disposed as a solidified hazardous and/or radioactive waste.

Some waters will require nitrate removal before they can be discharged. The existing unit at the facility may be used for this service or new units can be utilized, such as small sequencing batching reactors. Biological denitrification generates clean water for discharge and a biological sludge that can be disposed of at a sanitary landfill, as long as all radioactive contaminants were properly removed in prior treatment steps.

Figure B.3 presents a flow sheet for Water Treatment Option 3.

SLUDGE TREATMENT OPTIONS
OPERABLE UNIT 1
(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 consolidation, sand or cement addition, and compaction.

In situ vitrification involves adding sand to sludges, placing electrodes into the pit, and then electrically glass 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 water 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. Water 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.

SLUDGE TREATMENT OPTIONS
OPERABLE UNIT 1
(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, while others may require further treatment by vitrification.

The sludge drying process includes dewatering in a filter press or centrifuge. Water from this process will be discharged to one of the water 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 powder form. Sludges containing organics cannot be processed in this manner due to the generation of organically contaminated off-gas.

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 contaminated water stream that will be sent to a water treatment system. Alternatively, the waste could be placed in an engineered mound and vitrified using in situ techniques.

The sludge treatment options described above are shown in Figure B.4, Sludge Treatment Option 1.

SLUDGE TREATMENT OPTIONS
OPERABLE UNIT 1
(SOLID/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 water 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.

Stabilization is accomplished by adding fly ash, cement, asphalt, or other stabilizing materials to the sludge. Stabilized wastes will then be sent to disposal.

The sludge treatment options described above are shown in Figure B.5.

SLUDGE TREATMENT OPTIONS FOR ORGANIC CONTAMINATION
OPERABLE UNIT 1
(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. Depending on the organics present, off-gas from the incinerator may require further treatment using a scrubber system for particulate and chloride removal. Scrubber blowdown water is then sent to a water 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.

SLUDGE TREATMENT OPTIONS FOR K-65 MATERIALS
OPERABLE UNIT 4
(IN SITU VITRIFICATION)

In situ vitrification would be performed by installing graphite electrodes to heat the sludge until a molten glass is formed. Sand added at the top of the silo will provide additional silica that is necessary to convert the sludge to glass. The vitrification process will melt the sludge, concrete silos, and some of the surrounding earth. Thermocouples will be installed in the mounds around the silos to monitor the extent of the material melted and to monitor the temperatures in the mound.

A hood will be installed over the silos to capture off-gas that is generated during the vitrification process. The off-gases are expected to contain volatile metals, principally technetium and arsenic, and some radon gas. A wet scrubber will cool the off-gas and remove metals and other contaminants. Blowdown from the scrubber will be directed to one of the water treatment methods described in other process options. The cleaned off-gas will be further treated using the existing radon removal system.

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.

**SLUDGE TREATMENT OPTIONS FOR K-65 MATERIALS
OPERABLE UNIT 4
(SLUDGE REMOVAL, DRYING, AND/OR VITRIFICATION)**

Raffinate sludges from silos will be removed using one of the techniques for sludge removal. Water added for sludge removal will be removed using sludge drying in a heated dryer. This process will generate an off-gas composed of air and water vapor contaminated with radon gas. A wet scrubber will clean and cool the off-gas. Water blowdown from the scrubber will be treated using one of the techniques described in the water treatment process options. Sludges from water treatment could be processed along with raffinate sludge. Off-gas that passes through the wet scrubber will be treated using the existing dryer and carbon treatment system designed for radon removal.

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 contaminated water stream that will be sent to a water treatment system. Alternately, the wastes could be placed in an engineered mound and vitrified using in situ techniques.

The sludge treatment options described above are shown in Figure B.4.

**SLUDGE TREATMENT OPTIONS FOR K-65 MATERIALS
OPERABLE UNIT 4
(FILTRATION/STABILIZATION/DRYING)**

Raffinate sludge from silos will be removed using one of the techniques for sludge removal. These sludges may contain water that was added during the removal process or during metals reclamation that was performed before treatment. Sludge will be converted into a form suitable for disposal using filtration, stabilization, drying, or a combination of these techniques. The techniques and processing sequence used will depend on the physical and chemical characteristics of the sludge after its removal. Sequences that may be used are listed below:

- Filtration and stabilization
- Filtration and drying
- Filtration, drying, and stabilization
- Drying
- Drying and stabilization
- Stabilization

Sludge disposal will utilize one of the options listed in the section on disposal. The processing techniques used could allow either off-site or on-site disposal.

Filtration and drying operations could generate a wastewater requiring treatment. These operations and stabilization could also generate off-gas contaminated with radon gas. One of the options described for water treatment will be used to treat any wastewaters generated. Off-gas contaminated with radon may be treated in the existing radon removal system.

The sludge treatment options described above are shown in Figure B.5, Sludge Treatment Option 2.

SLUDGE TREATMENT OPTION FOR K-65 MATERIALS
OPERABLE UNIT 4
(CONTAMINANT SEPARATION)

The radionuclides and other hazardous metals could be removed from the raffinate sludges. These contaminants would be concentrated in a smaller volume of waste. This would reduce the radioactivity, radon emissions, and other hazards of the bulk of the sludges. Handling and disposal of the less-hazardous material would be easier and less costly. Producing a low-volume "concentrate" and a bulk waste similar to the pit sludges might result in a more-effective overall remediation for the K-65 wastes.

Contaminant separation would first involve a leaching process to remove the contaminants (radium, lead, etc.) from the raffinate sludges. The optimum chemistry and equipment to use would be determined by lab and pilot-plant testing. The leached raffinate sludges would go to physical/chemical treatment for dewatering, drying, or other operations.

The contaminants extracted from the K-65 wastes will next have to be recovered from the leachate. This could involve precipitation, ion exchange, liquid-liquid extraction, membrane separation, and evaporation. The products from this process would probably be a concentrated metals sludge and a wastewater stream. These would be treated as described in the appropriate process options. The contaminant concentrate would be more difficult to treat, handle, and dispose of than the original waste but its volume would be greatly reduced.

Contamination separation is shown in Figure B.6.

SILO ISOLATION OPTIONS FOR K-65 AND METAL OXIDE WASTES (SILO ISOLATION/SILO 3 REHABILITATION)

The purpose of this nonremoval option is to upgrade the performance of the existing silos so they are equivalent to the on-site disposal techniques. This can be accomplished by containing or entombing the K-65 silos or by rehabilitating the metal oxide silo (Silo 3). Silo 3 rehabilitation is discussed in Appendix A.

In the K-65 silo isolation option, the entire silo and any contaminated soil in the berm surrounding the silo will be incorporated into an engineered mound similar to the tumulus described in Appendix A under on-site disposal options. A slurry wall in the berm or grout injection technologies would be used to provide horizontal containment. The silo would then be capped after interim remedial measures were employed to reduce radon and gamma exposure. This may involve removing the silo dome after sand is placed on top of the silo wastes. A multilayer capping system, including a membrane will probably be employed. If containment on the bottom of the silo is required, grout injection may be used.

INSERT FIGURE B.1 WHICH WILL BE SENT FROM ASI, OAK RIDGE

Fig. B.1

Water Treatment Option 1

(Evaporation and Ion Exchange)

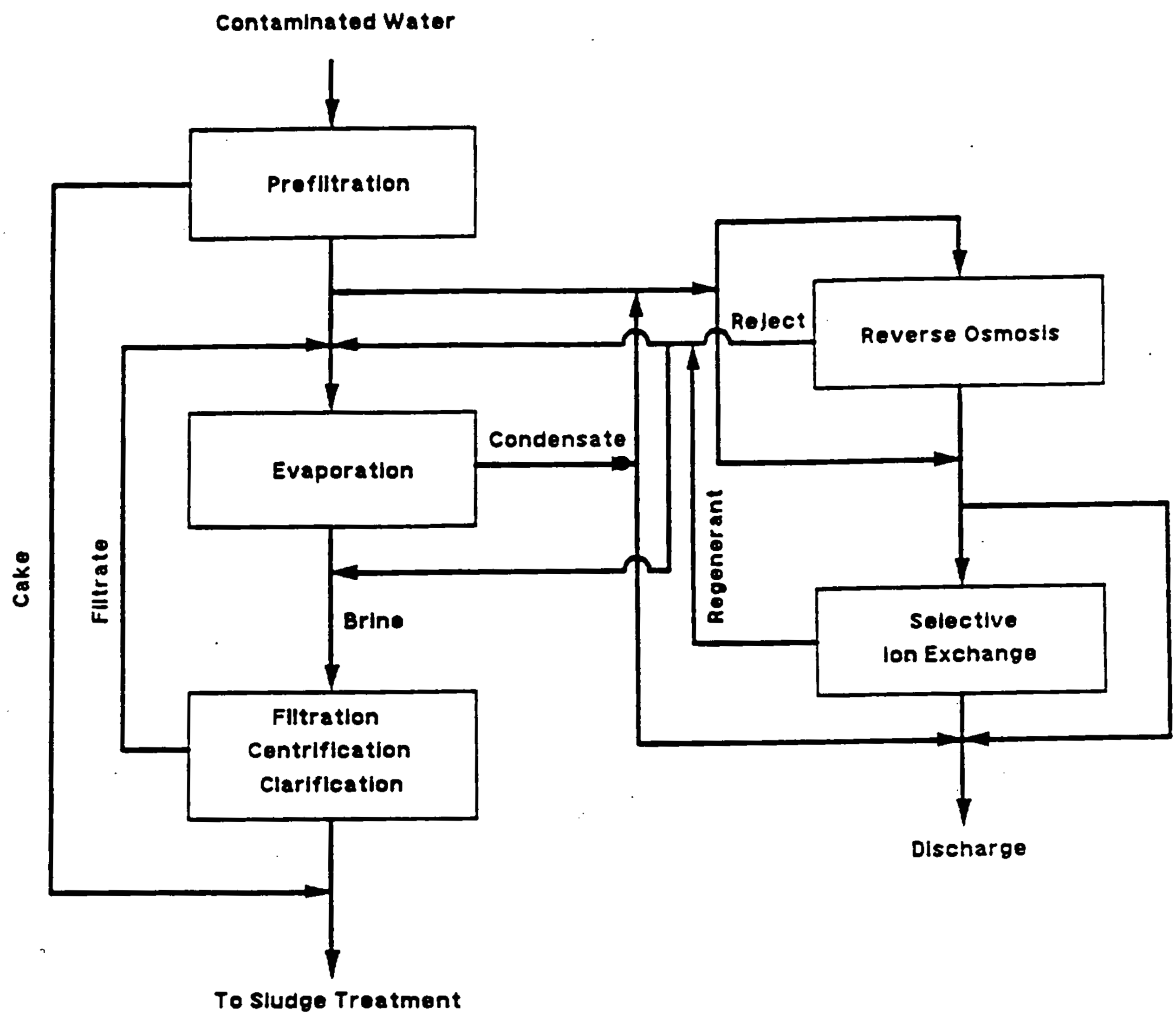


Fig. B.2

Water Treatment Option 2

(Ion Exchange and Denitrification)

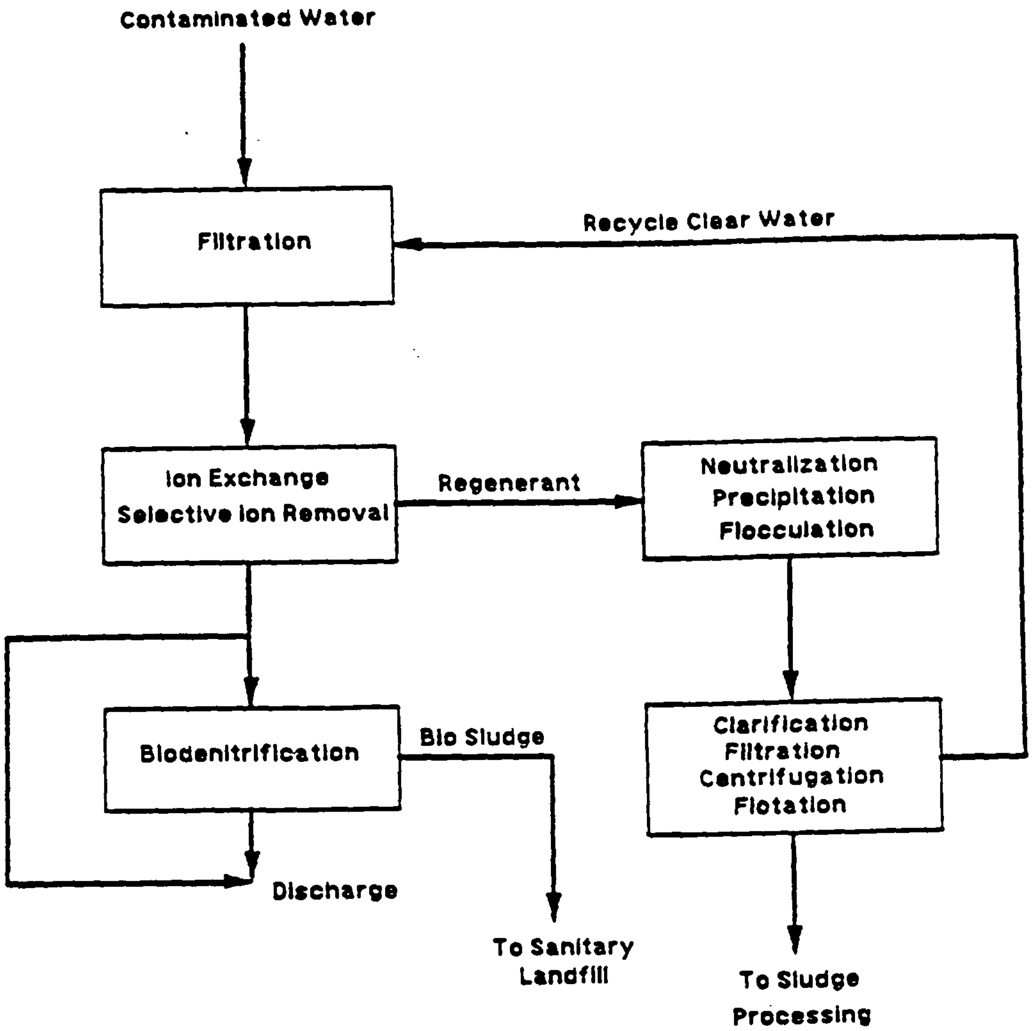


Fig. B.3

Water Treatment Option 3

(Metals Removal, Ion-exchange and Denitrification)

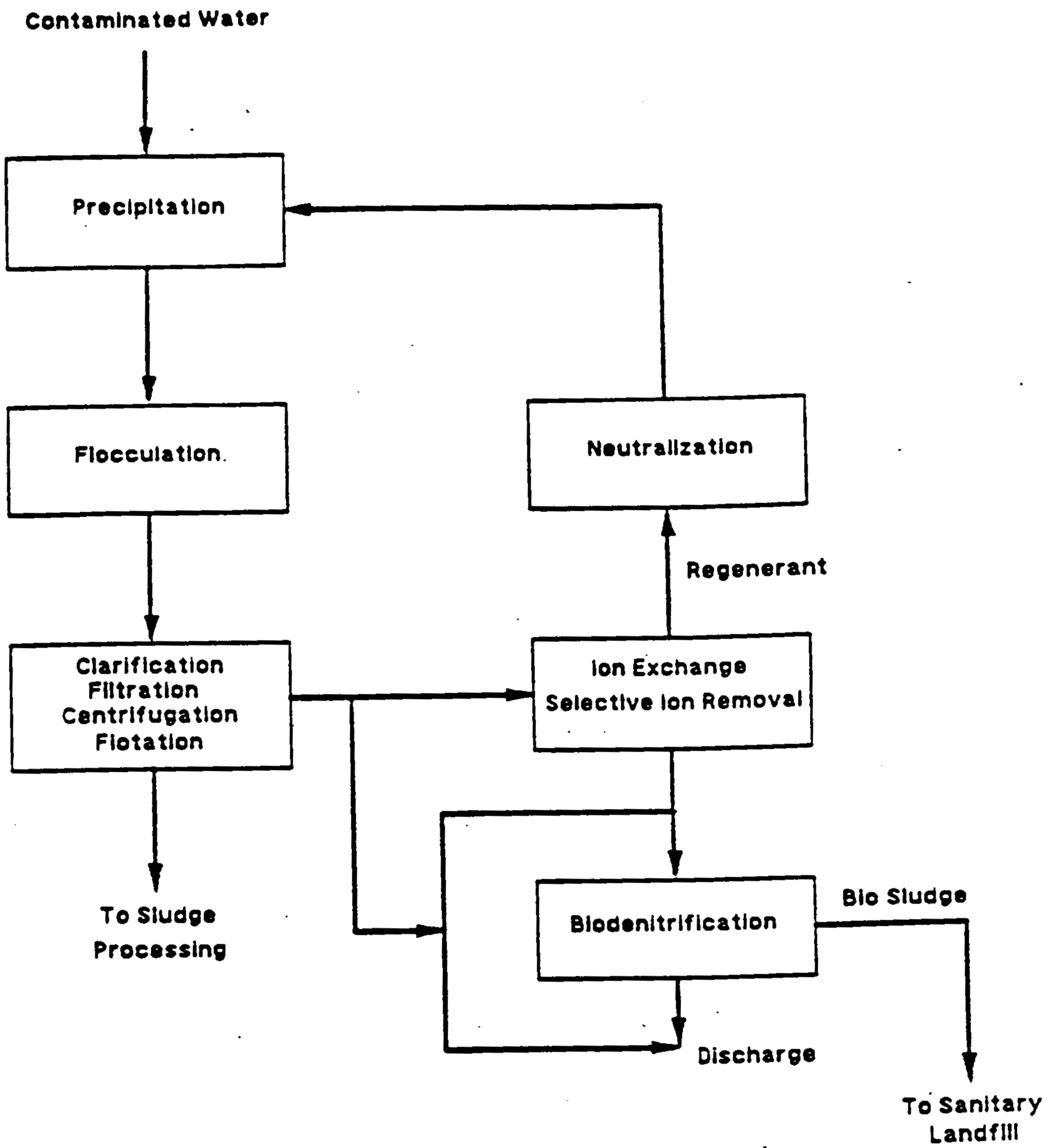


Fig. B.4
Sludge Treatment Option 1
Operable Unit 1 and 4
(Sludge Removal, Drying and/or Vitrification)

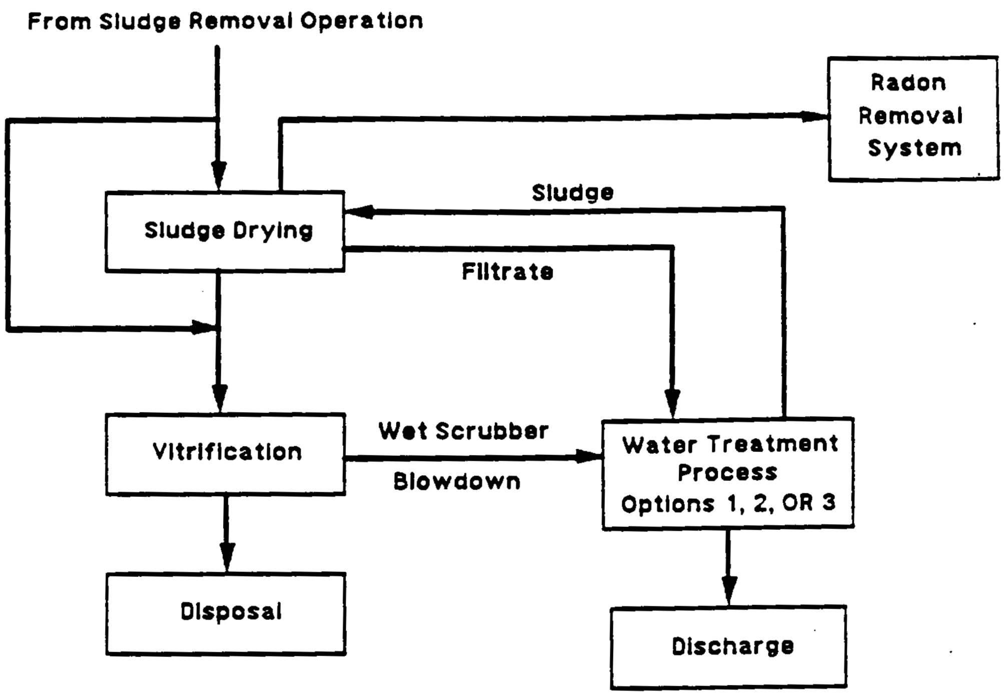


Fig. B.5
Sludge Treatment Option 2
Operable Unit 1 and 4
(Filtration, Drying and/or Stabilization)

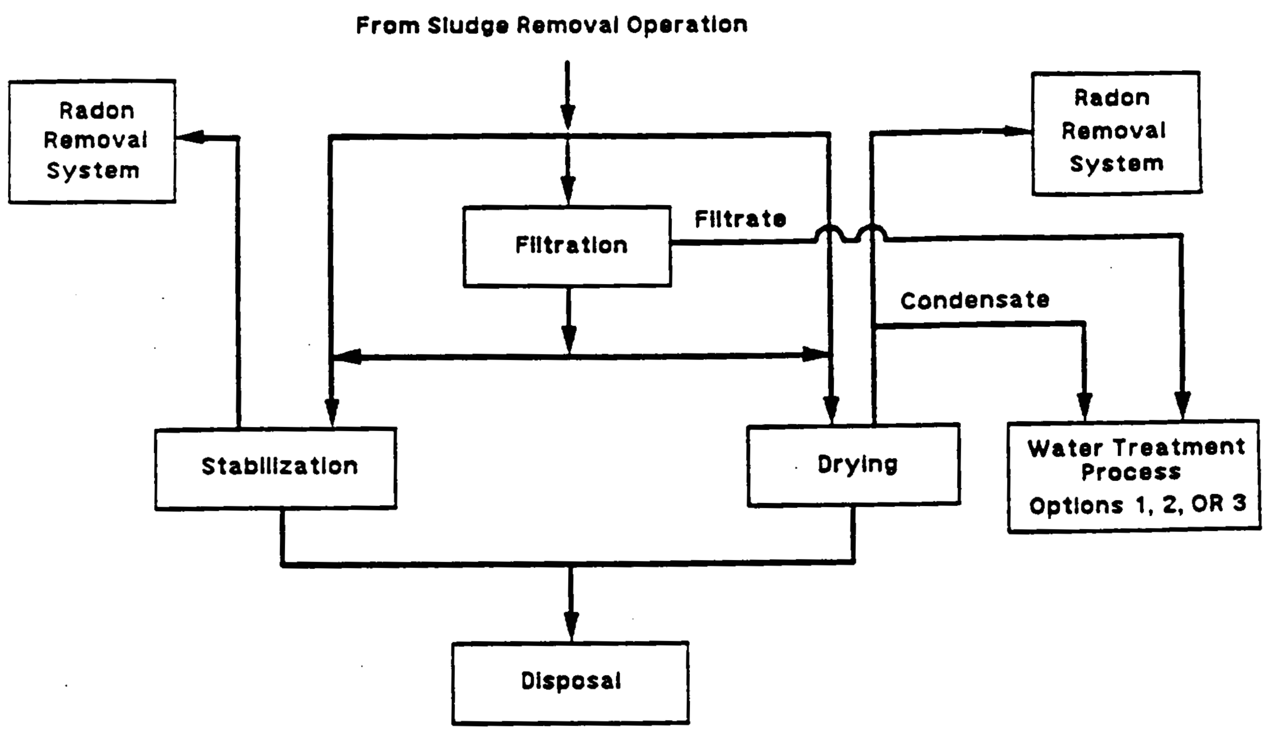


Fig. B.6
Contaminant Separation
Operable Unit 4