NOTICE

All drawings located at the end of the document.

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Draft Corrective Action Management Unit (CAMU) Interim Measure/Interim Remedial Action (IM/IRA) Decision Document and Application Support Document

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Rocky Flats Environmental Technology Site

November 1996

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Corrective Action Management Unit Interim Measure/Interim Remedial Action Decision Document and Application Support Document
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Rocky Mountain Remediation Services, L.L.C.

November 6, 1996

TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS v

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1

1.1 DECISION DOCUMENT ORGANIZATION 1-3

1.2 CAMU DECISION DOCUMENT SCOPE AND OBJECTIVES 1-4

1.2.1 Scope Description 1-4
1.2.2 Decision Document Objectives 1-5
1.2.3 Drivers 1-6

1.3 SITE DESCRIPTION 1-6

2.0 VERIFICATION OF CAMU DESIGNATION REQUIREMENTS 2-1

3.0 WASTE CHARACTERISTICS 3-1

3.1 REMEDIATION WASTE CHARACTERIZATION 3-1

3.2 REMEDIATION WASTE VOLUME 3-2

4.0 IDENTIFICATION OF SUBSTANTIVE CRITERIA 4-1

4.1 CAMU OBJECTIVES 4-1

4.2 RFCA REQUIREMENTS 4-1

4.3 CAMU REQUIREMENTS 4-3

5.0 SCREENING OF ALTERNATIVES 5-1

5.1 PHASE 1 - ONSITE REMEDIATION WASTE FACILITY SITING STUDY 5-1

5.2 PHASE 2 - SCREENING OF ONSITE DESIGN OPTIONS 5-5

6.0 COMPARISON OF ALTERNATIVES 6-1

7.0 SELECTED REMEDY 7-1

7.1 REMEDY DESCRIPTION 7-1

7.2 DECISION BASIS 7-2

7.2.1 Objectives 7-2

7.2.2 Summary of Selection Basis 7-9

7.3 RISK EVALUATION 7-10

7.3.1 Offsite transport of contaminants through the groundwater to neighboring surface waters 7-11

7.3.1.1 Remedial Waste Storage Facility Particle Tracking Model 7-12

7.3.1.2 Leachate Composition Analysis 7-12

7.3.1.3 Discharge Composition Analysis 7-13

7.3.2 Worker Exposure to Radionuclides During Operations 7-13

7.3.3 Fugitive Dust Emissions 7-14

7.4 TECHNICAL AND ADMINISTRATIVE CONTROLS 7-14

7.5 NEPA VALUES 7-16

7.6 CONCEPTUAL WASTE ACCEPTANCE CRITERIA 7-16

7.6.1 Physical and Chemical Compatibility Criteria 7-17

7.6.2 Health and Safety - Radioactive Dose Criteria 7-18

7.7 REMEDIATION WASTE STORAGE FACILITY OPERATIONS 7-18

7.8 CONCLUSION 7-19

8.0 SCHEDULE 8-1

9.0 REFERENCES 9-1

APPENDIX A - CORRECTIVE ACTION MANAGEMENT UNIT REQUIREMENTS AND CONSIDERATIONS A-1

APPENDIX B - EVALUATION OF ONSITE VS. OFFSITE REMEDIATION WASTE MANAGEMENT OPTIONS B-1

APPENDIX C - ONSITE REMEDIATION WASTE STORAGE FACILITY SITING STUDY.....C-1

APPENDIX D - SELECTION CRITERIA DESCRIPTIONS.....D-1

APPENDIX E - DESCRIPTIONS OF REMEDIATION WASTE STORAGE FACILITY DESIGN ALTERNATIVES.....E-1

APPENDIX F - BACKUP FOR FACILITY DESIGN SCREEN.....F-1

APPENDIX G - BACKUP INFORMATION FOR RISK EVALUATION.....G-1

APPENDIX H - NEPA VALUES ANALYSIS BACKUP DOCUMENTATION.....H-1

FIGURES

1-1 Location of the Rocky Flats Environmental Technology Site 1-2
1-2 Proposed Consolidated Operable Units 1-9
5-1 Decision Process for Remediation Waste Management 5-2
5-2 Location Map 5-7
7-1 RFETS Location Map 7-3
7-2 Conceptual Figure of Concrete-lined Cell w/ Bulk Waste Placement 7-5
7-3 Onsite Facility Cross Section of Interim Cover and Liner System 7-6
8-1 Proposed Remediation Waste Storage Facility Schedule 8-2

TABLES

3-1 Waste Identification and Volumes for a Remediation Waste Storage Facility 3-3
5-2 Methodology Weighting Factors 5-4
5-3 Summary of Facility Design Screen 5-9
5-4 Comparison of Design Alternative Costs 5-12
6-1 Summary of the Final Alternative Comparison for a Remediation Waste Storage Facility ... 6-2
7-1 Life Cycle Cost for Design Alternatives 7-8

ABBREVIATIONS AND ACRONYMS

AEC	United States Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
Am	Americium
APEN	Air Pollution Emission Notice
BMP	Best Management Practices
CAB	Citizens Advisory Board
CAMU	Corrective Action Management Unit
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHWA	Colorado Hazardous Waste Act
cm/sec	centimeters per second
cy	cubic yards
Decision Document	Interim Measure/Interim Remedial Action Decision Document
D&D	Deactivation and Decommissioning
DOE	United States Department of Energy
DOT	United States Department of Transportation
ER	Environmental Restoration
ERDA	Energy Research and Development Administration
ft	feet or foot
FY	Fiscal Year
PPE	Personal Protective Equipment
HW	Hazardous Waste
IA	Industrial Area
IA-East	Industrial Area-East
IA-West	Industrial Area-West
IDM	Investigation-Derived Material
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
in.	inch or inches
ITS	Interceptor Trench System
LDR	Land Disposal Restrictions
LLW	Low-Level Waste
LLMW	Low-Level Mixed Waste
nCi/g	nanocuries per gram
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NSL	New Sanitary Landfill
NTS	Nevada Test Site

OU	Operable Unit
QA/QC	Quality Assurance/Quality Control
QAT	Quality Action Team
PA	Protected Area
PAC	Potential Areas Of Concern
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethene
pCi	Picocuries
PPRG	Programmatic Preliminary Remediation Goals
Pu	Plutonium
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RWSF	Remediation Waste Storage Facility
SE Quad	Southeast Quadrant
Site	Rocky Flats Environmental Technology Site
Site Vision	Rocky Flats Conceptual Vision
SW Quad	Southwest Quadrant
TCE	Trichloroethene
TRU	Transuranic
TSCA	Toxic Substance Control Act
U.S.	United States
VOC	Volatile Organic Compounds
WAC	Waste Acceptance Criteria
WIPP	Waste Isolation Pilot Plant

EXECUTIVE SUMMARY

The Department of Energy is requesting that the State of Colorado designate a Corrective Action Management Unit (CAMU) for bulk storage of remediation wastes at the Rocky Flats Environmental Technology Site (RFETS). This facility would be known as the Remediation Waste Storage Facility (RWSF). This CAMU designation is being requested as an option to facilitate risk reduction activities in support of site closure at RFETS. This designation would serve as a contingency in the event assumptions in the Ten Year Plan (DOE 1996a) regarding offsite disposal capabilities prove to be invalid and onsite storage capabilities become necessary to facilitate risk reduction. This CAMU designation would be used in conjunction with a CAMU designation for a containerized storage facility. The CAMU designation would ensure that waste management logistics associated with onsite storage and offsite disposal capabilities would not impact schedules for risk reduction at RFETS.

The lack of complete site characterization data for RFETS environmental media (especially in the Industrial Area) and Deactivation and Decommissioning (D&D) waste results in a wide range of waste volume estimates. Current volume estimates for remediation wastes are approximately 94,000 cubic meters but have ranged up to over 300,000 cubic meters. This high degree of uncertainty in waste volume estimates and future offsite disposal resources underscores a need for a flexible waste management strategy in order to achieve cost-effective and timely site closure. Utilizing a combination of bulk and containerized storage as contingencies in the event that actual waste volumes exceed estimates in the Ten Year Plan, or offsite disposal capabilities limit waste shipment, would allow risk reduction activities to proceed and site closure to continue.

The CAMU designation request is presented in the form of this Interim Measures/Interim Remedial Action (IM/IRA) Decision Document and Application Support Document. The CAMU-designated RWSF would support a cost-effective, flexible, and achievable remediation waste management contingency for onsite storage at RFETS. The overall objective of this document is to support a State CAMU designation by providing the rationale and a proposed alternative that support the goals of the Rocky Flats Cleanup Agreement (RFCA) (DOE 1996b) and the Ten Year Plan. The CAMU would support the RFCA goal (Preamble, B2 [a]) of initially controlling sources of contamination as a priority over off-site shipment.

Only remediation wastes would be managed in this facility. Remediation waste types would include contaminated soil collected from cleanup actions; treated and untreated sludge and sediments; Toxic Substance Control Act waste, such as asbestos and PCBs; treatment by-products from groundwater, surface water, and/or soil remedial actions; investigation derived materials (i.e. drill cuttings) from past and future characterization activities; and decontamination waste which has been characterized as hazardous, low-level radioactive, or low-level mixed waste. It is the intent of DOE to request a CAMU for storage only. The request that CDPHE make a finding of fact as to whether the proposed facility also meets the requirements for a disposal facility, as describe in paragraph 80 of RFCA, is deferred. A determination was not made on the period of operation of the RWSF. Closure of the facility would be in accordance with cleanup levels established in RFCA.

This CAMU decision document details how the CAMU-designated RWSF supports risk reduction and eventual site closure in the following ways:

- The CAMU shall facilitate the implementation of reliable, effective, protective, and cost effective remedies. This would be implemented in accordance with the requirements of RFCA and serve as a contingency to the strategy detailed in the Ten Year Plan.

- This CAMU designation would support a flexible waste management strategy that emphasizes offsite remediation waste disposal, as described in the Ten Year Plan, while recognizing the

uncertainties associated with current remediation waste volume estimates and future disposal capabilities that may impact the ability to perform timely risk reduction.

- The CAMU would focus resources on immediate risk reduction by deferring treatment costs not necessary to protect human health or the environment, and would focus resources on actual cleanup and source removal.

- The CAMU would allow DOE to achieve economies of scale, making treatment and eventual disposal less costly and more practical by consolidating remediation waste and addressing long term liability and safety issues.

This decision document identifies applicable regulatory criteria for CAMU designation by the CDPHE and provides information on how the RWSF would meet these criteria. In addition, this document identifies the other appropriate criteria supporting the selection of the CAMU location and the conceptual design. National Environmental Policy Act (NEPA) values were also addressed within this selection process. Preliminary waste acceptance criteria, closure requirements, and a timeline are also included in this document.

Based upon the screening and comparison of alternatives, a concrete-lined cell design (which would be constructed over a double-lined leachate detection and collection system) was proposed for a bulk storage CAMU. This facility would be located in the eastern portion of the Protective Area near the solar evaporation ponds (formerly Operable Unit 4). This CAMU would incorporate design features compliant with the Resource Conservation and Recovery Act (RCRA) Subtitle "C" requirements, as stated in the Code of Colorado Regulations (CCR) 6 CCR 1007-3, Part 264 Subpart N and required in Paragraph 80 of RFCA. An operational cover would limit exposure of waste to the environment. Each cell would consist of at least three separate internal modules, the final configuration being dependent upon waste management needs at the time of operation. The modules would each store up to 33,000 cubic yards of bulk remediation waste for a total of 100,000 cubic yards per cell. The facility would be expandable to up to four cells, as necessary, for a total facility capacity of 400,000 cubic yards.

1.0 INTRODUCTION

The document serves as the application for designation of the proposed Remediation Waste Storage Facility (RWSF) as a Resource Conservation and Recovery Act (RCRA) Corrective Action management Unit (CAMU). This Decision Document provides the United States Department of Energy's (DOE) technical justification and decision-making process for the option of siting and construction of a RWSF for storage of remediation waste, including Deactivation and Decommissioning (D&D) wastes, at the Rocky Flats Environmental Technology Site (RFETS) (see Figure 1-1). The CAMU designation is available as a regulatory alternative to facilitate the implementation of reliable, effective, protective and cost-effective remedies.

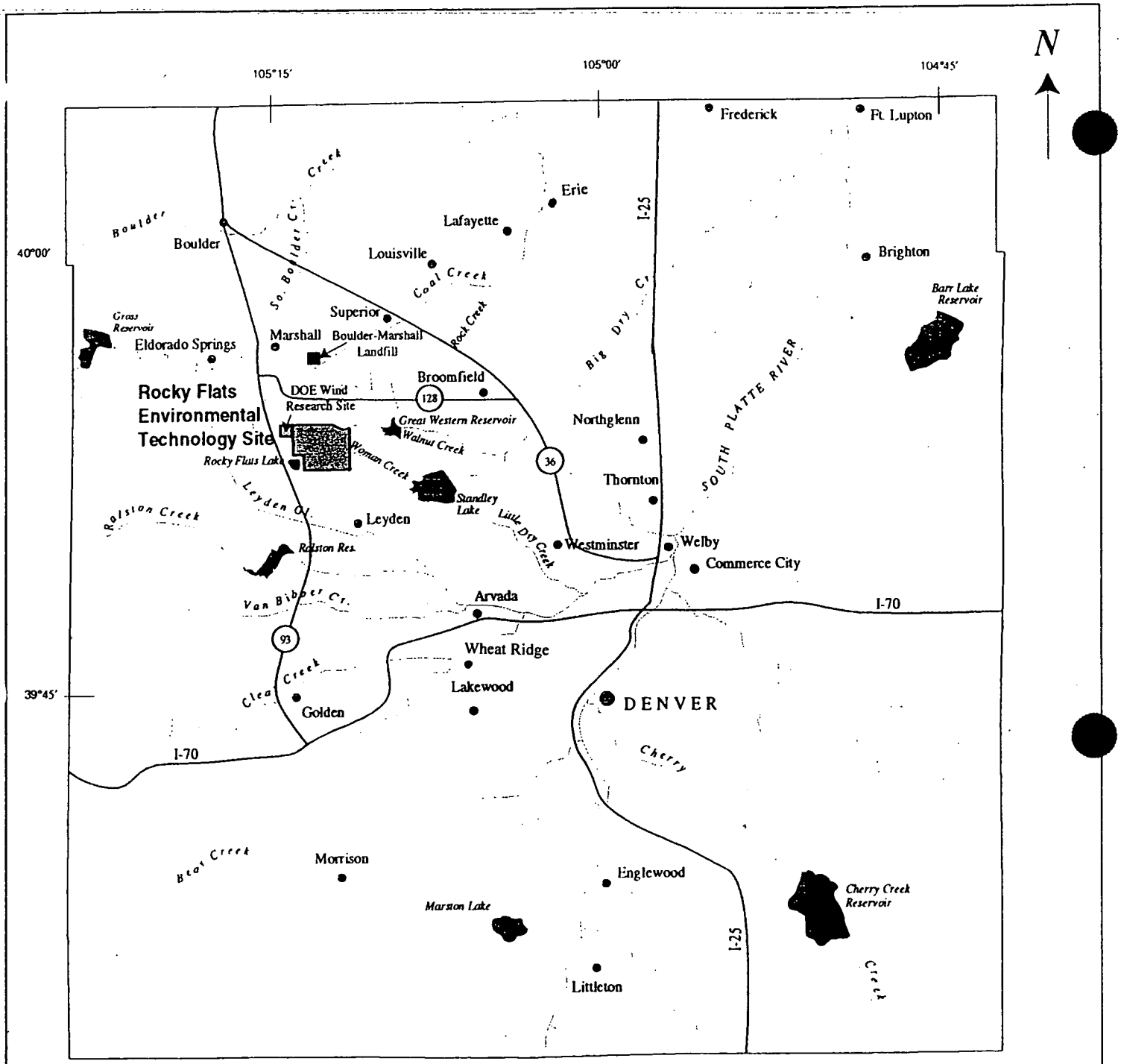
The strategy for site closure is detailed in the DOE 10 Year Plan (Ten Year Plan) for RFETS (DOE 1996a). This plan assumes that closure is linked to a policy of aggressive offsite shipment of waste. Assumptions in the plan that support schedules for both environmental restoration (ER) and building D&D include the availability of offsite facilities to accept the waste in a timely manner, onsite storage capabilities to facilitate shipment, and waste volume estimates. Uncertainties are associated with the current waste volume estimates due to a lack of thorough ER site and building characterization data. In addition, there are uncertainties associated with the availability of offsite disposal resources that may impact waste shipments. Changes from the assumptions described above could significantly impact the DOE's ability to perform timely risk reduction and eventual closure of RFETS. The CAMU designation for both bulk and containerized waste storage is necessary as a contingency to achieve the targeted ten-year cleanup goals These CAMU designations are requested to ensure that the ability to perform risk reduction activities would not be impacted in the event assumptions that drive the schedules in the Ten Year Plan are not valid.

The type of wastes to be managed at RFETS would be remediation wastes consisting of low-level, low-level mixed, and hazardous ER wastes and D&D waste, which is amenable to bulk handling and storage. Low-level waste refers to waste forms that are not high-level waste, spent nuclear fuels, by-product material, or transuranic wastes and which generally have less than 100 nCi/g of transuranic radioactivity.

Within this Decision Document is the information necessary for the Colorado Department of Public Health and Environment (CDPHE) to designate a CAMU with the RWSF being the facility used for storage. This CAMU designation by the CDPHE is required so that the CAMU/RWSF can be included as a regulated unit at RFETS. By having a CAMU designation, the DOE can meet the waste management objectives consistent with the recently signed Rocky Flats Cleanup Agreement (RFCA), July 19, 1996 (DOE 1996b). The importance of the CAMU option was also recognized by the State of Colorado Hazardous Waste Commission when it stated in the introduction of the CAMU Statement of Basis that a CAMU "can facilitate corrective actions" (i.e., environmental cleanups at facilities like RFETS). The approval process for a CAMU is envisioned as a three-step process as follows:

1. IM/IRA concept validation of the CAMU designation. Consisting of this IM/IRA Decision Document

2. Design/Preparation for Construction. Consisting of Title II design, Groundwater Monitoring Plan, Construction Quality Assurance Plan, Test Fill Plan, and Closure Plan



Rocky Flats Site, Golden, Colorado

Location of the Rocky Flats Site

Figure 1-1

G95\ES\RFP & Vicinity 3/27 update-2B10.8

3. Construction/Preparation for Operations. Including Inspection, Operation, Waste Acceptance, Emergency and Security Plans

All phases would have State and and public imput and Final State approval.

The CAMU area being sought through this Decision Document would be located within the eastern portion of the Protected Area (PA) of RFETS (see Section 7.1). Within this CAMU area, an above-grade concrete-lined storage cell serving as the RWSF would be constructed to store remediation waste primarily in bulk form. The CAMU would consist of up to four concrete-lined cells, each designed to hold up to 100,000 cubic yards (cu yd) of remediation waste for a total of 400,000 cu yd; the actual capacity, however, could be adjusted because of the conceptual modular design. Each cell would consist of at least three separate internal modules. The final configuration would be dependent on the waste management needs at the time of operation. The modules would each store up to 33,000 cu yd of bulk remediation waste for a total of 100,000 cu yd per cell. Furthermore, this RWSF would incorporate retrieval and monitoring aspects.

It is the intent of the DOE to request a CAMU for storage only, and that all waste would be removed from the RWSF prior to closure. The request that CDPHE make a finding of fact as to whether the proposed facility also meets the requirements for a disposal facility, as described in Paragraph 80 of RFCA, is deferred.

1.1 DECISION DOCUMENT ORGANIZATION

This Decision Document is structured to provide the information required to support the technical justification of the CAMU and to provide sufficient information for the CDPHE to designate the CAMU. This document also provides the decision-making process used by the DOE to arrive at the conclusion that a RWSF is required as a contingency to meet RFCA and Site Vision objectives.

This document is divided into 9 sections with 8 appendices and is structured as the following sequential decision process:

- This document identifies a need for a CAMU designation for waste storage.
- This document identifies the requirements for a bulk storage RWSF CAMU at RFETS.
- This document describes the RWSF alternatives analysis process, the recommended RWSF alternative, and how the proposed alternative meets the requirements previously identified.

The document also discusses facility-specific issues including:

- Waste characteristics and source volume estimates
- Conceptual waste acceptance criteria (WAC)
- General design requirements
- General monitoring requirements

With the final selection of the concrete-lined waste cell, this document addresses each of the seven decision-making criteria contained in the State of Colorado Hazardous Waste Regulations under 6

CCR 1007-3 Part 264.552 (Appendix A). By responding to these seven criteria, the DOE has demonstrated and documented the rationale for CDPHE to approve a CAMU. This is followed by an identification of the requirements that a CAMU would need to meet. This, in turn, is followed by an evaluation and recommendation of the specific type of CAMU needed to meet the requirements identified.

This Introduction presents the objectives of the Decision Document, the role of the CAMU and RWSF at RFETS, and a description and history of RFETS. Section 2 provides a point-by-point discussion of how the proposed CAMU and RWSF meet each of the seven decision criteria under RCRA for the CAMU. It is these criteria which would be used by the CDPHE to make a CAMU determination. Waste characteristics of the material to be stored in the CAMU are presented in Section 3.0.

The development of alternative actions and the selection of the preferred alternative for the management of low-level and low-level mixed, and hazardous remediation waste are presented in Section 4.0 through Section 6.0. Section 4.0 addresses substantive criteria as described in paragraphs 80 and 109 of RFCA and regulatory requirements spelled out in 6 CCR 1007-3, Subpart S, Part 264, to obtain CDPHE approval for a CAMU (Appendix A). Section 5.0 describes how the final alternatives for a CAMU were developed. It includes a description of the screening methodology and the description and results of the two screening phases: the facility siting study and the facility design screen (Appendices B, C, D, and E). Section 6.0 describes the final comparison of alternatives and the rational for the selected remedy. Section 7.0 is a detailed discussion of the selected remedy (i.e., the concrete-lined waste cell located in the eastern portion of the Protected Area). These details include a risk evaluation, waste acceptance criteria, facility operations, National Environmental Policy Act (NEPA) values, and a summary of the value engineering study. The schedule for the design and construction of the RWSF is presented in Section 8.0, and references are included in Section 9.0.

1.2 CAMU DECISION DOCUMENT SCOPE AND OBJECTIVES

The following two sections discuss the scope and objectives for this Decision Document.

1.2.1 Scope Description

All alternatives, including the "No Action" alternative, assume that the assumptions in the Ten Year Plan are no longer valid. The alternatives are evaluated in terms of a contingency supporting risk reduction goals while recognizing that offsite disposal, waste volume, and/or onsite storage assumptions have been impacted and no longer support the Ten Year Plan risk reduction/site closure schedules. In discussing the need for a storage facility, this document develops and evaluates the various alternatives available to manage remediation waste, including offsite disposal and various long-term storage.

Included as part of the decision-making process are two screening phases used to narrow the various alternatives:

- A siting study to select a suitable location for onsite options
- A facility design alternatives analysis to evaluate design alternatives for onsite storage

From the possible locations identified in the siting study, the best location was selected and then used as a basis for the facility design screen. All criteria and alternatives selected were developed based

upon onsite storage. The exception was a no-action alternative that examined the impact of immediate offsite disposal as embodied in the Ten Year Plan.

Pretreatment of remediation waste for specific Individual Hazardous Substance Sites (IHSSs) is not included in the scope of this document except for the purpose of cost estimating. This is because pretreatment is very specific to an IHSS action and specific waste types. The pretreatment discussion for each accelerated cleanup action would be included in Proposed Action Memorandum, Interim Measures/Interim Remedial Action Decision Documents, and Proposed Plans, or Remedial Action Plans for each specific IHSS or group of IHSSs; allowing treatment to be tailored to the specific action.

Waste acceptance criteria for the proposed RWSF would be addressed based on applicable RCRA and CERCLA requirements as well as applicable DOE policies. The types of requirements are described in Section 7.6, Conceptual Waste Acceptance Criteria. Waste acceptance criteria and operational details would be submitted during the design review and approval process. The scope of the Decision Document does not provide complete details of design, construction, startup, or operations; that information would be covered in subsequent documents following CDPHE designation of the CAMU.

The ability to retrieve and monitor the remediation waste was considered an important part of the decision process, especially in terms of community acceptance. Specific details of environmental monitoring are not in the scope of this document; groundwater monitoring, however, is addressed in Section 7.1; a groundwater monitoring plan would be prepared. Air monitoring would be addressed in any required Air Pollutant Emission Notices (APENs) and air permitting. Most air monitoring would be focused on construction and operation activities.

Closure plans would be prepared and submitted during the design review process. The disposal option discussed in RFCA paragraph 80 is deferred at this time.

1.2.2 Decision Document Objectives

In order to meet the primary objective of documenting the technical justification for the CAMU and RWSF, this document provides information on how the use of a CAMU can meet each of the seven decision criteria identified in the CAMU regulations (6 CCR 1007-3, Part 264, Subpart S).

The objectives which lead to the determination that a CAMU option is necessary as a contingency to the Ten Year Plan include the following:

1. In support of RFCA and the Ten Year Plan, the management of low-level. low-level mixed, and hazardous remediation waste must ensure the safety of the public, RFETS workers, and the environment through reliable, effective, protective and cost-effective management of remediation wastes at RFETS.

2. The solution must support a flexible waste management policy combining contingencies for both long-term storage and short-term staging/storage for offsite disposal while recognizing the uncertainties associated with current waste volume estimates and future offsite disposal availability. A flexible policy would ensure that the most timely and cost-effective strategy that supports RFCA and Ten Year Plan objectives could be implemented

3. The management of low-level, low-level mixed, and hazardous remediation waste must result in a cost-effective solution that would support RFETS Ten Year Plan closure schedules.

4. A means of consolidating remediation waste in one location would be needed to support near-term risk-reduction goals while addressing long-term liability and safety issues and be compatible with future land uses at RFETS.

1.2.3 Drivers

Several drivers established the need for a CAMU designation as a contingency to meet the Ten Year Plan as well as to serve as the basis for both the scope and the objectives of the Decision:

- The Site Vision is to have RFETS cleaned to a level that is consistent with planned future land uses within a ten-year time frame (as identified in the Ten Year Plan), a much shorter time frame than was previously considered.
- The Ten Year Plan assumes:
  - that all low-level and low-level mixed wastes would be shipped offsite for disposal
  - that low-level and low-level mixed waste generated in excess of shipping capacity would be managed in new onsite facilities
  - that when ER and D&D activities would begin in earnest, storage facilities would be available to support operations
- The RFCA objective listed in RFCA preamble Section (B) (2) (a) states "Initially controlling the sources of contamination will take priority over off-site waste shipments to maximize risk reduction."
- The need to limit placement of remediation waste in existing permitted units because of a lack of storage capacity.
- The uncertainties associated with the waste volume estimates and offsite disposal availability for D&D and environmental restoration as well as future offsite disposal capabilities for large volumes of waste create a need for a flexible waste management strategy that incorporates a CAMU contingency.

1.3 SITE DESCRIPTION

The Rocky Flats Environmental Technology Site (RFETS) is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (see Figure 1-1). Other surrounding cities include Boulder to the northwest, Broomfield and Superior to the northeast, Westminster to the east, and Arvada to the southeast, all located within 10 miles of RFETS,. The RFETS consists of approximately 6,550 acres of federal land in Sections 1 through 4, and 9 through 15 of T2S, R70W, 6th Principal Meridian. Most of the structures at RFETS are located within a protected central area of approximately 400 acres, and are surrounded by a buffer zone of approximately 6,150 acres.

The RFETS is bounded on the north by State Highway 128, on the east by Jefferson County Highway 17 (also known as Indiana Street), on the south by Highway 72 and agricultural and industrial properties, and on the west by State Highway 93.

The majority of residential development within five miles of RFETS is located immediately northeast, east, and southeast of RFETS. Commercial development is concentrated near residential developments north and southwest of Standley Lake as well as around Jefferson County Airport, approximately three miles northeast of RFETS. Industrial land use within five miles of RFETS is currently only quarrying and mining operations. Open space lands are located northeast of RFETS near the City of Broomfield, in small parcels adjoining major drainages, and in small neighborhood parks in the cities of Westminster and Arvada. The west, north, and east sides of Standley Lake are encompassed by Standley Lake Park open space. Irrigated and non-irrigated croplands, producing primarily wheat and barley, are located north and northeast of RFETS near the cities of Broomfield, Lafayette, Louisville, and Boulder, and in scattered parcels adjacent to the eastern boundary of RFETS. Several horse operations and small hay fields are located south of RFETS. Future land use in the vicinity of RFETS may involve continued urban expansion, increasing the density of residential, commercial, and industrial land use in the areas.

The RFETS is a government-owned, contractor-operated facility, that is part of the nationwide Nuclear Weapons Complex. The Rocky Flats Environmental Technology (RFETS) was operated for the United States Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for RFETS was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the United States Department of Energy (DOE) in 1977.

From 1953 through 1989, RFETS was used to produce components for nuclear weapons from materials such as plutonium, uranium, beryllium, and various alloys of stainless steel. Non-nuclear production continued through 1995 in Building 460. Additional plant missions included plutonium recovery and reprocessing, and waste management. Production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides. The consequence of these various activities over nearly 40 years was the contamination of some of RFETS soils, groundwater, buildings, process pipelines and associated waste management equipment.

While environmental cleanup and waste management were a part of routine day-to-day operations at RFETS, heightened environmental awareness on a national level and new environmental regulations have expanded and accelerated both activities. The DOE, in response to these changing conditions and the radical change in global politics, set a new mission for RFETS focusing on waste management, environmental restoration, and decontamination and decommissioning of facilities. Consistent with this new mission and with a view toward rapid and safe cleanup, RFCA sets a framework and approach for this final phase of the waste management and cleanup program. The United States Environmental Protection Agency (EPA), the CDPHE, and the DOE have agreed within RFCA to a wide range of objectives leading to the final disposition of the entire RFETS complex. Among these objectives are important areas necessary to responsibly address the environmental consequences of the past 40 years of operation and production.

Current waste management activities include the following:

- Onsite storage, followed by offsite recycling or treatment and disposal of hazardous waste
- Onsite storage, followed by limited onsite treatment and offsite disposal of low-level mixed waste
- Onsite storage followed by offsite disposal of low-level waste
- Onsite disposal of non-hazardous "municipal" type waste

Historically, the management of RFETS remediation waste has been cumbersome and has frequently required some form of storage. Investigation-derived materials (IDM), which are primarily drill

cuttings from environmental investigations, have been placed in 30- and 55-gallon drums and managed as hazardous waste. This process has been labor intensive due to characterization requirements and can, at best, provide only a short-term solution for these materials. A majority of the IDM drums have been released from CERCLA/RCRA management through a risk-characterization process. The locations of the individual IHSSs are shown in Figure 1-2.

2.0 VERIFICATION OF CAMU DESIGNATION CRITERIA

The ability to designate the RWSF as a CAMU is dependent on compliance with the criteria found in 6 CCR 1007-3 264.552 (c), Corrective Active Management Units (CAMU). In order to demonstrate a need for a CAMU at RFETS, these seven criteria were made an integral part of the decision-making process. Each of the seven CAMU criteria, listed below as numbers 1 through 7, is followed by a description of how the selected RWSF remedy demonstrates compliance with the criterion.

1) The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies.

The CAMU designation of the RWSF would be the cornerstone in successfully completing environmental restoration and D&D activities within the accelerated schedule for RFETS closure proposed in RFCA. The ability of the RWSF to provide readily accessible storage capabilities for large volumes of remediation waste, with generally low levels of contamination, would facilitate reliable, effective, protective, and cost effective remedies by:

- Accelerating IHSS closures by providing a facility for interim storage and/or treatment of contaminated material while simultaneously developing cost-effective offsite disposal capabilities. Currently, the logistics of offsite disposal limit schedules for closing IHSSs and would also impact D&D activities. Designation of a CAMU would allow resources to be focused on supporting near-term risk reduction. Current costs for offsite shipment, treatment, and disposal limit the amount of resources that can be focused on near-term risk reduction, including source removal and D&D.

- Allowing RFETS to minimize costs for treatment, storage, and disposal so that action levels for RFETS closure could be achieved.

The effectiveness of specific cleanup actions would be enhanced by the availability of the RWSF, allowing for a more aggressive remediation strategy. Source materials, including contaminated soils that might have been left in place for a number of years as a continuing source of contamination, would be removed from the environment and placed in the RWSF.

Waste destined for the RWSF would not have to be transported offsite, so little staging and packaging for transportation would be necessary. Waste would be transported from the IHSS or D&D location and placed in the RWSF in bulk. Issues of whether a shipment could be transported, whether the shipment would be returned, or whether the facility would be in operation when needed would not arise until final closure of the CAMU. The RWSF would accept only remediation waste (including D&D waste). The flow of waste into the facility, therefore, would not be impacted by waste from other generators.

Because of the modular, compartmentalized design of the RWSF, it would be able to accept a wide variety of remediation waste including D&D waste. Thus, changes in waste form could be accommodated so that operations would not be held up due to unanticipated conditions in the field. For example, if during remedial excavation of soils, a drum or block of concrete was uncovered, this material could be put into the RWSF without shutting down remedial or RWSF operations or requiring extensive paperwork. This availability of immediate storage

would facilitate the effectiveness of cleanup actions by allowing the contaminants and source materials to be removed at once and with minimal delay.

The RWSF CAMU alternative would also offer more protection than alternatives such as cap-in-place, several small storage facilities, or no action because it would consolidate the remediation waste into an engineered barrier that would protect human health and the environment. With this alternative, the remediation waste could be physically removed from an IHSS or building and placed into the RWSF. Additional engineered protection could be provided for the same cost as multiple smaller facilities because the RWSF CAMU would be a single large facility as opposed to numerous smaller facilities. Another benefit would be that remediation waste that might have been left capped in place or placed in several smaller storage facilities would be centrally located and completely surrounded by multi-layered, impermeable protection. In addition, the remediation waste would be monitored at a single location. Finally, the leachate generated by all the remediation waste would be isolated and recovered at this single location.

A number of studies were conducted to provide assurance that the recommended alternative would meet the established criteria for the RWSF. These analyses were conducted to support CAMU criteria for protection of public health and the environment as listed in 6-CCR-1007-3 Part 264.552 (c). The details of the risk evaluation are found in Section 7.3. The analysis of risk was divided into the following three main exposure pathways:

- Offsite transport of contaminants through the groundwater to neighboring surface waters
- Worker exposure to radionuclides during operations
- Offsite fugitive dust emissions

Exposure to the public from infiltration through the underlying geologic strata into the lower Laramie sandstone/Fox Hills drinking water aquifer was considered and ruled out due to the thickness (over 500 ft) of claystone underlying RFETS. Exposures from inadvertent intrusion into the RWSF after closure were also ruled out primarily because the RWSF would be actively managed by inspections and monitoring throughout the life of the facility.

Fugitive dust emission would be addressed by both administrative and engineering controls. Modeling calculations showed that the activity levels in soils that would be placed in the RWSF were much lower than activities that would pose a threat to human health at the plant boundary.

Contaminant sources that could impact other site activities and workers as well as generating potential exposures to offsite receptors could be removed from the environment sooner if the RWSF is available. This would facilitate site closure by allowing previously contaminated areas to be cleaned up to interim cleanup levels agreed to in RFCA rather than be closed with contamination above RFCA action levels in place. Once contaminant sources were removed from the environment through D&D, and environmental restoration activities, cost savings could be realized since these areas would no longer require active landlord management. This early closure could result in "mortgage reduction"; i.e., reduced costs of operating RFETS. And the savings achieved from these cleanup activities could be applied to accelerate additional activities supporting RFETS closure.

Treatment requirements which were not necessary to protect human health and the environment could be deferred under the flexibility of the CAMU regulations. This would further allow finite resources to be focused on actual cleanup sooner rather than in the future.

2) Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposure to hazardous waste or hazardous waste constituents.

This criteria is meant to address risks that occur during active waste handling and operation of the CAMU (Federal Register, Vol. 58, No. 29, Feb. 16, 1993). Not only would the RWSF CAMU not create unacceptable risks during operation, but it would eliminate risks that might be associated with alternative remedies. The RWSF CAMU would minimize risks to human health and the environment in the following ways:

- Safety precautions would be taken during construction of the facility. All activities would be performed within the extreme safety and radiological protection standards that exist at RFETS. Individuals with expertise specific to construction safety would ensure that construction activities are carried out in a safe manner. Construction quality assurance efforts would ensure that the RWSF would meet all design criteria and performance standards for protectiveness.

- Remediation waste would be removed from the environment and put into an effective and protective facility. No longer would it be exposed to natural transport phenomena that could spread the contamination.

- Initial transportation of the wastes would be performed in a controlled environment over short distances on non-public roads with minimal or controlled traffic. Operations would be closely monitored and safely controlled. Public exposure would be limited during remediation because the waste would not leave the plant site. Because the distances would be so short and the process would be tightly controlled, the risk of transportation accidents during remediation would also be minimized. Administrative and engineered controls would be used to ensure that high winds do not mobilize the contamination during transport. These measures might include precautions such as covered loads, spraying water or other dust suppressants on the loads, high wind shut downs, and other appropriate precautions.

- Safety during filling of the facility would also be closely monitored and controlled. Precautions being considered include spraying the waste for dust suppression, keeping the waste covered, high wind shut downs, and appropriate personal protective equipment. All filling activities would be conducted under appropriate health and safety plans.

- An interim operational cover would be installed to protect the waste from exposure to the elements during remediation. If any waste remains in place at closure, a final cap would be installed.

Indirect effects and cumulative impacts of the Environmental Restoration program at Site would be reduced by utilizing the centralized RWSF built on a previously disturbed and contaminated area. Impacts to the environment would be minimized because the footprint of contaminated areas would be reduced to one facility compared to multiple IHSSs that now

exist. Irreversible commitment of resources (soil and ecological) has already occurred at the Solar Ponds location due to the installation of the Solar Ponds and related facilities.

3) **The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purposes of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.**

This CAMU criteria requires justification for selecting a CAMU in an uncontaminated location, and it was a major influence upon the selection of the RWSF location east of the Solar Ponds. The location selected is in an area previously affected by waste management activities and thus meets this criteria (Federal Register, Feb. 16, 1993). The proposed RWSF location east of the Solar Ponds overlaps with the following areas of contamination:

- **IHSS 165 - The Triangle Area** This IHSS was part of the former OU 6. Drums containing plutonium-bearing wastes were stored in this area. The drums leaked and contaminated the soil. In 1973, 200 cubic yards of soil were removed from this site.

- **IHSS 176 - Swinerton and Walberg Contractor Storage Yard** This IHSS was part of the former OU 10. Water spray from the Solar Ponds blew into this area. Also, leaking drums containing waste oils and volatile organic compounds were stored here. Volatile organic compounds were detected during the soil gas survey characterization of this site.

- **IHSS 101 - Solar Ponds Area** These were former OU 4 solar evaporation ponds which were used for storage and evaporation of liquid low-level radioactive waste. All of the sludge was removed from the Solar Ponds but the liners are still in place. The proposed CAMU location overlaps the eastern edge of the ponds. Additional facilities could be placed on the ponds themselves if expansion of the RWSF is needed and designated in the future. Placement of the facility at this location would be expected to facilitate remediation operations at the Solar Ponds.

- **Building 964** - This building housed low-level waste storage. It was also exposed to the water spray coming from the solar ponds.

Although this area is contaminated, it was not expected that placement of the RWSF in this area would hamper any cleanup operations. Likewise, the levels of contaminants that would be found at the RWSF construction site were not expected to hamper its construction or operation.

4) **Areas within that CAMU, where remediation wastes remain in place after closure of the CAMU, shall be managed and contained so as to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment.**

This criterion was not applicable. At this time, the intended use of this facility is for monitored, retrievable waste storage.

5) **The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2)** (See criteria 1 and 2 above)

Once constructed, the facility would expedite remedial activities. Waste would be transported directly from excavation or treatment into the RWSF. Planning documents for cleanups would be simplified since the waste management methodology would be established. It would be possible to establish work crews that could clean up IHSSs in an almost assembly-line fashion, moving from IHSS to IHSS with the necessary equipment while trucks transport the remediation waste to the RWSF. Concurrent to these activities, new modules to the RWSF could be constructed so that there would be sufficient capacity available to accept the waste. Crews could be simultaneously performing D&D and environmental restoration, moving from building to building, and transporting these waste materials to the RWSF. Without the RWSF, cleanup and D&D activities may be limited by the rate at which wastes can be shipped off site.

6) The CAMU shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation waste that will remain in place after closure.

Because the proposed RWSF would be for storage of waste only, it would not impact or be impacted by the use of treatment technologies. Treatment to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation wastes that would remain in place after closure is a key element of the Environmental Restoration program and of all cleanup actions at RFETS. At RFETS, most IHSS source removals would involve thermal desorption treatment to remove the hazardous component of mixed low-level waste. Treated waste that meets the action levels in RFCA would be placed back in the IHSS and would remain in place after closure. This waste-minimization-and-reduction-of-toxicity-and-mobility approach would result in only shipping to the CAMU, or for offsite disposal, wastes that are either above RFCA action levels for radiological dose, or from which the hazardous component cannot be removed easily. D&D wastes were not anticipated to need treatment (other than sizing) prior to shipment for offsite disposal.

If it were deemed cost-effective for a specific cleanup or treatment technology, temporary or permanent staging areas near the facility could be set up, and mobile or permanent treatment equipment could be brought in. This would not, however, be performed as part of the CAMU designation request.

7) The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2) (See criteria 1 and 2 above)

This criterion was supported by the fact that multiple source areas at RFETS that might have previously been closed in place would now have the option of closure to the action levels agreed to in RFCA. The CAMU would support a bias towards removal rather than isolating sources in place. This would facilitate release of areas at RFETS for future land use, as described in the Site Vision.

3.0 WASTE CHARACTERISTICS

3.1 REMEDIATION WASTE CHARACTERIZATION

General waste types characteristics and volumes which may be placed into the RWSF are described in this section. Identification of waste characteristics, sources, and projected volumes for the RWSF clarify and substantiate the need for a contingency to existing waste storage. Only remediation waste would be considered for management in this facility. Conceptual waste acceptance criteria for the RWSF are discussed in section 7.0. No process waste would be accepted.

Remediation waste, is defined by RFCA in part 5, paragraph 25 bf:

> 1) solid, hazardous, and mixed wastes; (2) all media and debris that contain hazardous substances, listed hazardous or mixed wastes or that exhibit a hazardous characteristic; and (3) all hazardous substances generated from activities regulated under this Agreement as RCRA corrective actions or CERCLA response actions, including decommissioning. Remediation waste does not include wastes generated from other activities. Nothing in this definition confers RCRA or CHWA authority over source, special nuclear, or byproduct material as those terms are defined in the Atomic Energy Act.

The potential contaminants of concern in remediation waste include:

- Radionuclides (such as plutonium, americium, and uranium)
- Metals (such as cadmium and chromium)
- Volatile organic compounds (such as carbon tetrachloride, trichloroethene [TCE], tetrachloroethene [PCE])
- Semivolatile organic compounds
- Asbestos
- Polychlorinated biphenyls (PCBs) (such as Aroclor-1254)

Low-level waste, as defined by RFCA, has a radionuclide activity less than 100 (nCi/g) nanocuries per gram. In addition, RFCA defines low-level waste as "radioactive waste that is not high-level waste, spent nuclear fuel, by-product material, or transuranic waste (although it may contain small amounts of transuranic elements)." The majority of the low-level waste managed at the RWSF would have a radionuclide activity much less than 10 nCi/g based on the Hazard Categorization Analysis (see Section 9.0, Kaiser-Hill, 1996a). Acceptable waste media and forms (e.g., under 6 CCR 1007-3 Part 264.312-264.317, subpart N) for placement in the RWSF were modeled after Landfill restrictions, which include the following:

- No free liquids
- No compressed gases

- No transuranic (TRU) waste
- No incompatible wastes (such as pyrophoric uranium)
- No ignitable or reactive wastes

Remediation waste types include:

- Contaminated soil collected from remedial actions
- Treated and untreated sludge and sediments (e.g. Solar Ponds sludge)
- Toxic Substance Control Act (TSCA) waste (such as asbestos and PCBs)
- Treatment by-products from groundwater, surface water, and/or soil remediation actions
- Residual from the Solar Evaporation Ponds; e.g. portions of the liners would be considered remediation waste
- IDM from past and future characterization activities, such as wells, and borings, if the IDM is characterized as hazardous, low-level, or mixed remediation waste
- D&D waste which has been characterized as hazardous, low-level, or mixed waste; it includes building rubble, equipment, and utilities removed from the building prior to demolition. D&D waste does not include deactivation.

The low-level mixed waste and hazardous waste placed in the RWSF would consist of the remediation waste currently stored at RFETS and the remediation waste which would be generated in the future.

3.2 REMEDIATION WASTE VOLUME

Waste volume estimates were based on planned risk reduction activities. A preliminary estimate of remediation waste volumes is presented in Table 3-1 below. The total volume of remediation waste was estimated to be 94,100 m^3 or 123,200 cu yd which would be placed in a RWSF. These estimates were based on current information and coincide with the Ten Year Plan waste volumes. These volume estimates were not intended to limit the size of the facility, but serve as a tool to create alternatives for the decision making process.

The actual volume of soil defined by Tier 1 and Tier 2 cleanup levels in RFCA could be larger or smaller because volume estimates were made with preliminary data from limited characterization. Final volumes would be determined in the field based on RFCA action levels.

- ***Table 3-1 Remediation Waste Volumes for the Remediation Waste Storage Facility***

Remediation Waste Types	Total Estimated Volume (m^3)	Total Estimated Volume (yd^3)	Volume Ranges (m^3)
Low Level Waste	40,700	53,300	32,600 m^3 to 81,400 m^3
Low Level Mixed Waste	53,400	69,900	42,800 m^3 to 106,900 m^3
Total	94,100	123,200	75,300 m^3 to 188,300 m^3

Notes:

1. These waste volumes are estimated within a range of -20% to +100%.

4.0 IDENTIFICATION OF SUBSTANTIVE CRITERIA

This section presents the substantive criteria that 6 CCR Subpart 5 and RFCA require for a CAMU to be designated at RFETS. Paragraph 80 of RFCA provides: "[I]f the application meets the appropriate substantive criteria CDPHE will issue a CAMU designation." Likewise, the CAMU rule, promulgated pursuant to the CHWA, states that "[t]he Department shall specify, in the permit or order, requirements for CAMUs..." (See 6 CCR 1007-3, Part 264.552 (e).

4.1 RESOURCE CONSERVATION AND RECOVERY ACT CAMU CRITERIA

The designation of a Corrective Action Management Unit must be performed in accordance with the seven criteria enumerated in 6 CCR 1007-3, Part 264.552(c). The seven CAMU criteria were also discussed in section 2.0 of this document:

1. The CAMU must facilitate the implementation of reliable, effective, protective, and cost-effective remedies.

2. The waste management activities associated with the CAMU must not create unacceptable risks to humans or to the environment resulting from exposures to hazardous waste or hazardous waste constituents.

3. The CAMU may only include uncontaminated areas of the facility if including such areas is more protective.

4. Where remediation wastes will remain in place after closure the CAMU must be managed and contained so as to control, minimize or eliminate future releases to the extent necessary to protect human health and the environment;

5. The CAMU must expedite the timing of remedial actions.

6. The CAMU must enable the use, when appropriate, of treatment technologies to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation waste.

7. The CAMU must be placed on the minimal area necessary to provide a reliable, effective, protective, and cost effective remedy.

4.2 RFCA Requirements

The requirements under RFCA for CAMU designation are presented in paragraphs 80 and 109 of RFCA. Section 7.4 of this document discusses how the selected design addresses the RFCA requirements. Paragraph 80 of RFCA states:

> that the design criteria for the facility described in this paragraph shall be the same whether the facility is for the retrievable, monitored storage of remediation wastes or for the disposal of remediation wastes. Specifically, the facility described in this paragraph must ensure retrieval of wastes and protection of human health and the environment through a

> combination of requirements that include, but are not limited to: detection and monitoring/inspection requirements; operating and design requirements, including cap/liner system that meets the requirements as set forth in 6 CCR 1007-3, Part 264, Subpart N; a groundwater monitoring system; and requirements for responding to releases of wastes or constituents from the units. In addition, where necessary for protection of human health and the environment, waste treatment will be required. If DOE proposes a CAMU, it is the expectation of the parties that if the application meets the appropriate substantive criteria, CDPHE will issue a CAMU designation for storage or disposal in a timely fashion.

In response to RFCA paragraph 80, the following design and operating requirements would be addressed and implemented. These requirements are discussed in Section 7 for the specific selected alternative, the Concrete-Lined Cell:

- leak detection (Section 7.1, 7.4)
- inspections (7.4)
- a cap/liner system that meets RCRA Subpart N requirements (Section 7.1, 7.4)
- a groundwater monitoring system (Section 7.1, 7.4)
- corrective action for releases (Section 7.4)
- a waste acceptance criteria, consistent with design and operation, that provides treatment of wastes where necessary (Section 7.6)

In addition, as part of the IM/IRA process, paragraph 109 of RFCA also directs DOE to present an analysis of alternatives showing that DOE has considered the following:

- protection of human health and the environment
- transportation
- facility design, containment, and monitoring
- institutional controls
- cost
- community acceptance

The consideration and evaluation of the above RFCA criteria are addressed in Section 6.0 and summarized in table 6-1.

4.3 CAMU Requirements

After the CAMU designation is received, the DOE would be required to submit detailed plans as to how the following requirements would be met. In the event that a CAMU is necessary, these plans would be submitted during the design phase.

Six CCR Subpart S, Part 264.552 (a) (2) states:

> For the purposes of the application of the minimum technology requirements of 40 CFR Part 268.5 (h) (2); or of the minimum technology requirements of Subparts K, L, M, or N; or the groundwater protection requirements of Subpart F; or the closure and post-closure requirements of Subpart G of part 264 or 265 of these regulations; consolidation or placement of remediation waste into or within a CAMU does <u>not</u> constitute creation of a regulated unit.

Part 264.552 (a) (3) requires:

> Where the remediation wastes placed into a CAMU are hazardous wastes, the CAMU shall comply with Subparts B, C, D, and E of Part 264 or 265 of these regulations and, when such remediation wastes will remain in place after closure of the CAMU, the CAMU shall comply with the regulations for the siting of hazardous waste disposal sites, 6 CCR 1007-2, Part 2.

Additional requirements for designation are enumerated in 6 CCR Part 264.552(e) of the CAMU rule. The following are the additional requirements after the designation of the CAMU (Compliance with these requirements is discussed in section 7.7):

- specification of the area configuration, Part 264.552 (e) (1))
- specification of the design, operation, and closure requirements (Part 264.532 (e) (2)
- specification of groundwater monitoring requirements specific to (Part 264.552 (e) (3)
- specification of closure and post closure requirements (Part 264.552 (e) (4)

5.0 SCREENING OF ALTERNATIVES

A two-phase decision-making process was developed for screening and selecting remediation waste management storage alternatives that support the best remediation waste management strategy for RFETS. The first phase evaluated different onsite locations and the second phase evaluated conceptual storage design alternatives. The onsite location selected was then coupled with the conceptual storage design alternative for inclusion in the Final Comparison of Alternatives (Figure 5-1, Decision Process for Remediation Waste Management).

5.1 PHASE 1 - ONSITE REMEDIATION WASTE STORAGE FACILITY SITING STUDY

The selection of a location for a RWSF at RFETS is detailed in Appendix C, Onsite Remediation Waste Storage Facility Siting Study. The objective of Phase I was to evaluate and select an onsite location for a RWSF. The method used was as follows:

- Identify and rank criteria to be used for siting of an onsite RWSF location.
- Develop a methodology for a comparative analysis of different sites.
- Evaluate the criteria subjectively and assign a relative weighting factor to each criteria.
- Recommend an onsite location based on the above criteria and methodology.

This process is described below.

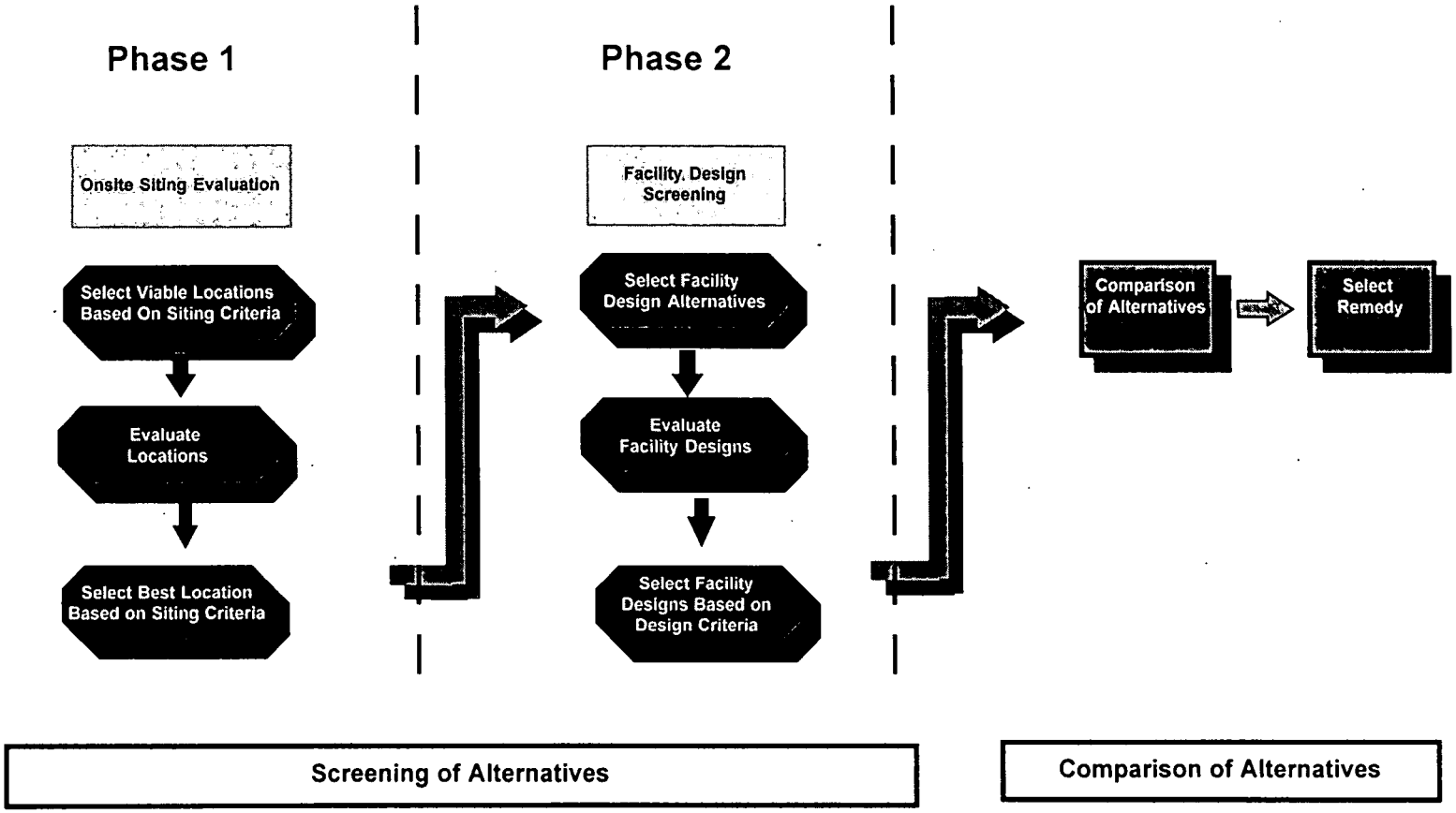
1. Identify and rank criteria to be used for siting an onsite RWSF location. This criteria required, at a minimum meeting the substantive requirements as discussed in Section 4, as well as general guidelines that had been discussed at various stakeholders' meetings regarding a RWSF at RFETS. The criteria were then organized into the six major categories summarized below and further divided into specific issues within each of these major categories. Details of the criteria are in Appendix D.

i. The ability to designate the RWSF as a CAMU: All CAMU criteria were evaluated, but the deciding criteria was the ability to facilitate the implementability reliable, effective, protective, and cost-effective remedies and not include uncontaminated areas of RFETS in the footprint of the RWSF 6 CCR-264,552 (b)(3) (Looby, 1995).

ii. The ability to ensure the protection of the public, per 6 CCR 1007-2 Part 2, Requirements for Siting of a Hazardous Waste Disposal Site: Although the RWSF would be a storage facility, these criteria, which relate to long-term disposal, were used to evaluate locations for storage as an additional degree of protectiveness. There are 12 separate associated criteria under this requirement:

   a) Geological and hydrogeological conditions of a site in which hazardous waste is to be disposed shall be such that reasonable assurance is provided that the wastes are within the disposal area and away from natural environmental pathways that could expose the public isolated for 1,000 years.

Figure 5-1 Decision Process For Remediation Waste Management



b) Structural-related issues including slope and geotechnical stability would be addressed.

c) The immediate area of the site should be in a strata of minimal groundwater flow.

d) Relative depth to bedrock and groundwater will be considered.

e) The evaluation of the relative distance to the nearest discharge area would include consideration of groundwater flow direction and travel time.

Additional requirements are in Appendix C.

iii. The ability to support the RFCA. The Preamble to RFCA Section B.2 stat es: "Waste management activities for low-level, low-level mixed, hazardous, and solid wastes would include a combination of onsite treatment, storage in a retrievable and monitored manner, disposal, and offsite removal. Low-level and low-level mixed wastes generated during cleanup would be stored in a safe, monitored and retrievable manner for near-term shipment offsite, long-term storage with subsequent shipment offsite and/or long-term storage with subsequent disposal onsite of the remaining wastes."

iv. Cost must be evaluated including the cost of pre-construction activities, and the following:

— Building demolition

— Subsurface utility line removal and re-routing

— Access requirements and power/facility requirements

— The cost of engineering and construction of protective measures

v. Regulatory Support must be focused on using CDPHE guidelines (Looby, 1995) for onsite waste management of contaminated materials. Key points evaluated include the minimization of the number of disposal sites, consolidation of contaminated materials, and having a centralized site in an area with optimum geologic parameters preferably close to or within the Industrial Area with limited future land use.

vi. Other Stakeholder concerns that must be include the general acceptance of the RWSF by the general public and the Municipal or County governments.

2. Develop a methodology for comparative analysis of the different sites: A basic assumption was that the entire RFETS, both within the buffer zone and the Industrial Area, would be included in the evaluation. A series of Geographical Information System (GIS) maps were produced to assist in this evaluation. These maps, which included key elements cited in the criteria, were evaluated for being beneficial or adverse to the siting of a RWSF.

The initial evaluation of the sites reduced the number of potentially useable locations to seven, with four in the buffer zone and three in the Industrial Area.

The following are Potential Industrial Area sites:

- Industrial Area-West (IA-West), an area on the west side of the Industrial Area
- Industrial Area-East (IA-East), an area on the east side of the Industrial Area

- Solar Ponds, an area adjacent and east of the Solar Pond in the northeast section of the Industrial Area

The following are potential buffer zone sites:

- The New Sanitary Landfill (NSL)
- An area encompassing the East Spray Fields (ESF)
- An area in the southeast quadrant (SE Quad) of the buffer zone
- An area in the southwest quadrant (SW Quad) of the buffer zone

3. Evaluate the criteria subjectively and assign a relative weighting factor to each of the criteria: For a more detailed description of the methodology see Appendix C, Section C.2.2, Methodology.

First, the methodology that was applied began by developing a relative weighting factor (%) based subjectively on the importance of each of the six categories of criteria as shown under Table 5.1.

Second, the categories were divided into 38 specific issues. Each of the issues was subjectively assigned a value between 0 and 3, with a 3 being a more important issue, 1 being less important, and a 0 being a potential fatal flaw.

Third, a matrix was developed using the 7 locations versus the 38 issues (see Appendix C, Table C-2). A score was assigned relative to the other sites and the criteria being evaluated. A score of 0 for any of the 38 issues signified a fatal flaw and the site was withdrawn from further consideration in the evaluation.

Table 5-1 Methodology Weighting Factors

Category	Criteria	Weighting Factor (%)	Number of Specific Issues	Total Number of Points Assigned
1	Corrective Action Management Unit (CAMU)	15	7	19
2	Public Protection (Geotechnical and Hydrological Criteria)	20	12	28
3	RFETS Special Issues	20	8	15
4	Cost Criteria	15	2	6
5	Regulatory Support	15	5	13
6	Other Stakeholder Concerns.	15	4	9
	* Total	100	38	90

* A weighted average was arrived at for each of the categories and the values were summed.

4. Recommend an onsite location based on the above criteria and methodology: The location receiving the highest score was the recommended onsite location for a RWSF (see Appendix C, Section C.2.3, Table C-5). The location recommended for a RWSF is the area in the northeast corner of the Industrial Area adjacent to and east of the Solar Ponds (see Figure 5-2).

5.2 PHASE 2 - SCREENING OF ONSITE DESIGN OPTIONS

The objective of Phase 2 was to select and evaluate different design options for an onsite RWSF. A list of innovative RWSF designs was developed. This list was compiled from literature and input from the Citizen's Advisory Board (CAB), current RFETS practices, and designs in use at other facilities in the United States and Europe. These design options are either actual facilities in use or under consideration elsewhere (see Appendix E, Remediation Waste Storage Facility Design Alternatives). All of these design alternatives are contingencies to the Ten Year Plan and assume that the storage and schedule assumptions in the Ten Year Plan are not valid. This means that the No Action alternative is a contingency to the Ten Year Plan and not the same as the Ten Year Plan.

The following design alternatives were proposed for the screening process:

- Pyramid- Bulk waste would be enclosed in a rectangular pyramid constructed out of granite blocks; alternative proposed at a meeting of the CAB by a member of the public

- Metal Buildings - Waste would be enclosed in cargo containers placed inside engineered metal buildings on concrete slabs; this is RFETS' current practice to store LLW and LLMW

- Slab on Grade - Waste would be stored in cargo containers placed on an abovegrade concrete slab; This is current practice at some DOE/DOD sites including RFETS, which stores much of its LLW in a similar manner

- Hardened Concrete Vault - Waste would be stored in cargo containers and placed in an abovegrade freestanding concrete structure with liners and a leachate collection system; this is a current practice at the DOE Savannah River Site for LLW & LLMW

- Concrete-Lined Cell with bulk placement - Bulk waste would be placed in modules in concrete-lined cell. Under the cell would be a liner and a leachate collection system

- Concrete-Lined Cell in Cargo Containers - Waste would be stored in cargo containers and placed in modules in concrete-lined cell. Under the cell would be a liner and a leachate collection system

- Abovegrade Storage Cell - Earthen structure similar to a RCRA cell except facility would be constructed Abovegrade with berms and a liner/leachate collection system; alternative as proposed would be similar to current practice around the nation to meet RCRA-Subtitle C, requirements

- Silo - Bulk waste would be placed in concrete cylinders which sit on top of a concrete pad. Under the pad would be a liner/leachate collection system; this alternative was proposed in an interim report by the Idaho National Engineering Laboratory (INEL) (EG&G, 1994)

- Entombment - Waste would be placed in 55 gallon drums and then sealed with grout in concrete boxes which would be stored in a hardened concrete vault. This alternative was proposed in an interim report by the INEL (EG&G, 1994)

- Waste Pile - Bulk waste would be compacted into a rectangular pile with all sides covered with a geomembrane. A liner system would be place under the pile. This alternative was based on the Interim Remedial Action for Basin F, Rocky Mountain Arsenal

- No Action (i.e., no CAMU designated Remediation Waste Storage Facility) - Remediation waste would have to be treated and shipped to an offsite disposal facility as soon as it was recovered, or stored at the action-specific locations until offsite shipment could occur. This alternative was included as required by NEPA

The initial conceptual design screen, summarized in Table 5-2, which used the same criteria as the Siting Study, narrows the 11 design alternatives to four final design alternatives. Table 5-3 is a cost comparison of the 11 design alternatives.

As a summary-by-design alternative, the following results explain the rationale of screening each alternative for the selection of the final four design alternatives.

The Abovegrade Storage Cell alternative would be similar to RCRA Subtitle "C" landfills except that the facility would be built above grade. This facility would also incorporate the concept of long-term waste management, with protection to the public and the environment, by constructing a double liner system with a leachate collection system. The total footprint of this facility would be larger than the other options because of the side berms required for construction of the cell. This feature would make the cost higher than the Concrete-lined Cell bulk storage option. Retrievability would be more difficult than a concrete-lined cell or options utilizing containers. This alternative was retained for further evaluation because it is a known, proven design that meets RFCA requirements, provides the necessary protection, and is one of the less costly alternatives evaluated.

The Concrete-lined Cell with bulk placement alternative would combine features of several alternatives. As a long-term RWSF, it would provide protection to the public and the environment because of the RCRA-type double liner system and a leachate collection system that allows for early detection of leaks. This facility would consist of a concrete-lined cell with integral walls to separate the remedial waste and provide for retrievability. The waste could be managed in both bulk and containerized forms. The cost for this option was the most reasonable compared to all other design alternatives for onsite bulk storage because of its flexibility in waste handling, smaller facility footprint, and protectiveness. The modular design would further enhance flexibility as well as waste segregation and retrieval abilities. This alternative was retained for further evaluation because it meets the substantive criteria, provides the necessary protection and retrievability, and is cost effective.

The Concrete-lined Cell in cargo containers alternative would be similar to the Concrete-lined Cell with bulk placement except that all remedial waste would be stored in cargo containers rather than as bulk. It would provide a slightly higher degree of protection for the public and the environment because the containers act as an additional barrier, and the containers enhance retrievability. The cost, however, would be significantly higher than bulk placement. This alternative was screened out because the containers, and the higher degree of protection and retrieval they provide, did not justify the additional cost.

Table 5-2 Summary of Facility Design Screen

Facility Design	CAMU Criteria	Public Protection (Geotechnical and Hydrological Criteria)
Pyramid	Not effective because of schedule concerns for expediting cleanup and higher costs. Hard to monitor. Reliability is not proven. Retrieval difficult.	Structure could experience differential settlement and breach the barrier. Rigid structure not as elastic as other alternatives.
Silo	Minimizes land area by consolidation of waste to one location. Retrieval difficult.	Alternative provides barriers and leachate collection to protect groundwater and surface water.
Metal Buildings Selected for further evaluation.	Intended as a short-term storage option with periodic maintenance. Costs are high due to bulk containers. Large area footprint because of number of buildings required. Retrieval would be easy.	Short-term storage. For up to 30 years it would provide adequate protection to environment. Protective barrier is the building shell and containers.
Slab on Grade	This alternative is a short-term storage option. Waste would be more exposed. Land area would be minimized. Retrieval would be difficult.	Exposes containers to the weather elements, has a greater risk of releases to surface water or groundwater. No barriers.
Hardened Concrete Vault	Not cost-effective because of storage containers and rigid structure. Good retrievability with a larger footprint because of accessible aisles.	Provides multiple barriers to limit release of contaminants with a leachate collection system. Enclosed concrete structure and containers provide additional protection.
Concrete-lined Cell with Bulk Placement Selected for further evaluation.	A good mix of cost-effectiveness and protectiveness. Supports expediting cleanup activities because of modular design with integral separation walls for good retrievability.	Provides numerous barriers to limit release of contaminants with a leachate collection system.
Concrete-lined Cell In Cargo Containers	Good retrievability but higher costs than Concrete-lined Cell because of waste containers.	Provides numerous barriers to limit release of contaminants with a leachate collection system. Containers provide additional protection.
Abovegrade Storage Cell Selected for further evaluation.	Provides good support for remedial activities, minimizes risk of future releases. Retrievability is moderate to difficult due to bulk placement.	Liners and leachate collection system provides reliability, and protection to groundwater.
Waste Pile	Retrieval is difficult, similar to Abovegrade Storage Cell.	Short term Storage. No protective barriers or leachate collection.
Entombment	Good protection to environment and public. Larger footprint because of smaller containers for storage of wastes. Retrieval is good.	Provides additional barriers other than the multiple liners and leachate detection (i.e., concrete canisters and drums).
No Action Selected for further evaluation.	Individual remedial actions would require handling the waste separately by temporary storing with ultimate offsite disposal of deferring cleanup. No retrieval necessary.	Individual remedial actions would require handling the waste separately by temporary storing for ultimate offsite disposal or deferring cleanup.

Table 5-2 (continued)

Facility Design	Site Special Issues	Cost Criteria
Pyramid	Does not provide an expeditious construction schedule because of logistics in acquiring the granite blocks. Does not support Site Vision.	This alternative fell in the middle of the range for total life-cycle costs.
Silo	Supports Site Vision and RFCA, relatively small footprint.	Cost-effective, third lowest total life-cycle cost due to small footprint .
Metal Buildings	Large footprint because of multiple facilities. Simple design allows quick construction.	Total cost is high due to cost of containers and multiple buildings.
Slab on Grade	Simple design allows quick construction. A short-term storage solution.	Total cost is high due to cost of containers.
Hardened Concrete Vault	Meets this criteria better than most designs, smaller footprint reduces impacts.	This option fell in the upper end of the cost range because of containers and free- standing rigid structure.
Concrete-lined Cell with Bulk Placement	Supports Site Vision and RFCA, small footprint, less impact to other RFETS programs. Flexible, modular type facility.	Low construction, site preparation, and closure costs yielded the second lowest total life-cycle cost of any of the alternatives.
Concrete-lined Cell In Cargo Containers	Supports Site Vision and RFCA, less impact to other projects.	This option fell in the middle of the cost range because of the cost of containers.
Abovegrade Storage Cell	Large footprint could cause additional impacts, supports Site Vision and RFCA.	Low total life-cycle cost in spite of high construction costs.
Waste Pile	Short term solution, consolidates wastes to one location, small footprint. Does not support RFCA or necessary requirements	Low life cycle costs due to a lack of protective features.
Entombment	The largest footprint of all alternatives. Construction would be very time-consuming and costly.	The most expensive alternative, highest life-cycle costs because of the double containment (drums and concrete bins).
No Action	Requires offsite disposal which could delay cleanup, shipments, and increase interim storage.	Include only shipping and offsite disposal cost.

Note: Costs for offsite shipment and disposal are included only in the **No Action Alternative.**

Table 5-2 (continued)

Facility Design	Regulatory Support	Other Stakeholder Concerns
Pyramid	Design is not state of the art. No barrier systems or leachate detection other than the solid granite walls.	Questionable design/technology. Availability of materials in a timely fashion is uncertain.
Silo	Limited flexibility for future uses. Consolidation of waste in one footprint.	Design is not widely used. Protects environment and public. Retrieval would be more difficult.
Metal Buildings	Large footprint poor consolidation of wastes since multiple buildings are required.	Proven technology and easy to implement quickly.
Slab on Grade	Small footprint for consolidation of wastes. Not a state of the art facility.	Provides only minimal barriers for protection of environment. Proven technology and easy to implement quickly.
Hardened Concrete Vault	Long-term waste management. Protects environment and public.	Proven technology but it would take more time and effort to construct.
Abovegrade Concrete-lined Cell with Bulk Placement	Long-term waste management that consolidates waste into modular/flexible facility.	Provides good protection to the environment and public health.
Concrete-lined Cell In Cargo Containers	Long-term waste management that provides good protection to public and environment. Retrievability is a little better than some alternatives because of accessibility to containers.	Provides good protection to the environment and public.
Abovegrade Storage Cell	Provides good protection to the public and environment. Consolidates wastes into one location.	Proven technology because of past performance. Retrievability is achievable but fair because waste is in bulk quantities.
Waste Pile	Short-term solution. Provides good protection to public and environment. Not designed to meet RCRA considerations.	Short-term solution.
Entombment	Provides enhanced protection to the public and environment by the additional containers. Footprint is enlarged because of unusable/wasted space.	Waste retrieval is good because waste is segregated in concrete bins and drums. Longer construction schedule because of the complexity and number of drums to handle.
No Action	Increased interim storage until the individual remedial actions can ship waste offsite of defer cleanup.	Requires offsite disposal. It could require additional onsite interim storage and would delay some cleanup activities.

Table 5-3 Comparison of Design Alternative Costs (Cost in thousands of dollars)

Alternative	Abovegrade Waste Cell	Pyramid	Concrete-lined Cell Bulk Placement	Concrete-lined Cell w/Containers	Hardened Concrete Vault
Total Cost [1]	$118,800	$140,300	$77,320	$165,650	$181,630
Cost of Construction					
Design	$2,200	$2,200	$1,600	$1,600	$2,200
Construction Management	$400	$400	$150	$150	$400
Construction	$41,700	$57,900	$18,600	$18,600	$26,000
Total Cost of Construction	$44,300	$60,500	$20,350	$20,350	$28,600
Cost of Site Preparation	$8,800	$14,500	$1,970	$1,970	$6,100
Cost of Closure					
Interim Cap	$5,300	N/A	$5,300	$5,300	$5,300
Interim Closure Care & Monitoring	$13,900	$13,900	$13,000	$10,400	$10,400
Total Cost of Closure	$19,200	$13,900	$18,300	$15,700	$15,700

Table 5-3 (cont.) Comparison of Design Alternative Costs (Cost in thousands of dollars

Alternative	Silo	Slab on Grade	Metal Buildings	Entombment	Waste Pile	No Action
Total Cost [1]	$107,300	$141,600	$161,400	$525,000	$36,669	$215,900
Cost of Construction						
Design	$2,000	$300	$2,300	N/A [3]	N/A [3]	N/A [3]
Construction Management	$400	$200	$1,300	N/A [3]	N/A [3]	N/A [3]
Construction	$30,400	$3,800	$17,900	N/A [3]	N/A [3]	N/A [3]
Total Cost of Construction	$32,800	$4,300	$21,500	N/A [3]	N/A [3]	N/A [3]
Cost of Site Preparation	$6,100	$6,100	$2,800	N/A [3]	N/A [3]	N/A [3]
Cost of Closure						
Interim Cap	$5,300	N/A	N/A	N/A [3]	N/A [3]	N/A [3]
Interim Closure Care & Monitoring	$13,900	$8,500	$10,400	N/A [3]	N/A [3]	N/A [3]
Total Cost of Closure	$19,200	$8,500	$10,400	N/A [3]	N/A [3]	N/A [3]

Footnotes:

1. Total costs also include costs for containers, permitting, operations, contingency, etc. More detailed estimates are presented in Appendix E.
2. The cost for waste retrieval and disposal is not included for any of the alternatives except the no-action alternative.
3. Costs for these alternatives were not broken down because of the following:
   - Entombment costs were based on a projected total cost that did not address specific costs.
   - Waste Pile costs were based on actual costs from Rocky Mountain Arsenal Cleanup in Colorado
   - These costs were not applicable for The No Action alternative.

The Hardened Concrete Vault alternative would be a free standing, totally enclosed concrete structure intended for long-term waste management. Remedial waste would be stored in cargo containers which, along with built-in aisles, makes them easily retrievable. Protection to the public and the environment would be good because of the RCRA-type double-liner leachate collection. The cost would be high, relative to other alternative, because of the cost of containers and free-standing rigid structure. The leachate detection systems makes the facility easy to monitor. This alternative was screened out because of its high relative cost and the time and effort it would take to design and construct such a facility would impact remedial activities.

The Silo alternative incorporates the concept of long-term waste management by storing remediation wastes in totally enclosed 5,000 cy concrete silos. As in some of the other alternatives, this facility would incorporate a double liner barrier with a leachate detection system. An extra level of protection for the environment and the public would be provided because of the concrete silos. The remediation waste would be retrievable because of the multiple silos, and the cost would be lower than most of the other alternatives. This design was screened out because it makes retrieval difficult, and because it cost more than the concrete-lined cell but provides only the same level of protectiveness.

The Slab on Grade alternative would be similar to the Metal Buildings alternative because it is a short-term (i.e., 25-30 years.) waste management option. The remedial waste would be placed in stored cargo containers which are stacked on a slab on grade. The slab on grade would be open to the environment and would not have any protective liners or barriers underneath. Liners were not deemed necessary because the cargo containers could be inspected and leakage could be detected early on. It would be possible to add a liner but the costs would increase. This option makes retrieval easy because of the accessibility to the cargo containers. Again, the maximum life cycle of this alternative would be approximately 25 to 30 years before the remedial waste would be re-dispositioned. The cost for this option was high because of the additional cost for containers. This alternative was screened out of its high cost and a low level of protectiveness.

The Metal Buildings alternative was more expensive than other alternatives because of the cargo containers and the number of buildings. Bulk storage was not considered for this alternative because the footprint would be too large, although some waste could be placed in bulk for temporary staging. The cost of this alternative was based on a design without a RCRA-type liner system other than the containers and the building structure which provides adequate protection for the life of the facility (25 to 30 years). A liner system could be added but would increase the total cost of the facility. Although this alternative supports the intended cycle of the 10 Year Plan, the protectiveness of this alternative would be less than the concrete-lined cell designs and the economies of scale achieved through bulk storage are absent. The facility footprint would be larger than other options because of the required large central corridor for routine access and monitoring. The retrievability of this option would be good because of the accessibility to cargo containers. This alternative was retained for further evaluation because it is an established design and would offer good retrieval and inspection capabilities.

The Entombment alternative protects the public and the environment because of the multiple barrier systems. Again, this facility would incorporate a double liner system with a leachate detection system. This design alternative stores remediation waste in 55-gal drums which are then stacked in clusters of eight in concrete bins. The enclosed concrete bins are then stacked within the cell liner. Because of the multiple container/barrier system, the cost for this alternative would be the most expensive. The footprint for this facility would be larger because of the wasted space within each concrete bin. The retrievability would be good for this alternative as well. This alternative was screened out because its cost, large footprint, and the additional time and effort to construct the facility could not be justified by its high level of protectiveness.

The Pyramid alternative was not as favorable as the other design alternatives because of several concerns. Schedule concerns for expediting the remedial actions would be dependent on acquiring the large volume of granite stone and construction. Monitoring and retrieving the remedial waste would be difficult in this structure due to accessibility. The downgradient wells would be the only indication of a contaminated plume. A liner system could be added to this alternative but would increase the total cost and the cost would be already one of the highest of any of the alternatives examined.. The remedial waste would be not segregated but would be stored in a bulk capacity. The facility would be a totally enclosed rigid structure and would require stringent alternative standards to prevent differential settlement which could crack mortar joints and ultimately breach the barrier. From this standpoint, long-term maintenance would be required. This alternative was screened out because of cost, concerns about settling, availability of materials, and concerns about the facility's ability to contain and monitor the waste.

The Waste Pile alternative would be a short-term waste management solution. The remediation waste would be enclosed with a surrounding geomembrane. The facility footprint would be smaller than the other alternatives because the waste would be stored as bulk. Waste retrieval would be achievable but would be more difficult and would be measured similar to the Abovegrade Storage Cell. Logistics of daily operations would be difficult because the waste pile would be open to the environment. The protectiveness of this alternative would be poor. The design used at Rocky Mountain Arsenal does not support the active management of waste as envisioned in the 10 Year Plan nor does it meet the basic requirements for a CAMU described in RFCA. This alternative could be modified to include a double liner/leachate system, but it would still lack the protectiveness of other alternatives. This alternative was screened out because of poor protectiveness, an inability to support cleanup operations, and an inability to meet 6 CCR 1007-3 Part 264, Subpart N as required by RFCA.

The No Action alternative was retained throughout the screening process because NEPA requires it as a baseline. The No Action Alternative essentially means the remediation waste would be prepared for offsite disposal when it is generated and no CAMU alternative would be available. This would result in an early expenditure of funds to meet treatment, transportation, and disposal costs which would limit the funds available for actual cleanup activities in support of site closure. The No Action alternative would have the lowest life-cycle cost in comparison to the other alternatives when disposal cost are included in each estimate. This cost would be offset be less protective storage which could be suitable for small volumes and short durations.

The following four selected alternatives reached the final screening:

- Abovegrade Storage Cell
- Concrete-lined Cell with bulk placement
- Metal Buildings
- No Action Alternative

Several of the factors which affected the selection of these alternatives for the final comparison are explained below.

The Abovegrade Storage Cell alternative was retained for further evaluation for several reasons. First, it is proven technology. Second, the liners and leachate collection system would provide the ability to detect leaks and recover contaminants prior to entering the environment. Third, this alternative would offer flexibility, retrievability and still remains one of the least expensive over the

long term. Finally, this alternative would support RFCA in terms of design requirements, and would support the 10 Year Plan by providing the necessary flexibility. This alternative would be similar to the standard hazardous waste landfill built to RCRA Subtitle "C" standards and would be built above the existing grade to prevent groundwater infiltration.

The Concrete-lined Cell with bulk placement alternative was retained for further evaluation for several reasons. First, the concrete cell would add another layer of protectiveness to groundwater from the leachate generated during placement and storage operations. Second, this alternative would be flexible and would allow for modular installation that would optimize the sizing of the cells and timing of the installation as waste is generated. For example, the first module would be sized for 25,000 to 33,000 cu yd of waste, and therefore, can be installed more quickly. Subsequent cells would be added as needed up to a total capacity of approximately 100,000- 400,000 cu yd. . This flexibility would also expedite risk reduction activities under the Site Vision. Third, this alternative provides a fair degree of retrievability because it uses a combination of containers and bulk storage. Finally, this alternative would meet the RFCA requirements in 6 CCR 1007-3, Part 264, Subpart N. which allows the flexibility to utilize the facility for either short-term or long-term storage.

The Metal Buildings alternative was retained for further evaluation because it would allow for interim storage of the waste until the final disposition is determined. Storage of waste would allow remediation to proceed in a timely fashion. The waste would be stored in cargo containers and could be fully monitored and recovered. It was, therefore, believed that public perception and acceptance of this alternative would be high despite the higher cost and shorter life.

The No Action alternative was retained for the final screening because it must be assessed to meet NEPA values and 10 CFR 1021.321(c) requirements.

The final design alternative comparison used the RFCA criteria, as discussed in Section 6, to select the best alternative.

6.0 COMPARISON OF SCREENED ALTERNATIVES

The four alternatives discussed below are all based on the scenario that assumptions used to generate the schedules for risk reduction in the Ten Year Plan become invalid. In other words, in the event that waste generation, storage, or shipment assumptions in the Ten Year Plan become invalid, one of these four alternatives would be necessary to ensure that risk reduction activities and site closure at RFETS remain on schedule. Any alternative used for storage at RFETS would be an interim action that would eventually require resources for offsite disposal. The value of these interim action alternatives is to serve as a contingency to ensure that risk reduction activities such as source removals and building D&D would be implemented in a timely fashion consistent with the Ten Year Plan.

Based on the analysis presented in this decision document, bulk placement of the remediation waste in the Concrete-lined Cell at the site east of the Solar Pond was the remedy selected for management of remediation waste. The abovegrade Concrete-lined Cell with bulk placement was selected from the four final alternatives screened in Section 5.0:

- No Action Alternative (Defined as utilizing current waste management resources and facilities recognizing Ten Year Plan assumptions would not be supported)
- Abovegrade Storage Cell
- Abovegrade Concrete-lined Cell with bulk placement
- Metal Buildings

These four design alternatives were compared using the seven RFCA criteria from Paragraph 109a (DOE, 1996a) to select the best alternative for remediation waste management at RFETS. The seven RFCA criteria are as follows:

1. Worker Safety
2. Protection of Public Health and the Environment
3. Transportation
4. Facility Design, Containment and Monitoring
5. Institutional Controls
6. Cost
7. Community Acceptance

Two other criteria have been included that address NEPA values:

- Short-Term Effectiveness
- Long-Term Effectiveness and Permanence

A summary of the final comparison of the four screened Alternatives is provided in Table 6-1. Statements concerning public acceptance serve as placeholders and would be modified based on public input as the review cycle progresses.

Table 6-1 Summary of the Final Alternative Comparison for a Remediation Waste Storage Facility

Final Design Alternative	RFCA Criteria Worker Safety	RFCA Criteria Protection of Public Health and the Environment	RFCA Criteria Transportation	RFCA Criteria Facility Design, Containment and Monitoring	RFCA Criteria Institutional Controls
Abovegrade Storage Cell	Risks to workers are similar for all alternatives considered. Spraying of water during construction would reduce exposure to dust. Location is in a low traffic area.	RCRA double liner system provides groundwater protection. Leakage would be detected in the liner system	Centralized location minimizes transportation requirements onsite. Design and location should have minimal impact on existing traffic patterns.	Liner system provides additional containment plus the ability to detect leaching. Air monitoring could be performed in conjunction with existing RFETS monitoring.	The RFCA acts as an institutional control requiring continued maintenance of the facility. Since the use of the facility is for short-term storage, controls beyond those inherent in RFCA are not necessary.
Concrete-lined Cell with Bulk Placement	Risks to workers is similar for all alternatives considered. Spraying of water during construction would reduce exposure to dust. Location is in a low traffic area.	RCRA double liner system provides groundwater protection. Concrete walls and floor provide additional protection. Leakage can be detected and collected prior to reaching liner system.	Centralized location minimizes transportation requirements onsite. Design and location should have minimal impact on existing traffic patterns.	Leachate would be detected and collected in a cell collection system prior to reaching the subsurface liner. Air monitoring would be performed in conjunction with existing RFETS monitoring.	The RFCA acts as an institutional control requiring continued maintenance of the facility. Since the use of the facility is for short-term storage, then controls beyond those inherent in RFCA are not necessary.
Metal Buildings	Risks to workers is similar for all alternatives considered. Spraying of water during construction would reduce exposure to dust. Location is in a low traffic area.	Containerized waste and building reduces exposure to the workers and the public. Visual inspections allow leaks to be detected before release to the environment.	Centralized location minimizes transportation requirements onsite. Design and location should have minimal impact on existing traffic patterns.	Waste would be in containers which would be more easily monitored visually. Air monitoring would be performed in conjunction with existing RFETS monitoring.	The RFCA acts as an institutional control requiring continued maintenance of the facility. Since the use of the facility is for short-term storage, then controls beyond those inherent in RFCA are not necessary.
No Action Alternative	Increased exposure due to less containment (sources exposed). Cleanup schedule could be impacted.	Less protective due to multiple storage areas with no containment. Sources could remain exposed to the environment for a longer period.	Upgrades to existing facilities would be needed to accommodate offsite shipments. Current RFETS storage capacity would not support Ten Year Plan.	Additional inspection due to unconsolidated sources. Less containment.	Institutional controls would exist for offsite facilities. Current RFETS institutional controls apply.

Table 6-1 (continued)

Final Design Alternatives	NEPA Evaluation Cost[1]	NEPA Evaluation Community Acceptance	NEPA Evaluation Short-Term Effectiveness	NEPA Evaluation Long-Term Effectiveness and Permanence
Abovegrade Storage Cell	This storage alternative has a high total cost of **$119M** plus cost of offsite disposal and requires a large footprint for the total facility.	Monitoring and retrieving the waste is more difficult with this option.	Reduces waste handling requirements for accelerated actions and D&D projects. Focuses resources on risk reduction. Design less flexible. than other alternatives.	Provides sufficient permanence for an interim solution. Utilizes natural non-degradable materials in cap and liner design to support long-term use.
Concrete-lined Cell With Bulk Placement	This storage alternative has a total cost of **$77M** plus cost of offsite disposal. The cost benefit outweighs other alternatives and allows more resources to be applied to risk reduction rather than waste management. Option offers an ability to monitor and retrieve waste at a relatively low cost.	This alternative offers monitoring and retrievability of the remediation waste but physical inspection is not to the degree that metal buildings would offer.	Reduces waste handling requirements for accelerated actions and D&D projects. Modular design allows for rapid construction. Focuses resources on risk reduction.	Provides sufficient permanence for an interim solution. Utilizes natural non-degradable materials in cap and liner design to support long-term use.
Metal Buildings	This storage alternative has a cost of **$161M** plus cost of offsite disposal, not including the additional lost for the liner system required in RFCA. The high cost is the result of the container costs.	This alternative combines easy monitoring and retrievability with offsite disposal. Visual leak inspection is possible. Protectiveness is less than other onsite options.	Additional packaging requirements needed to containerize waste. Rapid construction would speed up availability of facility. Not as suitable for volumes >100K yd	Provides sufficient permanence for an interim solution The buildings themselves are not as effective for the long-term due to high maintenance. Not very reasonable for volumes >100K cy yd
No Action Alternative	This alternative has cost of **$216M**. This cost is driven by the cost for containers, waste treatment, and offsite disposal costs. Cost does not include onsite waste management if offsite availability is impacted.	Waste would be sent offsite on a schedule not consistent with the Ten Year Plan. Risk reduction timeline may increase.	Readily available to support on going projects. Additional effort needed for packaging, transportation, and documentation requirements. Ability to store on site may limit risk reduction.	All offsite disposal facilities under consideration have been designed for long-term use. Not effective if source removal delayed.

1. Cost estimates, except the No Action Alternative, do not include offsite shipment and disposal which is deferred until closure of the RWSF.

Worker Safety - Each of the Alternatives posed standard industrial risks to workers. All of the Alternatives would be labor intensive to implement but would not pose any unusual risks. Air monitoring, spraying to minimize dust, and the use of a daily cover would protect plant workers from airborne contaminants during construction and operations. Once constructed, the onsite Alternatives would pose minimal risk to RFETS' workers because engineered barriers would contain the remediation waste. In addition, the selected site is in an area of minimal traffic. The No Action alternative could require that sources remain exposed to the environment, increasing risk.

Protection of Human Health and the Environment - In terms of design, the Concrete-Lined Cell with bulk placement had the most protective design elements. The leachate collection system in the concrete floor of the cell would have a significant advantage. Unlike the above-grade storage cell, contaminants could be detected and captured within the cell. In the above-grade storage cell design, the contaminants would be captured in the first or second layer of liners. The Metal Building alternative could also contain the leakage in the structure or in a liner system.

The No Action alternative would immediately have to rely on an offsite facility to provide protection. Unfortunately, because this alternative would provide less immediate source removal, the overall RFETS protectiveness would decrease since risk reduction could not occur as scheduled. It was assumed that a permitted offsite disposal facility would afford adequate protectiveness once the waste is placed. The additional time necessary to achieve risk reduction due to waste volume, storage, or shipment restrictions would increase risk to human health and the environment. This would result in more contaminant sources remaining exposed in the environment and could actually increase the risk to human health and the environment.

All of the Alternatives would offer protection from erosion. Likewise, there would be little difference among the Alternatives in terms of biological impacts since these impacts were expected to be minimal.

Transportation - The central location of the RWSF would minimize onsite transportation of remediation waste. In addition, the location is in a low traffic area. The eventual shipment offsite, however, would require additional transportation either by truck or by rail. For all of the alternatives, upgrades to RFETS shipping and transportation facilities would be necessary.

Facility Design, Containment and Monitoring - All of the onsite Alternatives would have features to provide additional containment and monitoring. The Concrete-lined Cell with bulk placement would have the best physical containment because both the cells and the liners have a leachate collection system. The Metal Building alternative would offer the ability to visually monitor the waste, plus the waste and the containerized waste could be easily retrieved for shipment. This design was not, however, as conducive to extremely large volumes of bulk storage. The Abovegrade Storage Cell would not offer the same degree of monitoring or containment as the two other onsite options. The No Action alternative would require additional resources for inspection of remediation wastes awaiting shipment and disposal.

Institutional Controls - The selected location in the Solar Ponds Area combined with RFCA would act as an institutional control since the DOE must comply with paragraph 278 of RFCA which would require continued maintenance of a containment system in the event that the property is leased or the title is conveyed to another party. Because the RWSF would only be operational as long as operations were continued in the Industrial area, additional institutional controls beyond the existing controls were not deemed necessary. For the No Action alternative, institutional controls of some

form would likely exist; for offsite facilities, however, DOE and CDPHE involvement in those controls could be minimal.

Cost - Based on near-term costs, the concrete-lined cell would be the least expensive interim alternative ($77,300,000). The Abovegrade Storage Cell would be more expensive ($118,800,000) than the concrete-lined cell because its footprint would be bigger and would require more site preparation and fill material. The cost of the Metal Buildings ($161,400,000) was also greater than the cost of the concrete-lined cell because it would require containers and would have a larger footprint.

The costs for each alternative are listed in Table 6-1. A more complete breakdown of costs are in the alternative descriptions in Appendix E and in the backup for the facility design screen in Appendix F. None of the cost estimates (except No Action) included offsite disposal which was assumed to be deferred until the waste could be removed from storage.

Community Acceptance - The no action alternative would limit risk reduction and therefore was deemed least acceptable. Because only temporary storage of the waste is being proposed, ultimately there must be some community impact with any of the options. Of the three onsite options, the metal buildings would likely be the most acceptable option to the public since this alternative would offer the ability to inspect the waste in containers and to easily retrieve the containers for offsite shipment. Furthermore, since metal buildings would have a limited useful life, the community might find this a more acceptable alternative since it would have a limited ability to provide long-term storage. All of the alternatives would have the ability to monitor and retrieve the stored waste. The ease of retrieval varies between alternatives.

Short-Term Effectiveness - Because only temporary storage is being considered, the relative importance of that criterion was elevated. Particular emphasis would need to be placed on supporting an accelerated cleanup of RFETS as described by the Ten Year Plan and RFCA. One of the main advantages of the onsite alternatives was the ability to defer the cost of offsite disposal. Use of the RWSF would allow the immediate cleanup of high risk IHSSs as well as the D&D of more buildings in a shorter time frame. The RWSF could also impact the plant mortgage by allowing more mortgage reduction activities to occur and thereby reducing the mortgage sooner.

The other issue of short-term effectiveness was logistics. In the event Ten Year Plan assumptions fail, short-term effectiveness at RFETS would be limited until a facility was available to handle large volumes of remediation waste. Once the RWSF was built, dealing with the remediation waste would be easier than shipment to an offsite facility because packaging, sampling, documentation, and transportation issues would be much easier to address. An Abovegrade Storage Cell and the Concrete-lined Cell would allow bulk waste to be placed in the facility without additional containerization, and onsite transportation requirements would be minimal.

Because of convenience and initial cost, the Abovegrade Storage Cell and the Concrete-Lined Cell would best support the implementation of D&D and Environmental Restoration actions if waste volumes significantly exceed projected estimates. The Metal Building alternative would require some additional packaging effort and the No-Action alternative would require additional preliminary efforts to both package and transport the waste; however; all of the alternatives would require these actions for eventual offsite shipment.

Long-Term Effectiveness and Permanence - Since at the closure of the RWSF all of the waste would be shipped offsite for disposal, the long-term ability of any alternative would be dependent on the offsite disposal facility selected. However, the relative permanence and long-term effectiveness

of the selected alternative would be important because they would generally be indicative of the facility's protectiveness. Also, permanence would allow the flexibility for long-term storage should there be a need.

Of the four alternatives, the Concrete-Lined Cell with bulk waste placement would have the greatest degree of long-term effectiveness and permanence based on the extra protection offered by the 12-inch-thick concrete walls and 18-inch-thick floor. The internal concrete structure would add both an additional barrier to leakage as well as internal structural support for the facility.

The No-Action alternative and the Abovegrade Storage Cell would also offer good long-term effectiveness and permanence. The Abovegrade Storage Cell would offer about the same degree of permanence as the concrete-lined cell because it would utilize a similar liner system and a contoured, impervious interim cap. However, the Abovegrade Storage would not have the additional protection of the concrete infrastructure of the concrete-lined cell. The Metal Building alternative would offer the least amount of long-term effectiveness and permanence. Since the facility would only be intended for temporary storage this translates into only limited flexibility.

The Concrete-Lined Cell was selected because of the following criteria:

- It would be protective of the environment and human health. The engineered features would provide additional protection that the other alternatives do not have such as a multiple layer interim cap and an 18-inch concrete floor with its own leachate collection system.

- It would provide more flexibility in storage options since it could accommodate either bulk storage or containers and would be suitable for volumes from a minimum of 33,000 cu yd to 400,000 cu yds.. It would also offer the retrievability needed for short-term storage combined with the protectiveness of a more permanent facility.

- It would best support environmental restoration and D&D activities since bulk waste could go from treatment or excavation right into the facility. Plus the circumvention of the transportation requirements and packaging requirements would allow these activities to become more efficient and cost-effective. In the near-term, it would cost less than the No-Action alternative and, therefore, would free up funding for additional mortgage reduction activities and accelerated environmental actions. Finally, it would be the least costly of the onsite alternatives.

- It could be easily expanded. Because this alternative would be installed in a modular fashion, additional cells could be built adjacent to the original cell if needed. What is more, the use of modules would allow one module to be filled while another is being constructed. This would create flexibility for future waste management decisions while not committing funds until necessary. Finally, this modular design would conform well to the Ten Year Plan and RFCA as well as plans for the future use of RFETS.

7.0 SELECTED REMEDY

Section 7.1 describes the selected alternative and gives more detail of how the alternative meets the objectives of the IM/IRA, the RFCA, and the CAMU criteria. The basis for the selection of the specific alternative is described in Section 7.2, with a discussion of how the selected alternative meets the objectives of the IM/IRA that were outlined in Section 1. A Risk Evaluation is provided in Section 7.3 which discusses studies that were performed to assure that the RWSF would meet design and monitoring requirements included in RFCA and in the CAMU rule. Section 7.4 discusses technical and administrative controls for the CAMU that would meet the requirements identified in RFCA paragraph 80. Discussion of how NEPA values were addressed throughout the document is included in Section 7.5. Conceptual waste acceptance criteria (WAC) are described in Section 7.6. Section 7.7 discusses operational controls and plans that would control the activities and waste operations of the RWSF.

7.1 REMEDY DESCRIPTION

The selected alternative, the Concrete-lined Cell, would consist of a series of modular cells, each sized for approximately 33,000 cu yd of waste with the ability to expand up to 400,000 cu yd, as appropriate, to meet storage needs. The concrete-lined cell would be located immediately east of the Solar Ponds in the northeast quadrant of the Protected Area. (See Figure 7-1). This facility would be placed abovegrade with the lowest point of the leak detection system also being abovegrade. The RWSF would be designed with a double composite liner system with modular concrete cells which meet the requirements of 6 CCR 1007-3, Part 264, Subpart N (See Figures 7-2 and 7-3.) An impervious interim cover would isolate wastes from infiltration and erosion. An example of a type of impervious interim cover is included in Figure 7-3. The liner would comply with RCRA Subtitle "C" requirements as defined in 6 CCR 1007-3, Part 264. For the purpose of cost estimating, the conceptual design currently incorporates the following features:

- Self-supporting reinforced concrete structure
- A facility size of 500 ft long by 360 ft wide and 14 ft deep (approximately 4.13 acres)
- Up to three modules, each 500 ft long by 120 ft wide further divided into compartments for waste segregation in bulk or cargo containers
- A reinforced concrete slab with cast-in-place drain channels and sumps to collect leachate
- External and internal reinforced concrete walls with integral waterstops
- A composite double liner and leachate detection/collection system
- An operational cover to enclose the cell/module during operations for fugitive dust controls and to reduce the generation of leachate
- An impermeable interim cover system which would slope at a 3% grade
- Five monitoring wells for groundwater monitoring

The leachate transfer and storage system would be provided to manage leachate that would be collected in the RWSF. Leachate would be transferred from the RWSF to a treatment system, as necessary.

Groundwater monitoring would be done in accordance with all applicable rules and regulations, including, but not limited to, CAMU requirements in 6 CCR 1007-3, Section 264, Subpart S. A groundwater monitoring plan would be prepared and submitted during the design review process.

During operations, an operational enclosure (a sprung structure) would cover the cell/module to minimize fugitive dust and reduce the infiltration and generation of leachate until the interim cover has been established. Waste would be placed in the facility in bulk or in containers. In addition, this facility would allow for the options of placing waste in cargo containers or segregating wastes.

Once a module/cell had reached capacity with remediation wastes, an interim cover would be constructed and the temporary sprung structure would be removed. The interim cover would be approximately two feet thick and consist of vegetative cover, drainage layer, and an impervious geosynthetic membrane (e.g., high density polyethylene). The cover would be sloped 3% - 5% to promote drainage.

7.2 DECISION BASIS

A concrete-lined cell in the Solar Ponds Area was selected and justified based on the screening criteria and the final comparison criteria presented in Sections 5 and 6 of this Decision Document. To further support that selection, this section provides an evaluation of the selected remedy in terms of the original objectives of this document as presented in Section 1.0. Section 7.2.2 summarizes the value engineering study performed and the basic benefits of the selected remedy.

7.2.1 Objectives

As stated in Section 1.1.1, there are four main objectives of this IM/IRA. The selected remedy meets those objectives in the following manner:

1. **In support of the RFCA and the Ten Year Plan, the management of low-level, low-level mixed and hazardous remediation waste must ensure the safety of the public, RFETS workers, and the environment through reliable, effective, protective, and cost-effective management of remediation wastes at RFETS.**

The selected remedy addresses this objective through the following safety features:

- All work including construction, filling operations, handling, and transportation would be done under an approved health and safety plan (HASP).
- The remediation waste that would be placed in this facility would generally have very low levels of radionuclides.
- Work would be performed under the oversight of industrial hygienists, occupational safety professionals, and radiological engineers.
- Workers would be required to undergo extensive training based on the specific hazards of their job.

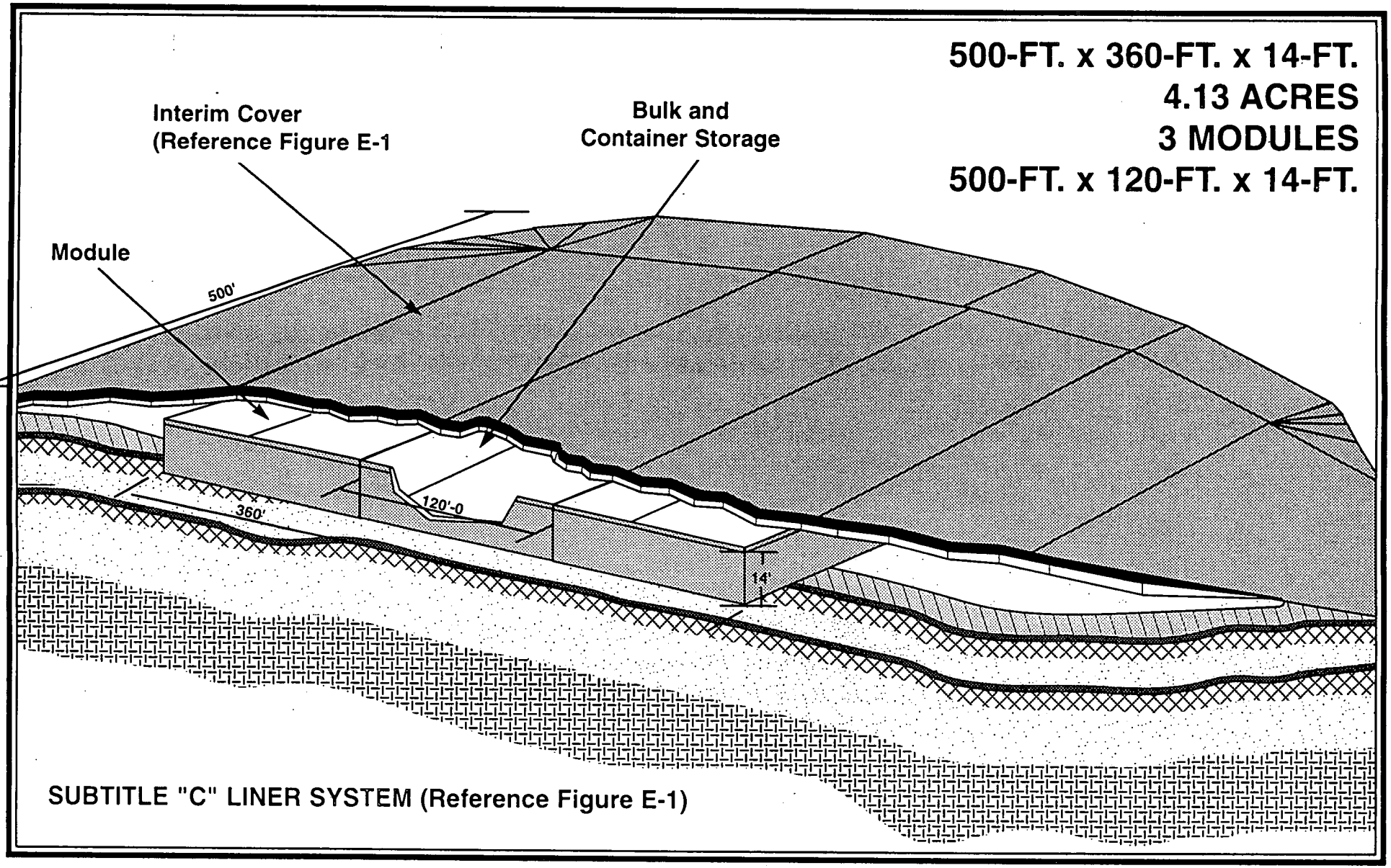
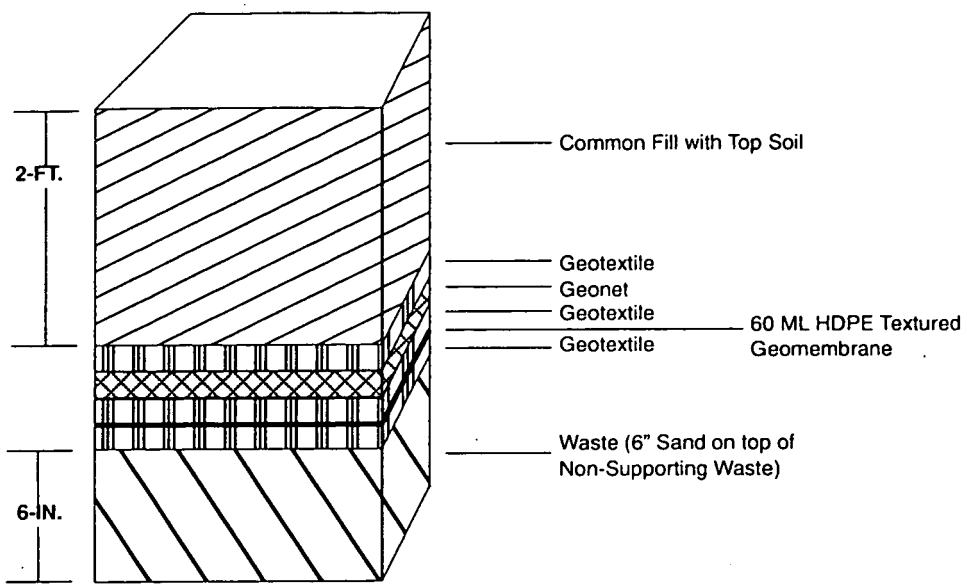


Figure 7-2

CONCRETE-LINED CELL WITH BULK WASTE PLACEMENT

INTERIM CELL COVER



CELL LINER

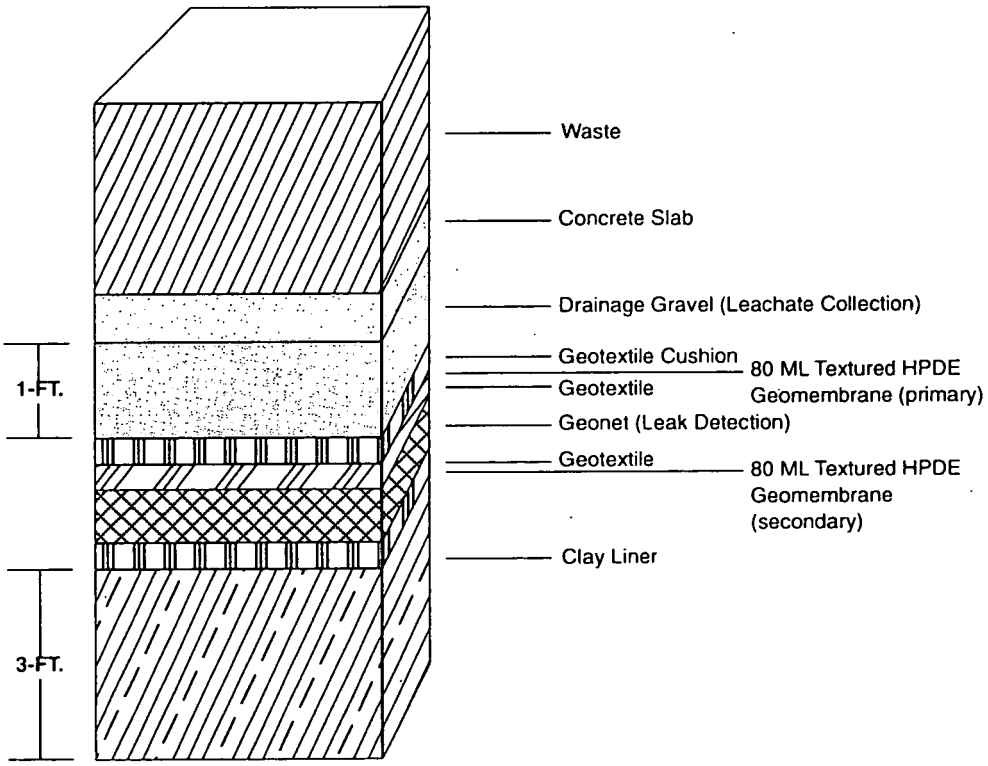


Figure 7-3

ON-SITE FACILITY CROSS SECTION

- A wide range of dust suppression measures would be taken during construction, transportation, handling, and filling operations to ensure that fugitive emissions of vapors or particulates were not generated. Dust control activities during handling, transportation, construction, and placement could include an operational cover, dust suppression sprays, high wind shut-downs, or other precautions.

- Various types of monitoring would be performed to ensure not only the safety of the public and RFETS workers but also the protection of the environment. This would potentially include air monitoring for particulates and contaminants, radiological monitoring, ground water monitoring, and surface water monitoring.

- Once a module or cell was filled, an interim protective cover would be placed over it

The facility has numerous design features added to ensure protection of human health and the environment. Some of these protective measures are as follows:

- An impervious interim cover to reduce infiltration-related leaching and soil erosion

- An 18-in.-thick reinforced concrete slab floor

- Waste separation through the use of compartments built into the modular design

- 12-in.-thick reinforced concrete walls

- Two leachate collection/detection systems, one system to be built into the floor of the facility; the second system to be built into the liner system

- A multiple-layer liner system that utilizes both synthetic and natural materials

- A groundwater monitoring system

2) **The solution must support a flexible waste management policy combining contingencies for both long-term storage and shorter-term staging/storage for offsite disposal while recognizing the uncertainties associated with current waste volume estimates and future offsite disposal availability. A flexible policy would ensure that the most timely and cost-effective strategy that supports RFCA and TYP objectives can be developed.**

The selected alternative would support a flexible waste management policy by serving as a bulk storage facility in the event that remediation waste must be stored onsite for an extended duration. This CAMU would compliment another CAMU designation for a storage facility to hold containerized waste since this would cover a full spectrum of contingencies. A storage facility for containers could meet the need for staging, handling, and short-term storage, whereas the RWSF would be needed if the waste had to be stored for long period or if the volume of waste was so large that a metal building would be impractical. In addition, the RWSF would support a flexible waste management policy as follows:

- The RWSF would be able to accept both containerized and bulk waste.

- The RWSF would have a small footprint that would allow more waste to be stored in a single area.

- The RWSF would use a modular design that would allow the facility to be adjusted for varying waste volumes and waste types. The facility could be adjusted to the influx of remediation waste.
- The RWSF could segregate and isolate different waste types.
- Future modules could have customized containment and monitoring features.

3) The management of low-level, low-level mixed, and hazardous remediation waste must result in a cost-effective solution.

If storage is needed, the Concrete-lined Cell would be the most cost-effective of the alternatives considered that could meet RFCA criteria. Table 7-1 gives the total life cycle costs for all of the design alternatives considered.

Table 7-1 Life Cycle Costs for Design Alternatives

Alternative	Total Life Cycle Cost
Abovegrade Landfill	$118,800,000
Pyramid	$140,300,000
Concrete-lined Cell with bulk placement	**$77,320,000**
Concrete-lined Cell with containers	$165,650,000
Hardened Concrete Vault	$181,630,000
Silo Design	$107,300,000
Slab on Grade	$141,600,000
Metal Buildings	$161,400,000
Entombment	$525,000,000
Waste Pile	$36,669,000
No Action	$215,900,000

* 1. The No Action alternative represents the cost for disposal of remediation waste volumes offsite whereas the other alternatives do not address disposal costs. The No Action alternative has the lowest cost meeting offsite disposal goals.

Based on professional judgment, the cost differences between location alternatives were not as significant as cost differences between the design alternatives and the final alternatives.

In terms of cost, the CAMU should still be an alternative to the Ten Year Plan in case additional storage is needed. Even though onsite storage could have lower initial costs because disposal would be deferred, the No Action alternative for shipping remediation waste offsite offers the lowest life-cycle cost.

4) A means of consolidating remediation waste in one location is needed to support near-term risk reduction goals while addressing long-term liability and safety issues.

The location and design were selected to allow large quantities of remediation waste to be consolidated at a single location. Not only does the location and design allow the physical consolidation of the waste but it also allows waste management activities such as operations, monitoring, and inspection to be consolidated as well.

The selection of a Concrete-lined Cell in the Solar Ponds Area would be consistent with future land use, (DOE, 1995a) the Site Vision, (Kaiser-Hill, 1996b), and also the RFCA. The ways that the selected alternative supports the Site Vision and reasonably foreseeable future land uses are as follows:

- The RWSF would be a storage facility which would be consistent with the Site Vision goal of dispositioning remedial waste in a safe manner.
- The site selected is in the Industrial Area of RFETS and could potentially extend over several IHSSs. Reasonably foreseeable future land use for this area would be for limited industrial use. The area near the Solar Ponds would be far enough away from any building that might be reused so as not to impact any future RFETS activities.
- The design and centrally located site would facilitate monitoring and maintenance. Monitoring could be performed in conjunction with monitoring activities already required for the industrial area. Existing air monitoring systems could also support monitoring for the RWSF.

7.2.2 Summary of the Value Engineering Study and Selected Remedy Benefits

As part of the effort to define the design concept for the RWSF and in accordance with DOE Order 4010.1a, a value engineering study was performed. In the value engineering analysis method, multiple alternative approaches of accomplishing the project functions were subjected to qualitative and quantitative techniques to determine the value of each. The alternative which represents the highest value was selected for further development.

Four categories of protective elements, elements that were considered essential components of any acceptable design and that represent the highest costs of implementability and operation of the facility, were selected for inclusion in the value engineering study:

- Protective barriers at the bottom of the facility (liners and/or other structures)
- Protective barriers at the top of the facility (interim cover and/or other structures)
- Waste placement
- Waste removal (exhumation at end of storage period)

Many combinations of construction and placement were identified that could accomplish the functions associated with the four categories. An application of the value engineering techniques identified a design incorporating a concrete structure, conventional liners, and an interim cover. Waste would be placed in bulk (rather than in individual containers) to represent the highest value. The results of the value engineering study independently validated the selection—of the Concrete-lined Cell with bulk storage—attained through the alternatives analysis process.

To support the selection of a Concrete-lined Cell at the Solar Ponds Area, the following advantages are cited:

- The modular design offers the greatest degree of flexibility including the following attributes:
  - A wide variety of waste types could be accepted and kept segregated

— Debris could be placed in the facility without additional characterization, compaction, or size reduction

— The facility could be expanded as needed to meet the needs of cleanup at RFETS as the cleanup progresses

— The RWSF could accept both bulk and containerized wastes

— The RWSF could store waste for varying durations

- The facility would have a high degree of protectiveness because of the concrete containment system, the additional liners in the subsurface liner system, and the interim cover. All of these features offer much greater protection than would be found in a typical storage facility.

- One major advantage would be that the concrete containment system would allow for the capture of contaminants before they reach the subsurface rather than depending on the liner system. Media below the facility would not be contaminated should leaching occur. The liner system would act only as additional back up barriers or as tertiary containment, rather than as the secondary containment system.

- The facility would be situated in an area where contamination is already present.

- The selected location had strong CDPHE support based on previous input.

- The facility would be centrally located to many of the IHSSs that need remediation.

- The RWSF would minimize indirect effects on the environment its location in the Industrial Area where existing infrastructure would support the use of the facility.

Because the RWSF would be built on an existing facility in an area previously contaminated, it would not disturb additional areas on RFETS and it would minimize cumulative effects on the environment.

In selecting a remedy, emphasis was placed on flexibility and environmental protection. In part the remedy was selected because it could safely contain remediation waste for any period of time necessary. If the waste could not be removed in a reasonable amount of time, then the facility would have to be durable enough to ensure the protection of human health and the environment until the waste could be removed. An added benefit of using this facility for long-term storage is that it could allow the time needed to develop new treatment technologies or alternative offsite disposal sites.

7.3 RISK EVALUATION

A number of studies have been conducted to provide assurance that the recommended alternative would meet the established criteria for the RWSF. These analyses were conducted to support CAMU criteria for protection of public health and the environment as listed in 6-CCR-1007-3 Part 264.552 (c). The analysis of risk was divided into the following three main exposure pathways:

- Offsite transport of contaminants through the groundwater to neighboring surface waters

- Worker exposure to radionuclides during operations

- Offsite fugitive dust emissions

The potential for vertical contaminant migration through underlying geologic strata into the Laramie-Fox Hills aquifer was previously addressed and was considered to be an unrealistic scenario (RMRS, 1996). The most conservative calculations of volatile organic contaminant transport indicated that travel times of at least 17,000 yr would be required for contaminants to migrate to the deep aquifer, which greatly exceeds the 1,000 yr time-frame considered in this document. The analyses performed in this report confirmed the conclusions reached by the U.S. Geological Survey (Hurr, 1976) that plant operations would not impact this aquifer. More information on potential contaminant migration to the Laramie-Fox Hills aquifer is contained within the "White Paper Analysis of Vertical Contaminant Migration Potential" (RMRS, 1996).

Exposures from inadvertent intrusion into the RWSF after closure were also ruled out primarily because waste would be actively managed by inspections and monitoring throughout the life of the facility as per RFCA paragraph 80. In addition, it was assumed that as long as wastes remain on-site in the protected area (PA) and the site was on the CERCLA National Priorities List (NPL), administrative controls would be required to limit access onto the site and five-year public health reviews would be required to ensure that the remedies used remained protective as long as waste remained onsite. It is also assumed that a fully integrated sitewide monitoring network would remain in effect to detect any releases from this action or any other as long as waste remained on site.

In addition to the pathways analyses referenced above, an analysis of technical and administrative controls were included. These controls are the administrative, design, operational, and post closure practices put in place to ensure releases are prevented or are prevented from impacting human health and the environment. Institutional controls could include deed restrictions, interagency agreements, and other controls.

7.3.1 Offsite transport of contaminants through the groundwater to neighboring surface waters

As with most waste management systems, potential accidental offsite releases to the public or the environment constitute the majority of risk. Siting criteria, design requirements, and facility monitoring requirements were all established to mitigate the likelihood of a release event occurring. Several studies relative to the location of the RWSF, as well as the design itself, were conducted to assess the likelihood of a release and the resulting level of contamination associated with such an event. One of the pathways considered was a release of contamination from the facility to groundwater and the subsequent transport of contamination to surface waters, where exposures to the environment or the public could occur. Three integrated studies were conducted to assess what, if any, risks might result from such a release:

- Remediation Waste Storage Facility (RWSF) Particle Tracking Study
- Leachate Composition Analysis
- Discharge Composition Analysis

The first two studies identified the primary parameters for an exposure to occur, travel times, and source concentrations of contaminants. The final study defined the overall estimated concentrations based upon infiltration through interim and long term cover designs. These studies are attached to the decision document as Appendix G and are summarized below.

7.3.1.1 Remediation Waste Storage Facility Particle Tracking Model

The particle tracking study used a site-validated mathematical model to track contaminant flow through the groundwater beneath the RWSF and estimated travel times to neighboring surface waters. Travel times were based upon varying retardation factors for a particle in contaminant categories that include metals, organic compounds, and radionuclides Retardation factors were based upon solubility, adsorption coefficients, and other factors that influence a contaminant's ability to flow freely within the groundwater. The retardation factors were either obtained from literature values or from RFETS-specific values. The time frames considered for transport were 30 yr, 500 yr, 1,000 yr, and 10,000 yr. The times used all exceeded the estimated operational life of the storage facility since the intent of the facility would be to support site closure within the 10 Year Plan time frames by providing a facility for storage only. Travel times did not assume any engineered barriers at the top or the base of the RWSF. These times were extremely conservative due to the assumption of no engineered barriers and represented a worse case scenario. In addition to the conservative travel times, the study made no representation as to what levels of contaminants would reach neighboring surface waters within these time frames but was strictly limited to the travel time for a particle of material.

Metals and radionuclides have extremely high coefficients of adsorption, meaning that metals and radionuclides tend to adhere to clays within the surrounding soils and, therefore, exhibit limited movement. In addition, clay liner systems within the RWSF would further limit migration. The particle tracking models showed that migration would be limited for periods of nearly 1,000 years. Given the engineered barriers designed for the RWSF and the limited operational life cycle, discharges to surface waters were not expected. In addition, given the levels of metals and radionuclides associated with the estimated leachate composition and the estimated infiltration rates into the RWSF, no contaminant levels above stream standards were anticipated within the unit boundary.

Organic compounds present the predominant risk for completing the pathway to neighboring surface waters. The particle tracking model predicted that organics could conceivably reach surface waters within 100 yr without the engineered caps and liner systems designed for the RWSF. Organics levels however, were expected to be very low since thermal desorption technology is currently being used to treat soils and debris prior to disposition into a storage facility. Given the anticipated levels of organics within the leachate, the levels of organics discharged to surface waters if a potential release occurred, would be significantly less than what would be allowable to protect human health or the environment and would meet RFCA Action Levels and standards for water. The leak detection system of the liners would signal an alarm before a potential release to the groundwater or surface waters occurred. These results are detailed in the leachate composition analysis and waste composition analysis.

7.3.1.2 Leachate Composition Analysis

This analysis identified an estimated leachate composition that was statistically based upon actual analytical results for areas at RFETS which were considered possible candidate sites for which materials could be placed into the RWSF. Multiple waste streams were used to ensure that the analysis was based upon a representative sample of likely contaminants for RFETS. This analysis considered organics, metals, and radionuclide concentrations (see Table 1, Appendix G, p21).

7.3.1.3 Discharge Composition Analysis

The maximum contaminant concentrations that may occur in groundwater from a potential release from the RWSF were calculated. These calculations were performed on the basis of estimated concentrations of contaminants from the leachate composition analysis and the estimated volumes of leachate anticipated to be generated as a result of moisture infiltration into the RWSF through the interim cover. Two cover scenarios were evaluated, a final closure cover, and a less extensive interim cover. The intent of this analysis was to provide a benchmark for estimating maximum potential values of contaminant discharge via groundwater into neighboring surface waters from the RWSF. This study assumed that no leachate collection was included in the RWSF design. However, both a leachate collection system and liner were designed to capture any discharges from the RWSF eliminating contaminant transport to the groundwater. The discharge composition analysis study represented a worst case scenario where the leachate collection system was inoperable. This did not assume a catastrophic breach however, only a failed collection system where leachate was allowed to accumulate within the liner system and eventually discharge through the liners into the groundwater. Since active management of the system would occur, it is highly unlikely this scenario would exist for a time frame long enough to allow leachate to migrate through the liners. These flow rates were based upon infiltration rates calculated with the HELP model, an EPA approved model for evaluation of engineered barriers (EPA, 1985).

Based upon an estimated waste stream leachate analysis, no discharges to surface waters above action levels were anticipated for either cover scenario. A detailed table listing estimated discharge levels for specific contaminants is included in the study (see Table 3, Appendix G).

7.3.2 Worker Exposure to Radionuclides During Operations

A radiological dose assessment was conducted to assess the maximum radionuclide activities allowable in soils at the RWSF, based on annual exposure limits. The dose assessment used an upper annual exposure limit for a worker of 5,000 mrem/yr (10 CFR 834), and a lower limit of 100 mrem/yr (DOE Order 5400.5). The exposure scenario was for a RWSF operational worker and used site-specific exposure factors. (See Programmatic Risk-Based Preliminary Remediation Goals, Rev 2, DOE 1995).

The soil activity for each individual radionuclide necessary to give a 5,000 mrem annual dose to a worker at the RWSF is 64,100 pCi/g of americium-241, 74,900 pCi/g of plutonium-239, and 1,020,000 pCi/g of uranium-238. The activity of each radionuclide to deliver a 100 mrem annual dose is 1,280 pCi/g for americium-239, 1,500 pCi/g for plutonium-239, and 20,400 pCi/g for uranium 238. These activities were calculated separately for each radionuclide. If all were present, the maximum concentration of each to deliver a given dose would be reduced. Actual activities of radionuclides in the RWSF would be much lower than those calculated for even the 100 mrem dose.

Soils and other materials from across RFETS would be deposited in the RWSF. Average activities would be well below those calculated above for the 100 mrem annual dose, and were estimated to be below the Tier I Action Levels for radionuclides in surface soils (Am-239 = 215 pCi/g, Pu-239 = 1,429 pCi/g, and U-238 = 506 pCi/g, DOE, 1996a). The average activities for soils from the 903 Pad area, which would be deposited in the RWSF, are 10 pCi/g for Am-241, 347 pCi/g for Pu-239/240, and 3 pCi/g for U-238. This indicated that wastes that would be deposited in the RWSF would not pose a radiological health threat to operations personnel. Waste acceptance criteria (WAC) for the facility would establish conservative limits on contaminant levels in deposited wastes,

and significant health and safety monitoring would also be conducted.

7.3.3 Fugitive Dust Emissions

The fugitive dust emissions study estimated maximum-allowable activities in wastes deposited in the RWSF to deliver a known dose from airborne radionuclide contaminants, transported with dust particulates, to an offsite human receptor at RFETS boundary, at 96th and Indiana Street. The study conservatively assumed a five-acre area, continuously exposed to wind erosion, with no effects from operational barriers such as cover on wastes or containers, and 1995 RFETS meteorological wind data. A fugitive dust emissions factor of 66.84 grams/m^2 was calculated using EPA procedures. A regulatory limit for exposure dose was assumed to be 10 mrem per year.

As in the worker dose calculations reported above, the upper limit activity to deliver the maximum allowable dose (10 mrem/yr) was calculated for each radionuclide. The results estimate that if 100 percent of the dust load at 96th and Indiana was from the RWSF the activities of Am-241 or Pu-239/241 could be up to 220,000 pCi/g. The actual contribution of dust from the RWSF would be much less than 100 percent and contributions from RFETS would lower the allowable activity, based on air emissions at the RWSF. However, the RWSF WAC would establish administrative controls on maximum contaminant levels at the RWSF that would be well below the level of concern for air emissions.

The average levels of radionuclides in RFETS soils were much lower than activities necessary to pose a threat to human health of a residential receptor at RFETS boundary. Average activities were not estimated for contaminated debris resulting from D&D actions. The WAC would need to ensure that levels of radionuclides in debris are controlled within acceptable limits by pre-disposal, decontamination, or packaging.

7.4 Technical and Administrative Controls

Technical and administrative controls were implemented in order to ensure that human health and the environment were protected from areas where present or past activities preclude unrestricted access or use, controls are implemented. The technical and administrative controls met the requirements in RFCA paragraph 80 for a CAMU. For the RWSF, controls could be grouped into four major elements:

- Engineering Controls (e.g. double liner system, leachate collection/detection system, interim cover)
- Facility Monitoring (e.g. groundwater monitoring plan)
- Operational Controls (e.g. waste acceptance criteria, inspection, H&S plan, contingency/spill response plan)
- Administrative Controls (e.g limited access; institutional controls)

Engineering controls - There would be specific engineering controls designed into the facility in order to support protection of human health and the environment throughout the operational life of the facility. The following engineering controls of the RWSF would comply with 6 CCR 1007-3, Part

264, Subpart N, 264301 - Design and operating requirements: 264.302 - Action leakage rate; 264.303 - Monitoring and inspection; and 264.304 - Response actions:

- Double liner system (e.g. primary barrier - geosynthetic layer; secondary barrier - composite layer consisting of clay layer overlain by geosynthetic)
- Leachate collection/removal system (e.g. two systems; the first system is an integral collection/removal system constructed in the floor slab with sumps and piping; the second system is the coarse sand drainage layer above the primary barrier with integral collection pipes, pumps and sumps)
- Leak detection system (e.g. geonet layer between the primary and secondary barriers)
- Interim cover design which eliminates infiltration to the greatest extent practicable and promotes drainage with minimum erosion per Subpart 264.310
- An internal infrastructure designed to facilitate placement and retrieval of wastes

Facility Monitoring - In addition to the monitoring and inspection per 264.303 for the double liner system and a fully instrumented leak detection system, an extensive monitoring network would ensure no releases pass undetected from the unit boundary. This would include both air and surface water monitoring stations and groundwater monitoring wells upgradient and downgradient of the RWSF which would require a groundwater monitoring plan in accordance with 6 CRR 1007-3, Subpart F. These requirements would also be integrated into the overall RFETS monitoring program to ensure that a comprehensive network was in place to help protect human health and the environment.

Operational Controls - Operational controls would be put in place to ensure that waste management operations were conducted in such a way as to minimize the risk of release from the facility or exposure to personnel:

- An agency-approved waste acceptance criteria specifying a safety envelope for chemical and physical waste parameters including appropriate treatment requirements
- An operational health and safety plan approved by the agencies designed to provide operational constraints for personnel protection, weather conditions, decontamination procedures, training requirements, emergency response, and health and safety monitoring
- Standard operating procedures that establish clear repeatable guidelines for conduct of operations, including packaging and transporting of waste from D&D or IHSS remediation locations to the RWSF
- Numerous quality assurance procedures from construction quality assurance, as cited earlier per Subpart 264.303 (a) monitoring and inspection, to procedural audits all designed to ensure the facility and operations meet designated performance standards
- Closure plans that define how the facility would be decommissioned after the life of the operations and the performance standards for closure per Subpart 264.310 and 264.552 (e)
- Contingency/spill response plans per Subpart 264.304 would define how the facility responds to a release of waste or constituents from the RWSF

Administrative Controls - Administrative controls are defined to ensure that risk of exposure during construction, operations, and closure are minimized. These may include:

- Appropriate institutional controls (e.g. warning signs, fences, deed restrictions)
- Security plans which define site restriction requirements throughout the life of the project
- Cleanup standards which define the level of cleanup necessary to certify closure

In summary, numerous technical and administrative controls would be in place to insure that all aspects of this effort were conducted in such a way that risks to human health and the environment would be minimal.

7.5 NEPA VALUES

The proposed RWSF would be authorized using a single, integrated Decision Document that would be signed by the DOE, and the State of Colorado, when approved. The Decision Document and review process would satisfy the documentation and procedural requirements of the RFCA. The National Environmental Policy Act (NEPA) process was integrated into the RFCA documentation and procedure, especially public involvement and decision-making, to reduce duplication and paperwork, and streamline the combined NEPA/CERCLA process. In accordance with the DOE Secretarial Policy issued in June 1994, integrated CERCLA/RCRA documents for environmental clean up activities are to incorporate NEPA values to the extent practical. This policy is intended to minimize the cost and time for document preparation and review while meeting the requirements of both acts.

The RWSF would be anticipated to minimize cumulative effects on the environment by being placed in the Industrial Area because of the following:

- The proposed area in the industrial area was already contaminated and consolidation of waste is achieved
- Existing infrastructure already existed which would support the RWSF
- The proposed area was selected based on a detailed siting study which screened out sensitive areas (e.g. areas populating the endangered species Prebles Jumping Mouse, steep slopes, wetlands, etc., were avoided)

The analyses required by NEPA were integrated throughout the Decision Document, with a summary of the analyses provided in Appendix H. Based on the analyses, the decision-making process requires no further documentation to complete the NEPA process.

7.6 CONCEPTUAL WASTE ACCEPTANCE CRITERIA

Waste acceptance criteria (WAC) would be developed for the RWSF to ensure that remediation wastes would comply with applicable regulatory and site requirements. The WAC would set levels for those criteria that could be quantified. The WAC would undergo review and approval by regulators as part of the detailed Title II design review process. The following objectives would be achieved in compliance with the WAC:

1. Remedial wastes would be effectively isolated from potential natural environmental pathways to protect the public health and the environment.

2. RWSF operating personnel and generators would ensure continuous protection to the public health and the environment.

3. Characterization data of the remediation waste would be documented.

The RWSF would receive remediation wastes from the Site Accelerated Actions and D&D cleanup activities which include the following waste types: RCRA; TSCA; LLW; and/or LLMW. The majority of remediation waste would be handled in large bulk volumes, such as roll off containers or tandem dump trucks, rather than small containerization, such as drums or crates.

7.6.1 Physical and Chemical Compatibility Criteria

The WAC would provide physical and chemical limitations and requirements of the remediation waste and for the proper management. Process knowledge and/or chemical and radiological analyses would become the tools to document accurate characterization of the remedial waste. The following areas represent physical and chemical criteria for remedial waste compliance:

General Requirements

1. Waste in monolithic or particulate form will be accepted for disposal.

2. Waste will contain no free liquids.

3. Lack of free liquids shall be demonstrated by EPA Test Method 9095 (Paint Filter Test) or by EPA Test Method 9096. If the generator determines that the waste form is not conducive to either test method, then documentation must be provided to substantiate the claim that no free liquids are present.

4. Gaseous waste will not be accepted. Compressed gases as defined by Title 49, CFR 173.300, including un-punctured aerosol cans, will not be accepted.

5. Aerosol cans will have punctures. Expended gas cylinders must have the valve mechanism removed and shall meet the requirements of Section 3.2.4 for debris.

6. Pyrophoric waste will not be accepted.

7. Sanitary waste will not be accepted.

8. Personnel protective equipment will be accepted.

Physical Requirements

1. Physical properties of monolithic bulk wastes (e.g. maximum size range, specific weight, moisture content)

2. Physical properties of wastes classified as debris (e.g. maximum size range, specific weight, biodegradable)

3. Conditions for filled and emptied containers (6 CCR 1007-3 Subpart N 264.315)

4. Prohibitions of containerized gases, free liquids, pyrophorics, and sanitary wastes

5. CCR 1007-3 Subpart N 264.312, 313, and 314)

6. Management of personal protective equipment (e.g. radiological screen of PPE after usage; followed by disposal)

Chemical Requirements

1. Chemical Analyses, acceptable analytical methods, and detection ranges.

2. Prohibited constituents and chemical characteristics including reactive or ignitable substances (e.g. pyrophoric uranium. See 6 CCR 1007-3, Subpart N, 264.312.)

3. Chemical compatibilities (6 CCR 1007-3, Subpart N, 264.313).

4. pH limitations

5. Composition of waste

7.6.2 Health and Safety - Radioactive Dose Criteria

The WAC would address the radiological limitations and requirements for the waste to meet the CAMU goals and objectives. The RWSF was categorized as less than a Category 3 Facility and designated as a Radiological Nonnuclear Facility based on a hazard categorization analysis for preliminary threshold quantity of plutonium and other radioactive isotopes (Kaiser-Hill, 1996a). All projects at RFETS are designated under two areas, safety class or non-safety class. The safety class was further defined by categories such as Category 1 and 2, with Category 1 being the higher risk. Under the non-safety class, Categories 3 and 4 exist. The RWSF was designated as less than a Category 3 Facility which, by definition, is a non-safety class in accordance with the Conduct of Engineering Manual (COEM) Volume 2, Classification of Systems, Components, and Parts; 2-D03-COEM-DES-223 Revision 1. This categorization analysis was based on sampling data from some of the more radioactive IHSSs, such as the Solar Ponds, the 903 Pad, and Lip Area, and the original Process Waste Lines. To be conservative, the highest activity concentration was used. This categorization was the lowest level of risk categorization. The facility would not receive transuranic (TRU) waste. Radiological requirements specified by the WAC would include the following:

1. Radiochemical analyses for characterization

2. Threshold limits of radionuclides for the RWSF

7.7 REMEDIATION WASTE STORAGE FACILITY OPERATIONS

The RWSF would be operated and maintained under a number of administrative requirements, as previously mentioned in section 7.4 "Technical and Administrative Controls," to ensure compliance with paragraph 80 of RFCA. Administrative controls would be administered for activities of waste operations in the following areas:

1. WAC documents and forms - These would be required to demonstrate compliance with the RWSF WAC and paragraph 80 of RFCA requirements previously mentioned in section 4.2

2. Operating procedures - Procedures for handling and placement of waste, facility maintenance and documentation to ensure safe and efficient operation of RWSF

3. Training Plans - A plan to administer required training for operating personnel in procedures, safety, and quality assurance

4. Health & Safety plans - The health and safety requirements for operating personnel to conduct operations in a safe manner

5. Contingency/spill response plans would define, per Subpart 264.03, how the facility would respond to a release of waste or constituents from the RWSF

6. Limiting operating conditions - Identification of abnormal events which would require operations to temporarily stop activities (e.g. excessive wind velocities, and other weather conditions) to ensure safety to the public, the workers, and the environment

7. Administrative procedure and plans - Additional procedures and plans to ensure compliance with RFCA, DOE orders, and RFETS rules and policies

8. Control of fugitive dust emissions - Facility Monitoring plan as cited in section 7.4 to reduce dust emissions and monitor results to protect the public and worker

9. Closure Plan - This would include the requirements and performance standards for closure per Subpart 264.310 and 264.552 (e) to close the facility after the end of its operational life

Additional requirements addressed in the WAC or Facility Operations Plan for compliance were areas addressing administrative controls. The following requirements would ensure the RWSF to be operated in a safe manner:

- Recordkeeping and documentation
- Waste information from process knowledge and/or sampling and analysis data for waste characterization
- Quality assurance/quality control (QA/QC) certification program and verification;
- Status reports and waste forecasts
- Shipment notification
- Packaging and labeling requirements

7.8 CONCLUSION

The RWSF is proposed as a contingency plan to the existing Ten Year Plan. This IM/IRA Decision Document is the tool to designate the proposed Solar Ponds area as a CAMU for storage of remediation waste as a contingency to the Ten Year Plan. The Decision Document identifies and

explains, in a detailed study and analysis, the best location onsite for the selected remedy—the Concrete-lined Cell. In the event remediation waste could not be shipped offsite as originally anticipated under the Ten Year Plan, then the DOE could implement the CAMU as their contingency in storage of remediation waste.

8.0 SCHEDULE

This Section provides a conceptual schedule for the CAMU process. It includes the designation process outlined in the RFCA, then presents the duration for design and construction of the RWSF if it is constructed. Except for the designation of CAMU, all other activities would be contingency actions to the TYP should the need arise for onsite bulk storage.

This Gantt chart presents project task information as both text and graphics. Information about each task is listed in the Gantt table on the left side of the figure. The Gantt bar chart displays task durations and start and finish dates on a time scale. The relative positions of the task bars show which tasks start and finish before each other and which task overlap other tasks.

In paragraph 109 of RFCA, subparagraphs (b) and (c) durations for the CAMU designation process are given as such:

b. Within 45 days of receipt of DOE's draft IM/IRA, CDPHE shall determine whether the IM/IRA meets or fails to meet the criteria in subparagraph (a). If CDPHE determines that the draft fails to meet the criteria, the draft shall, at the end of a 45-day review, explain with specificity the necessary modifications and allow the DOE to resubmit within 30 days, or to invoke dispute resolution within 14 days. If the CDPHE determines that the application meets the criteria described in subparagraph (a), the CDPHE shall issue the draft IM/IRA for public comment for a period of 60 days.

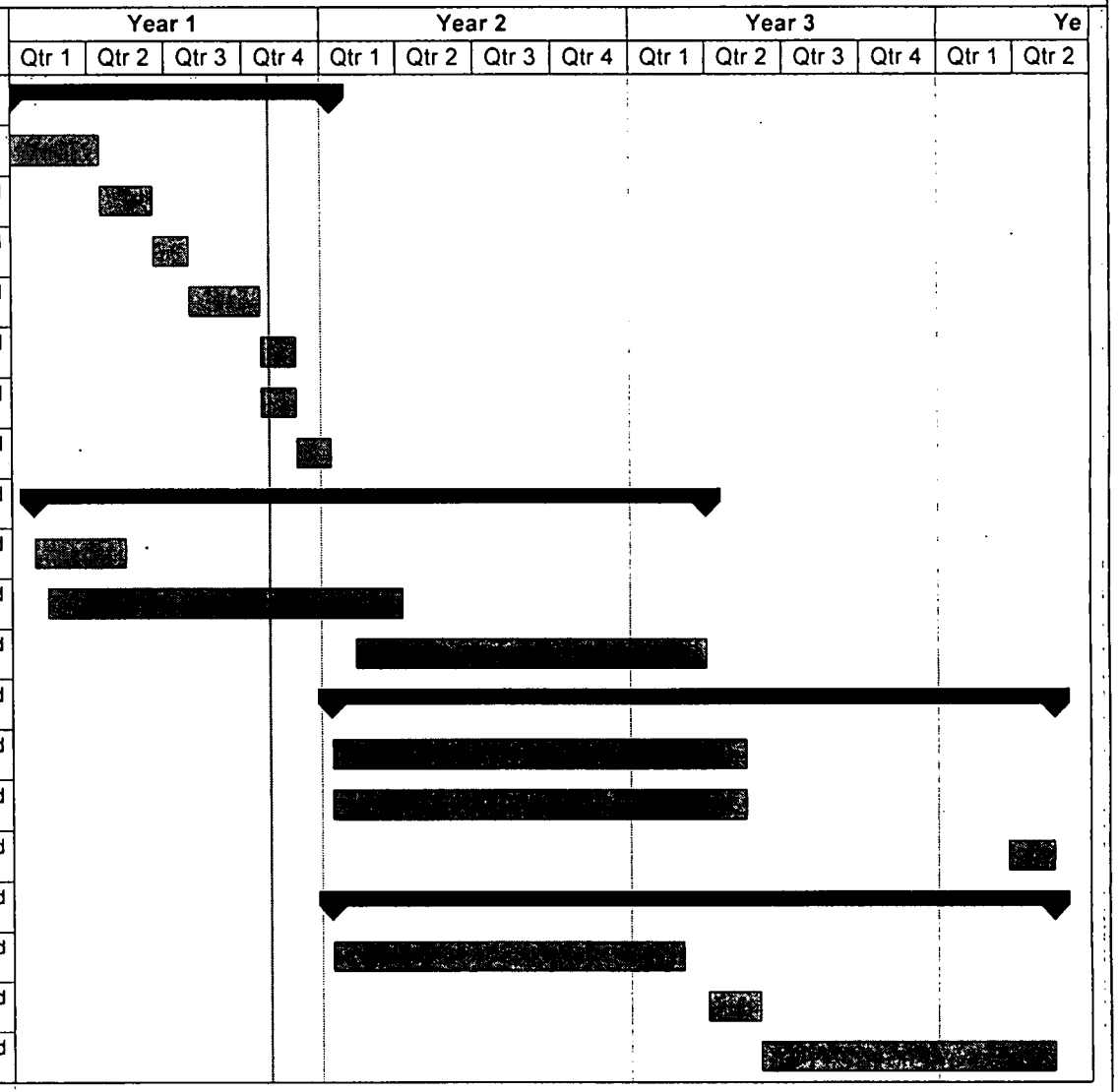
c. Within 30 days of the close to the public comment period, the CDPHE shall review the comments received and modify the draft, if appropriate. The agency shall also prepare a response to significant public comments at this time. At the end of this 30-day period, if the CDPHE still agrees that the IM/IRA, as modified, meets the regulatory criteria for designation and the criteria in paragraph 80, the CDPHE shall designate the storage CAMU. If the CDPHE has determined that the IM/IRA does not meet these same criteria, the CDPHE shall state the changes that DOE must make to receive approval.

Once the CAMU designation is complete, design and construction of the RWSF would be dependent on the need for a contingency to the Ten Year Plan. Construction of the facility, including design, is estimated to take a little more than two years. Placement of remediation waste in the facility would be dependent on the progress of D&D and remediation activities. The schedule for eventual shipment of the waste in the RWSF offsite has not been determined. The Ten Year Plan assumes that all low-level mixed waste would be disposed offsite by the year 2007. The RWSF would likely be utilized past 2007 since it is a contingency action to the Ten Year Plan in case the shipment goal of all remediation waste by 2007 cannot be met. The actual shipping schedule would be dependent on funding and the availability of offsite facilities.

The schedule for implementation of this Decision Document is provided as a Gantt Chart in Figure 8-1.

FIGURE 8-1: PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

ID	Task Name	Duration
1	**Decision Document**	271d
2	PREPARE DECISION DOCUMENT (DD)	76d
3	CDPHE REVIEW DD	45d
4	MODIFY DD BASED ON CDPHE COMMENTS	30d
5	PUBLIC COMMENT PERIOD ON THE DD	60d
6	MODIFY DD BASED ON PUBLIC COMMENT	30d
7	PREPARE RESPONSIVENESS SUMMARY	30d
8	FINAL APPROVAL OF DD	30d
9	**Design**	568d
10	GEOTECHNICAL INVESTIGATION	78d
11	PREPARE CONCEPTUAL DESIGN	300d
12	PREPARE DETAILED DESIGN	297d
13	**Operational and Monitoring Plan Preparation**	612d
14	PREPARE OPERATIONAL DOCUMENTATION	350d
15	PREPARE MONITORING PLAN	350d
16	OPERATIONAL TESTING	40d
17	**Construction**	612d
18	PRECONSTRUCTION PLAN PREPERATION	297d
19	PREPARE SITE FOR CONSTRUCTION	45d
20	CONSTRUCTION OF PREFERED ALTERNATIVE	250d



PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

Task | Summary | Rolled Up Progress
Progress | Rolled Up Task
Milestone | Rolled Up Milestone

FIGURE 8-1: PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

ID	Task Name	Duration	Year 1				Year 2				Year 3				Ye	
			Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2
21	Begin Operations	0d														◆
22	Project Close-Out	55d														

PROPOSED REMEDIATION WASTE STORAGE FACILITY SCHEDULE

Task		Summary		Rolled Up Progress	
Progress		Rolled Up Task			
Milestone	◆	Rolled Up Milestone	◇		

9.0 REFERENCES

DOE, 1995a, EG&G Rocky Flats Environmental Technology Site Land Use Manual, Manual No. 3-END.01.

DOE, 1995b, Programmatic Rick-Based Preliminary Remediation Goals, Rev. #2.

DOE, 1996a, Final Rocky Flats Cleanup Agreement, July 16.

DOE, 1996b, Draft Ten Year Plan, July 30.

EPA, 1985 "Covers for uncontrolled Hazardous Waste Sites" (EPA/540/2-85/002).

EG&G, 1994, INEL, Interim Report; Waste Management Facilities Costs, Information for Mixed Low-Level Waste; March 1994.

Kaiser-Hill, 1996b, Vision of the Rocky Flats Environmental Technology Site, February 9.

Kaiser-Hill, 1996a, Hazard Categorization Analysis for Waste Management Facility, January.

Looby, T., CDPHE, 1995, to J. McGraw, EPA, and M. Silverman, DOE, Subject: Principles for On-Site Disposal of Contaminated Materials, February 27.

RMRS, 1996, White Paper; Analyses of Potential Vertical Contaminant Migration Potential, (RF/ER-96-0040.UN), August 16, 1996. Report prepared for the Kaiser-Hill Company.

APPENDIX A

Corrective Action Management Unit Requirements and Considerations

Rocky Flats Cleanup Agreement Requirements

The following Paragraphs 80, 81, 82, 109, and 110 from the RFCA are specific to CAMU designation and use.

guidelines will be contained in the IGD, in Appendix 3. While these guidelines are not binding on DOE, CDPHE and EPA will use them in reviewing the adequacy of documents submitted and work proposed by DOE.

79. To expedite remedial work and maximize early risk reduction at the Site, the Parties intend to make extensive use of accelerated actions to remove, stabilize, and/or contain Individual Hazardous Substance Sites (IHSSs). Focussing on IHSSs rather than OUs will allow most remedial work to be reviewed and conducted through one of the accelerated review and approval processes described in Part 9, rather than the RI/FS process. The Parties have agreed upon a risk ranking of the IHSSs, which is contained in Attachment 4. The ranking of IHSSs will be reviewed annually, and may be revised as appropriate. The Parties will consider the risk ranking and other factors to prioritize work for the baseline, in accordance with Part 11 (Budget and Work Planning).

80. The Parties recognize that the facility described in this paragraph providing for retrievable, monitored storage of remediation wastes may be converted at a future date to a disposal facility. The Parties also recognize that some remedial actions (e.g., in-place closures) may incorporate disposal as an initial proposal. The Parties anticipate that consistent with the Preamble Objectives, retrievable, monitored storage of remediation wastes (except for TRU or TRU mixed wastes), with an option for conversion to disposal in-place in accordance with future decision-making, may be accomplished through use of a Corrective Action Management Unit (CAMU). The Parties agree that the design criteria for the facility described in this paragraph shall be the same whether the facility is for the retrievable, monitored storage of remediation wastes or for the disposal of remediation wastes. Specifically, the facility described in this paragraph must ensure retrievability of wastes and protection of human health and the environment through a combination of requirements that include, but are not limited to: detection and monitoring/inspection requirements; operating and design requirements, including cap/liner system that meets the requirements as set forth in 6 CCR § 1007-3, Part 264, Subpart N; a ground water monitoring system; and requirements for responding to releases of wastes or constituents from the units. In addition, where necessary for protection of human health and environment, waste treatment will be required. If DOE proposes a CAMU, it is the expectation of the Parties that if the application meets the appropriate substantive criteria, CDPHE will issue a CAMU designation for storage or disposal in a timely fashion, consistent with its general commitment to expedite regulatory approval of those activities required to achieve the Preamble Objectives. If DOE proposes a storage CAMU, it may request that CDPHE make findings of fact as to whether the proposed facility also meets the requirements for a disposal CAMU that are in effect at the time of the request. CDPHE agrees to make such findings upon request. The Parties also agree that a CAMU for remediation wastes and another RCRA/CHWA Subtitle C unit for storage or disposal of process wastes (except TRU and TRU mixed wastes) not regulated under this Agreement may be co-located. The review, approval and oversight of any unit for process wastes is also not regulated under this Agreement, but by CDPHE under the existing CHWA permit, as set forth in Appendix 8.

81. For purposes of this Agreement, wastes generated by activities regulated under this Agreement are remediation wastes. All such wastes, except for TRU and TRU mixed wastes, are suitable for storage or disposal in an approved on-site CAMU, in accordance with the terms of any such approval.

82. Any proposal for a centralized facility at RFETS for the retrievable, monitored storage or disposal of remediation wastes shall be subject to approval only by CDPHE as the LRA, regardless of its location. Notwithstanding any other provision of this Agreement regarding the role of the SRA, EPA may participate fully in the review and consultative processes related to such a facility. In addition, EPA shall have the right to invoke the dispute resolution provisions of Part 15E regarding any CDPHE decision related to such a facility, within 15 days of the issuance of any such decision.

83. Following implementation of all planned accelerated actions, CDPHE and EPA shall evaluate the Site conditions and render final remedial/corrective action decisions for each OU. Notwithstanding the emphasis on accelerated actions and IHSS-based approach, the Parties recognize that the final remedial/corrective action decisions may require some additional work as specified in the CAD/ROD to ensure an adequate remedy.

84. Following implementation of all planned accelerated actions, for the Industrial Area OU, CDPHE will make a final corrective action decision for hazardous constituents pursuant to its CHWA regulatory authority, and DOE, consistent with its authority under CERCLA § 120, shall make a proposed remedial decision under CERCLA. CDPHE shall make a recommendation to EPA whether to concur with DOE's proposed remedial decision for radionuclides and other hazardous substances that are not hazardous constituents. EPA, consistent with CERCLA § 120, shall review DOE's proposed remedial decision and CDPHE's recommendation thereon, and shall then concur or non-concur with DOE's proposed remedy. EPA's decision regarding radionuclides and other hazardous substances that are not hazardous constituents shall incorporate CDPHE's recommendation, so long as EPA determines that the recommendation is consistent with CERCLA. EPA and DOE, consistent with CERCLA § 120, shall also review CDPHE's corrective action decision and shall issue a concurrence remedial action decision under CERCLA, so long as CDPHE's selected corrective action decision is consistent with CERCLA.

85. Following implementation of all planned accelerated actions, for those OUs in the Buffer Zone or offsite, EPA and DOE, consistent with CERCLA § 120, will make a final remedial decision pursuant to CERCLA. CDPHE shall review the final remedial decision and shall issue a concurrence corrective action decision under CHWA, so long as the final remedial action is consistent with CHWA and applicable State law.

PART 9 REVIEW AND APPROVAL OF DOCUMENTS AND WORK

Subpart A. General

86. The provisions of this Part establish the procedures that shall be used by the Parties to provide each other with appropriate notice, review, comment, and responses to comments regarding submitted documents. As of the effective date of this Agreement, all documents identified herein shall be prepared, distributed, reviewed, approved or disapproved, and subject to dispute resolution in accordance with this Part. The Parties shall implement the provisions of this Part in consultation with each other. Schedules for submittal of documents are contained in the baseline in Appendix 4. Procedures in this Part for the review and approval of CAD/RODs shall not alter, but shall supplement the procedures set forth in paragraphs 83 and 84.

scoping process described in paragraph 89, unless the LRA extends this period based on good cause communicated to DOE in a timely fashion. If the LRA disapproves the revised IM/IRA, it shall state the changes that DOE would have to make to receive approval. DOE shall then have 21 days to incorporate the LRA's changes or invoke dispute resolution. If the LRA does not approve or disapprove the revised IM/IRA within the time allotted (including any extension of time), any milestone associated with the IM/IRA shall be suspended and will be re-established as agreed by the Parties. If the Parties cannot agree, EPA and CDPHE shall unilaterally re-establish the milestone. A unilaterally re-established milestone shall be extended by a period no less than the excess time taken by the LRA to render the IM/IRA decision.

108. If there is an activity that DOE expects to undertake in the Industrial Area which is an activity listed as requiring a Class 3 permit modification pursuant to CHWA regulations, and for which no permit by rule would be available, DOE shall--prior to submitting the draft IM/IRA to CDPHE, but after the scoping period--make the draft IM/IRA available for a 60 day public comment period. DOE shall transmit all comments to CDPHE for its subsequent review. CDPHE shall use its best efforts to issue its draft decision, including applicable requirements, and other information as required by current regulation within 30 days of receipt of the draft IM/IRA and public comments. This draft decision shall itself be made available for public comment for 60 days, with an opportunity for public hearing. Within 30 days of the close of the public comment period, CDPHE shall revise its proposed decision accordingly and respond to significant public comment. If CDPHE denies DOE the authority to proceed with the activity or imposes conditions thereon with which DOE disagrees, DOE may invoke dispute resolution.

109. Since the beginning of FY 1996, DOE has engaged members of the public in an on-going conversation, including a dozen meetings and work sessions, regarding whether and how to construct a storage or disposal facility for remediation wastes at RFETS. As a result of this interaction, DOE's ideas about the design and purposes of such a facility have evolved. DOE anticipates that it will be applying during 1996 for designation of a storage CAMU. The Parties commit to a meeting with the public to discuss the CAMU application prior to its submission.

a. When DOE determines that it is prepared to seek designation of a CAMU for storage of remediation wastes, DOE shall submit a draft IM/IRA to EPA and CDPHE which satisfies applicable regulatory criteria for designation and the criteria described in paragraph 80, and presents an analysis of alternatives showing that DOE has considered the following:

(1) worker safety,
(2) protection of public health and the environment,
(3) transportation,
(4) facility design, containment and monitoring,
(5) institutional controls,
(6) cost, and
(7) community acceptance.

The Parties recognize the special expertise of CDPHE with respect to the design of hazardous waste storage and disposal facilities. Therefore, with respect to DOE's obligation to incorporate NEPA values into any decision document associated with the

designation of a CAMU at RFETS, CDPHE will be designated by DOE as a cooperating agency to assist DOE in the analysis of reasonable alternatives, including the "No Action" alternative. As a cooperating agency, CDPHE's participation will be sought by DOE early in the alternatives analysis process to ensure CDPHE's special expertise is available to DOE as it incorporates relevant NEPA values into any decision document associated with the designation of a CAMU.

b. Within 45 days of receipt of DOE's draft IM/IRA, CDPHE shall determine that the IM/IRA meets or fails to meet the criteria in subparagraph (a). If CDPHE determines that the draft fails to meet the criteria, it shall, at the end of its 45 day review, explain with specificity the necessary modifications and allow DOE to resubmit within 30 days or to invoke dispute resolution within 14 days.If CDPHE determines that the application meets the criteria described in subparagraph (a), it shall issue the draft IM/IRA for public comment for a period of 60 days.

c. Within 30 days of the close of the public comment period, CDPHE shall review the comments received and modify the draft if appropriate. The agency shall also prepare a response to significant public comments during this time. At the end of this 30 day period, if CDPHE still agrees that the IM/IRA as modified meets the regulatory criteria for designation and the criteria in paragraph 80, CDPHE shall designate the storage CAMU. If CDPHE has determined that the IM/IRA does not meet these same criteria, it shall state the changes that DOE must make to receive approval.

d. Time is of the essence regarding a final decision on a storage CAMU for remediation wastes. CDPHE recognizes this, and has therefore committed to the review times set forth in this paragraph. CDPHE's failure to meet these time frames does not result in approval of the proposed document.

110. If DOE determines, after a process of public consultation that shall occur in accord with the Community Relations Plan, and after consideration of:

a. protection of public health and the environment;
b. worker safety;
c. transportation;
d. facility design, containment and monitoring;
e. institutional controls;
f. cost; and
g. community acceptance

that it intends to proceed with either (i) building a new on-site disposal facility for remediation waste, or (ii) converting or upgrading an existing unit at Rocky Flats into a disposal facility for remediation wastes, DOE shall apply to CDPHE in accord with then-applicable law. The application shall describe the types of wastes that would be disposed, the location of the facility and its design, along with other information as specified in the IGD; include an analysis of alternatives; and demonstrate that the facility would meet then-applicable legal requirements. This application shall be processed either as an accelerated action pursuant to the process established in RFCA paragraphs 89, 107 and 108, or as part of the CAD/ROD, whichever is

appropriate at the time, as well as in a manner that is consistent with then-applicable requirements.

111. DOE shall submit appropriate Air Pollution Emission Notices as part of the draft decision document for all work, regardless of whether it is to be performed in the Industrial Area or the Buffer Zone. This information shall be available for inspection at RFETS.

112. In responding to draft decision documents that are not Site-Wide documents, the LRA shall obtain comments from and, where appropriate, consult with the SRA. Following such consultation with the SRA (if any) the LRA shall submit a single set of consistent, consolidated comments to DOE on or before the close of the comment period. The LRA agrees to use its best efforts to provide a comprehensive set of comments on draft documents to DOE so as to avoid, to the extent possible, raising issues of first impression at a later stage. Comments shall be provided with adequate specificity so that DOE may respond to the comments and, if appropriate, make changes to draft documents. If the LRA takes more time than allotted pursuant to paragraph 89 to respond to a draft decision document, such a delay may constitute good cause for regulatory milestone modifications.

113. For Site-Wide documents, EPA and CDPHE shall attempt to reach concurrence and provide DOE with a single set of consistent, consolidated comments to DOE on or before the close of the comment period. EPA and CDPHE agree to use their best efforts to provide a comprehensive set of comments on draft documents to DOE so as to avoid, to the extent possible, raising issues of first impression at a later stage. Comments shall be provided with adequate specificity so that DOE may respond to the comments and, if appropriate, make changes to draft documents. If the regulators take more time than allotted pursuant to paragraph 89 to respond to a draft decision document, such delay may constitute good cause for regulatory milestone modifications.

114. Following the close of the review and comment period for a draft decision document (including any public comment), DOE shall prepare a proposed final decision document. In so doing, it shall give full consideration to all written comments submitted by the LRA (or, in the case of Site-Wide documents, EPA and CDPHE). DOE shall seek clarification of the intent and purpose of any comment from the LRA (or, in the case of Site-Wide documents, EPA and CDPHE) that DOE finds is unclear before preparing the proposed final decision document.

115. The LRA (or, in the case of Site-Wide documents, EPA and CDPHE) shall review the proposed final decision document and shall approve or disapprove it. If the proposed final decision document is approved, that document shall become final. If the LRA disapproves a document, it must explain the necessary modifications or reasons for disapproval and delineate the actions that must be taken for approval. If the proposed final decision document is disapproved, DOE shall revise and re-submit those portions of the document that require revision in compliance with the notice of disapproval, unless DOE invokes dispute resolution pursuant to Subpart 15B or 15E, as appropriate, within the period allowed for re-submittal. When dispute resolution is invoked on a proposed final document, work may be stopped in accordance with the procedures set forth in Part 14.

6 Colorado Code of Regulations 1007-3, §264.552, Subpart S - Corrective Action

The following text from the CCR, also known as "the CAMU Rule", defines the conditions for designating a CAMU.

Subpart S-Corrective Action

§ 264.552 Corrective Action Management Units (CAMU).

(a) For the purpose of implementing remedies under § 264.101, § 265.5 or section 25-15-308, C.R.S., the Department may designate an area at the facility as a corrective action management unit, as defined in § 260.10, in accordance with the requirements of this section. One or more CAMUs may be designated at a facility.

(1) For the purposes of the application of the land disposal restrictions found in Part 268, placement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes.

(2) For the purposes of the application of the minimum technology requirements of 40 CFR § 268.5(h)(2), or of the minimum technology requirements of Subparts K, L, M, or N, or the groundwater protection requirements of Subpart F or the closure and post-closure requirements of Subpart G of Part 264 or 265 of these regulations, consolidation or placement of remediation wastes into or within a CAMU does not constitute creation of a regulated unit.

(3) Where the remediation wastes placed into a CAMU are hazardous waste, the CAMU shall comply with Subparts B, C, D and E of Part 264 or 265 of these regulations and, when such remediation wastes will remain in place after closure of the CAMU, the CAMU shall comply with the regulations for the siting of hazardous waste disposal sites, 6 CCR 1007-2, Part 2.

(b)(1) The Department may designate a regulated unit (as defined in § 264.90(a)(2)) as a CAMU, or may incorporate a regulated unit into a CAMU, if:

(i) The regulated unit is closed or closing, meaning it has begun the closure process under § 264.113 or § 265.113; and

(ii) Inclusion of the regulated unit will enhance implementation of effective, protective and reliable remedial actions for the facility.

(2) The subpart F and G requirements and the unit-specific requirements of part 264 or 265 and the financial assurance requirements of Part 266 that applied to that regulated unit will continue to apply to that portion of the CAMU after incorporation into the CAMU.

(c) The Department shall designate a CAMU in accordance with the following:

(1) The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies;

(2) Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposure to hazardous wastes or hazardous constituents;

(3) The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purpose of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility;

(4) Areas within the CAMU, where remediation wastes remain in place after closure of the CAMU, shall be managed and contained so as to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment;

(5) The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with § 264.552(c)(1) or (c)(2).

(6) The CAMU shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation wastes that will remain in place after closure of the CAMU; and

(7) The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU, unless to do so would be inconsistent with § 264.552(c)(1) or (c)(2).

(d) The owner/operator shall provide sufficient information to enable the Department to designate a CAMU in accordance with the criteria in § 264.552.

(e) The Department shall specify, in the permit or order, requirements for CAMUs to include the following:

(1) The areal configuration of the CAMU.

(2) Requirements for remediation waste management to include the specification of applicable design, operation and closure requirements.

(3) Requirements for ground water monitoring that are sufficient to:

(i) Continue to detect and to characterize the nature, extent, concentration, direction, and movement of existing releases of hazardous constituents in ground water from sources located within the CAMU; and

(ii) Detect and subsequently characterize releases of hazardous constituents to ground water that may occur from areas of the CAMU in which remediation wastes will remain in place after closure of the CAMU.

(4) Closure and post-closure requirements.

(i) Closure of corrective action management units shall:

(A) Minimize the need for further maintenance; and

(B) Control, minimize, or eliminate, to the extent necessary to protect human health and the environment, for areas where remediation wastes remain in place, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground, to ground water, to surface waters, or to the atmosphere.

(ii) Requirements for closure of any CAMU shall include the following, as appropriate and as deemed necessary by the Department to protect human health and the environment:

(A) Requirements for excavation, removal, treatment or containment of remediation wastes;

(B) For areas in which remediation wastes will remain after closure of the CAMU, requirements for lining and/or capping of such areas; and

(b) Any temporary unit to which alternative requirements are applied in accordance with paragraph (a) of this section shall be:

(1) Located within the facility boundary; and

(2) Used only for treatment or storage of remediation wastes.

(c) In establishing standards to be applied to a temporary unit, the Department shall consider the following factors:

(1) Length of time such unit will be in operation;

(2) Type of unit;

(3) Volumes of remediation wastes to be managed;

(4) Physical and chemical characteristics of the remediation wastes to be managed in the unit;

(5) Potential for releases from the unit;

(6) Hydrogeological and other relevant environmental conditions at the facility which may influence the migration of any potential releases; and

(7) Potential for exposure of humans and environmental receptors if releases were to occur from the unit.

(d) The Department shall specify in the permit or order the length of time a temporary unit will be allowed to operate, to be no longer than a period of one year. The Department shall also specify the design, operating, and closure requirements for the unit.

(e) The Department may extend the operational period of a temporary unit once for no longer than a period of one year beyond that originally specified in the permit or order, if the Department determines that:

(1) Continued operation of the unit will not pose a threat to human health and the environment; and

(2) Continued operation of the unit is necessary to ensure timely and efficient implementation of remedial actions at the facility.

(f) Incorporation of a temporary unit or a time extension for a temporary unit into an existing permit shall be:

(1) Approved in accordance with the procedures for Department-initiated permit modifications under § 100.61; or

(2) Requested by the owner/operator as a Class II modification according to the procedures under § 100.63 of these regulations.

(g) Incorporation of a temporary unit or a time extension for a temporary unit into a new permit shall be approved by the Department according to the permit review and issuance procedures of § 100.5 of these regulations.

(h) Incorporation of a temporary unit or a time extension for a temporary unit into an order issued pursuant to § 265.5 must be in accordance with the permits by rule provisions of § 100.21(e) of these regulations.

(i) The Department shall document the rationale for designating a temporary unit and for granting time extensions for temporary units and shall make such documentation available to the public.

Subparts T through V [Reserved]

Appendix B

Draft Evaluation of Onsite Versus Offsite Remediation Waste Management Options

TABLE OF CONTENTS

ABBREVIATIONS, ACRONYMS, AND INITIALISMS vi

EXECUTIVE SUMMARY ES-1

B.1 INTRODUCTION B-1

B.2 STRATEGIC TIES TO THE ACCELERATED SITE ACTION PROJECT AND THE SITE VISION B-3

B.3 PLANNED REMEDIAL ACTIVITIES B-5

B.4 DESCRIPTION OF OPTIONS B-9

B.4.1 ONSITE WASTE MANAGEMENT OPTION B-9

B.4.2 OFFSITE DISPOSAL OPTION B-9

B.4.3 NO ACTION ALTERNATIVE B-10

B.5 COST ANALYSIS B-11

B.6 SCHEDULE ANALYSIS B-15

B.7 RISK ANALYSIS B-25

B.7.1 HUMAN HEALTH RISKS TO THE SITE WORKERS AND THE PUBLIC B-25

B.7.2 LIABILITY RISKS B-28

B.7.3 IMPACT TO THE ENVIRONMENT B-30

B.7.3.1 No Action Alternative B-30
B.7.3.2 Offsite Disposal B-31
B.7.3.3 Onsite Waste Management Option B-32

B.8 CAPACITY AND AVAILABILITY B-35

B.9 RECOMMENDATIONS B-39

Attachment 1—Assumptions

Attachment 2—Basis of Estimates for Onsite Waste Management and Offsite Disposal Cost

Attachment 3—Description of Hypothetical Cost Model for Accelerated Actions at the Rocky Flats Environmental Technology Site

FIGURES

B-1 Onsite Waste Management Versus Offsite Disposal Cost Comparison B-13
B-2 Process Flow Diagram for the Offsite Disposal Option B-17
B-3 Process Flow Diagram for the Onsite Waste Management Option. B-20
B-4 Onsite Waste Management and Offsite Disposal Approval Schedules. B-21
B-5 Remediation Waste Disposal Versus Fiscal Year B-42
B-6 Total Waste Dispositioned from Accelerated Actions Versus Time. B-43

TABLES

B-1 Waste Identification and Volumes for a Waste Management Facility B-7
B-2 Onsite Waste Management Versus Offsite Disposal Costs. B-12
B-3 Comparison of Liability Between Onsite Waste Management and Offsite Disposal Options B-29
B-4 Summary of Environmental Impacts. B-33
B-5 Permitted and Interim Status Storage Units B-36
B-6 Comparison of Capacity and Availability of Waste Management Options. B-38
B-7 Remediation Waste (cubic yards) Treated by Fiscal Year. B-41

Foreword:

This document was developed in March 1996 to compare various onsite and offsite disposal options. The focus of the low level, low level mixed, and hazardous remediation waste program at that time was to determine which option was most favorable and to recommend that option for implementation. The final recommendation reached was to use an onsite waste disposal facility with appropriate monitoring and retrievable features. The negotiation process in achieving the Rocky Flats Cleanup Agreement (RFCA) and the responses and comments from various Stakeholders has caused a reevaluation of the original recommendation for onsite disposal.

In keeping with RFCA and the Draft DOE Ten Year Plan, there is a renewed focus on maximizing the amount of remediation waste which will be treated and disposed of offsite. With the possibility of lower volumes of remediation waste requiring treatment and disposal, because of less restrictive cleanup levels, the cost competitiveness of offsite treatment and disposal shows more promise. Thus, the conclusions from this document for onsite disposal are not as clearly distinct as the volume of remediation waste decreases. The use of the storage facilities described in the main document accompanying this appendix is evidence of the shift to more flexible options.

The data presented in this appendix remain valid in demonstrating that a thorough cost analysis was conducted to evaluate offsite disposal and that significant up front cost savings can be achieved through the use of onsite storage. The use of storage facilities will help the RFETS achieve safe and effective cleanup consistent with RFCA and the draft Ten Year Plan.

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

ASAP	Accelerated Site Action Project
CAMU	Corrective Action Management Unit
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CY	calendar year
cy	cubic yard
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
ER	Environmental Restoration
FY	fiscal year
HW	hazardous waste
IA	Industrial Area
IDM	Investigation-Derived Material
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
LDR	Land Disposal Restrictions
LLMW	low-level mixed waste
LLW	low-level waste
nCi/g	nanocuries per gram
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Act
OU	Operable Unit
PCB	polychlorinated biphenyls
PPRG	programmatic preliminary remediation goal
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RSR	Radioactive Waste Shipment and Disposal Record
Site	Rocky Flats Environmental Technology Site
Site Vision	Rocky Flats Conceptual Vision
TSCA	Toxic Substance Control Act
VOC	volatile organic compounds
WAC	waste acceptance criteria
WMF	waste management facility

EXECUTIVE SUMMARY

The purpose of this evaluation is to select the best waste management option for remediation waste at the Rocky Flats Environmental Technology Site (Site). It is part of the decision-making process for an Interim Measure/Interim Remedial Action (IM/IRA) to address remediation waste, and the intent is to reflect the current waste and environmental strategies and to be consistent with input from stakeholders. Onsite waste management was selected as the best of three options: onsite disposal, offsite disposal, and no action. The selection of onsite waste management was based on the following:

- Projected costs for onsite waste management were lower than for offsite disposal.
- Accomplishment of more risk reduction activities in support of the Rocky Flats Conceptual Vision (Site Vision). These activities could be accomplished in less time, and at a lower cost.
- Less public exposure during transportation, along with less involuntary risk.
- Less risk of spills in handling and transportation.
- Greater capacity for onsite waste management compared to offsite disposal. An onsite facility would be more accessible and more available when needed.
- Fewer schedule restrictions for an onsite facility.
- Fewer analytical requirements for an onsite facility because there is less redundancy in sampling requirements.

Ultimately, the most important difference between the onsite and offsite options is total cost and the effect of cost for reducing risk at the Site. In essence, the more it costs to dispose of a cubic yard (cy) of contaminated material, the fewer cubic yards of material the Environmental Restoration (ER) program will be able to clean up in a given timeframe. This prolongs the cleanup efforts at the Site and allows contaminated materials to remain uncontrolled in the environment for much longer periods of time. In turn, this increases the overall risk at the Site to human health including the offsite population, the onsite workers, and the environment.

In the past, environmental restoration activities at government facilities have been regarded as having unlimited budgets. Funding was expected to increase with each fiscal year and all restorations were expected to be funded. Hard choices are now necessary because federal spending reform has imposed limits on funding for environmental restoration. As part of this evaluation, it was necessary to select the waste management option that could best reduce the overall risk to human health and the environment while remaining fiscally responsible. Budget restraints now directly affect the degree of risk reduction possible. Because the onsite option can more effectively reduce the overall risk to both the public and the environment at a lower cost, it is clearly the best selection. With a given budget to

perform work onsite, more cleanup actions can be performed more effectively, and therefore, the Site can be made safer with onsite waste management.

B.1 INTRODUCTION

As part of risk reduction activities at the Rocky Flats Environmental Technology Site (Site), a projected 100,000 cubic yards (cy) of remediation waste will be excavated and appropriately managed over the next several years. This remediation waste from high risk Individual Hazardous Substance Sites (IHSSs), hot spots, and the Solar Evaporation Ponds primarily consists of either excavated media with hazardous constituents or with mixed hazardous/low-level radioactive constituents. The reduction of environmental risk is directly dependent on the ability to disposition remediation waste. This document addresses the overall approach to the disposition of remediation waste, and evaluates whether this remediation waste should be managed onsite or offsite.

The following three objectives were developed to reflect risk reduction goals as well as safety:

1. **Ensure the safety of the public, onsite workers, and the environment through safe management of remediation waste in a timely manner**

2. **Develop a viable means of consolidating and managing of remediation waste to support the Rocky Flats Conceptual Vision (Site Vision), Accelerated Site Action Project (ASAP), and risk reduction goals in the near term while addressing liability and safety issues in the long term.**

3. **Provide a cost-effective solution that can support aggressive environmental remediation and be implemented under existing budgetary constraints.**

The general approach of this evaluation is as follows:

1. Define the objectives needed to support risk reduction at the Site.

2. Develop three waste management options: no action alternative, onsite waste management, and offsite disposal. The no action alternative was evaluated as an option to not implementing or not resolving the other two options.

3. Evaluate the options in terms of cost, schedule, risks, capacity, and availability. Emphasis was placed on the ability of each option to support overall risk reduction and the Site Vision.

4. Recommend an option based on the above criteria.

This document is organized as follows:

Section B.2 - Strategic Ties to the Accelerated Site Action Project and the Site Vision describes the importance of resolving remediation waste disposal to achieve the goals of the Site Vision.

Section B.3 - Planned Remedial Activities summarizes the remediation activities scheduled for fiscal year (FY) 96 through FY98 that will require disposal of remediation waste.

Section B.4 - Description of Options describes the different options evaluated for remediation waste management.

Section B.5 - Cost Analysis evaluates each of the options based on estimated cost.

Section B.6 - Schedule Analysis compares the time required for disposal of remediation wastes for each option.

Section B.7 - Risk Analysis evaluates the risks associated with each option.

Section B.8 - Capacity and Availability evaluates the storage capacity and ability for each option to accept the remediation waste as generated.

Section B.9 - Recommendations presents the recommended option and supporting rationale.

The evaluation focuses on risk reduction activities scheduled for the near term in the Environmental Restoration (ER) budget baseline. These activities target areas with the greatest risk based on currently available data from documented environmental releases. Contamination levels, contaminant-specific risks to human health and the environment, and potential exposure pathways were considered in selecting these areas. The goal of these early actions is to remediate most of these areas in the near term. To achieve this goal, a cost-effective waste management facility (WMF) needs to be operable as soon as possible. This facility must demonstrate protectiveness for human health and the environment within a limited budget. In addition, any WMF must have the capacity to accept large quantities of remediation waste in a short timeframe to support the more streamlined and aggressive cleanup program required for the Site Vision.

B.2 STRATEGIC TIES TO THE ACCELERATED SITE ACTION PROJECT AND THE SITE VISION

Under the Site Vision, the United States Department of Energy (DOE) will remediate the Site in a manner consistent with future projected land and water uses. The future land use of the buffer zone, as recommended by the future Site Use Working Group and the Site Vision, is for open space; whereas the Industrial Area (IA) is projected to be used for industrial use. Low-level radioactive and hazardous waste will be left onsite in a stable configuration. The goal of the Site Vision is to reach an operational state in which all of the plutonium at the Site will be consolidated and stabilized, and most of the risk reduction activities completed. Under the Site Vision, high risk and no further action Individual Hazardous Substance Sites (IHSSs), including the former Operable Unit (OU) 5 (IHSS 115 of the Industrial Area OU [formerly OU 5]) and OU 7 landfills outside of the IA, will undergo closure. Many of the contaminants are not amenable to treatment and will require excavation and placement in a facility.

To implement the Site Vision, an overall approach to remediation waste management is needed. Continued use of temporary storage at the Site is not feasible because of the shortage of permitted space and the logistics of storing and monitoring the anticipated large volumes of remediation waste. The volume of remediation waste and the logistics of handling it, require that a WMF (onsite or offsite) be available to accept the remediation waste as it is excavated. A decision on the approach to remediation waste management must be determined early and implemented prior to excavation to support environmental risk reduction, and the Site Vision. Without a waste management pathway, not only will specific near-term risk reduction actions not be possible, but long-term activities will also be impacted.

Plans for the disposition of the remediation waste must fit into the Site Vision. In particular, a waste management approach must be incorporated into a Site closure strategy. Likewise, all waste management options must integrate with the overall Site closure strategy and the Site Vision statement. Each option must be evaluated according to its ability to meet the schedule requirements for Site closure, to support individual closure activities, to maximize land use flexibility, to meet cleanup standards relative to the projected land use, and to mesh with building closures and the planned capping of the IA.

B.3 PLANNED REMEDIAL ACTIVITIES

A means for dispositioning remediation waste must be available to support planned activities on high risk areas in the near term. These activities include the following:

- The Solar Evaporation Ponds remediation waste, which will include materials from the solar pond liners, basecourse, sludge, miscellaneous debris, and some vadose zone soils (now on hold) will require disposition

- The excavation of East Trenches (i.e., trenches T-1, T-3, and T-4), the 903 Pad and Lip Areas, and the Mound Area. The typical excavated media from these locations will be soils, sanitary sludges, and decomposed drums

- The excavation of soil and debris from the cleanup of Industrial Area OU tanks T-2, T-3, T-9, T-10, T-14, T-16, and T-40 from IHSS 121 and tanks from IHSS 129

- The excavation of remediation waste and IHSS 119.1 in OU 1

- The excavation of remediation waste from hot spots

- The disposition of the remaining precasting volume of Investigation-Derived Materials (IDM) from drilling activities

- The decontamination and decommissioning of Site facilities

Remediation wastes include, but are not limited to, the following:

- Contaminated soils and debris collected from accelerated actions and hot-spot removal

- Pond sludge currently stored in Resource Conservation and Recovery Act (RCRA)-certified tanks

- Sediments

- Toxic Substance Control Act (TSCA) waste, such as asbestos and polychlorinated biphenyls (PCBs)

- Treatment by-products from groundwater, surface water, and/or soil remediation actions

- IDM from characterization activities, such as wells and borings, are also defined as remediation waste

- Debris from decontamination and decommissioning activities

Only remediation wastes are considered in this evaluation; process waste is not included. For the purposes of this document, saltcrete and pondcrete generated from the Solar Ponds are considered as process waste. The contaminants of concern in these media can be summarized as: radionuclides (e.g., plutonium and americium), heavy metals (such as cadmium and chromium), volatile and semivolatile organic compounds, asbestos, and PCBs.

Waste volume estimates and the dates when these wastes would be generated from planned risk reduction activities over the next three years are presented in Table B-1. These waste volume estimates include only near-term accelerated actions. Additional remediation waste, including remediation waste from decommissioning activities could also be disposed of in the near term. A basis of 100,000 cubic yards (cy) was used for comparing the options to ensure that planned early actions were covered as well as near-term decommissioning activities. It is assumed that soils contaminated with volatile organic compounds (VOCs) would be treated by thermal desorption, after which the residuals would be disposed of at the original excavation location if they comply with the programmatic preliminary remediation goals (PPRGs). The assumptions for this estimate are presented in Attachment 1.

Table B-1 Waste Identification and Volumes for a Waste Management Facility

Waste Source (OU/IHSSs)	Description of Media	Waste Type	Estimated Total Volume (cy)	Anticipated Volume after Thermal Desorption (cy)
Solar Ponds				
Liners	Asphaltic Material	LLMW (rads/metals)	11,800	11,800
Liners Basecourse	Soils	LLMW (rads/metals)	11,800	11,800
Sludge	Solidified Sludge	LLMW (rads/metals)	6,000	10,000
Vadose Soil	Soil	LLMW (rads/metals)	20,000	20,000
Debris	Building Materials	LLMW (rads/metals)	700	700
Subtotal for Solar Ponds			50,300	54,300
Potential Early Actions - Top IHSSs				
Trench T-1	Soil, Drums, Pyrophoric Uranium	LLMW (rads/VOC)	3,000	1,000
Trench T-3	Soil, Drums, Sanitary Sludge	LLMW (rads/VOC)	2,700	300
Trench T-4	Soil, Drums, Sanitary Sludge	LLMW (rads/VOC)	2,500	300
Trenches T-5 through T-11	Soil, Sanitary Sludge, Planking	LLMW	6,000	1,000
Mound Area	Soil and Drums	LLMW (rads/VOC)	5,000	1,500
903 Pad and Lip Area	Soil and Asphaltic Material	LLMW (rads/VOC)	13,200	13,200
Tanks 9 and 10 (includes OU 8 IHSS 118.1)	Soil, tanks, piping	LLMW (rads/VOC)	2,000	500
Tanks 2 and 3	Soil, tanks, piping	LLMW (rads/VOC)	500	500
IHSS 119.1	Soil	LLMW (rads/VOC)	1,500	50
Tanks 14 and 16	Soil, tanks, piping	LLMW (rads/VOC)	4,450	3,340
IHSS 129	Soil	HW (VOC)	2,200	0
Tank 40	Soil, tanks, piping	LLMW	1,300	130
Miscellaneous Hot-Spot Removals	Soil	LLMW	50	50
Subtotal for Potential Early Actions			44,400	21,870
Investigation-Derived Material (IDM)	Drill Cuttings/Soil	LLMW, HW, LLW	1,200	180
Subtotal			95,900	76,350
Expansion Factor; 15%			14,385	11,453
Grand Total			110,285	87,803

B.4 DESCRIPTION OF OPTIONS

The options for onsite waste management and offsite disposal of remediation waste were evaluated for all waste management activities including transportation to the disposal/storage facility, operations at the facility, and closure. The onsite waste management option, requires the design and construction of a new WMF, because an onsite facility that can accept this type or volume of material does not exist.

B.4.1 ONSITE WASTE MANAGEMENT OPTION

In the onsite waste management option, remediation waste would be managed in an onsite WMF designed to handle remediation waste. Appendix C, Onsite Waste Management Facility Siting Study, evaluates seven onsite locations, that would be potentially suitable for a WMF. For this onsite option, it was assumed that the remediation waste must be placed as bulk into a cell; however, the cell would be segregated for differing wastes types to support retrievability. The design of the cell would meet RCRA Subtitle "C," 6 Code of Colorado Regulations (CCR) 1007-3, Subpart S, Corrective Action of 264.552, 6 CCR 1007-3, and 6-CCR 1007-2, Part 2, "Requirements For Siting of Hazardous Waste Disposal Sites." The facility would accept media with low-level radioactive (e.g., less than 100 nanocuries per gram [nCi/g]) and/or hazardous constituents. This would not preclude the shipment of remediation waste that could be more effectively and economically managed offsite. The facility would be designed and constructed to meet all of the applicable federal, state, and local regulatory requirements.

B.4.2 OFFSITE DISPOSAL OPTION

Several offsite locations were considered under this option. Low-level waste (LLW) can be sent to the Nevada Test Site (NTS); however, NTS cannot accept low-level mixed waste (LLMW) under their current waste acceptance criteria. The Waste Isolation Pilot Plant (WIPP) location does not accept LLW or LLMW as part of their waste acceptance criteria (WAC); the option therefore was not carried forward in the study. The best facilities for the disposition of remediation waste with only hazardous constituents are Subtitle "C" landfills, such as the RCRA landfill in Last Chance, Colorado. At this time, the only facility accepting mixed remediation waste is the Envirocare facility in Tooele, Utah. For near-term remedial actions, it is anticipated that 90% of the waste will be mixed and could therefore go to the Envirocare facility under this option.

The construction of a new offsite facility was considered; however, it was rejected because it would not meet the schedule requirements for the Site Vision. Depending on the location and the operator, many years would be required for a Nuclear Regulatory Commission License, an Environmental Impact Statement, a RCRA permit, land acquisition, and other requirements. Only existing facilities that could support the accelerated action schedule were considered.

B.4.3 NO ACTION ALTERNATIVE

This no action alternative is an option to the development of an ER waste management strategy. It was included in the evaluation to furnish a baseline for risk reduction at the Site that did not include the excavation and removal of remediation waste. In this option, all waste materials would be left in place with the exception of those materials that could be treated to remove organic compounds and still meet the PPRGs.

B.5 COST ANALYSIS

Based on the waste volume estimates discussed in Section B.3, Planned Remedial Activities, 100,000 cy was selected as the basis for this cost analysis. Two cost estimates were developed: one for offsite disposal and one for onsite waste management. The estimates are based on previously incurred costs, professional experience, vendor quotes, conceptual design information, current labor rates, and current adjustment factors.

The major factors that affect offsite disposal costs include handling, packaging, transportation, the waste acceptance criteria, amount of waste being shipped at one time, the time of year during placement, the treatment method used, and the amount of debris in the waste. Where possible, assumptions for offsite disposal were selected to lower the cost and improve the feasibility of this option. Based on these assumptions, a life-cycle cost of approximately $2,302/cy was estimated (see Table B-2 for the cost summary, Attachment 1 for assumptions, and Attachment 2 for the cost basis). This cost includes packaging, handling, treatment, characterization, transportation, and disposal charges. Previously published estimates included only treatment and disposal charges, not the entire life-cycle cost.

The life-cycle cost for onsite waste management will be approximately $948/cy. This estimate includes packaging, handling, transportation, treatment, characterization, cell design and construction, operations, cap design and construction, and postclosure care and monitoring (see Attachment 1 and Attachment 2). The magnitude of the cost differences between onsite waste management and offsite disposal is illustrated in Figure B-1.

It is important to note that both estimates are conceptual and are subject to variations as additional information is obtained. However, because offsite disposal is twice as expensive as onsite waste management, it has been concluded that the onsite waste management option is the only viable alternative, based on the rough order-of-magnitude estimates.

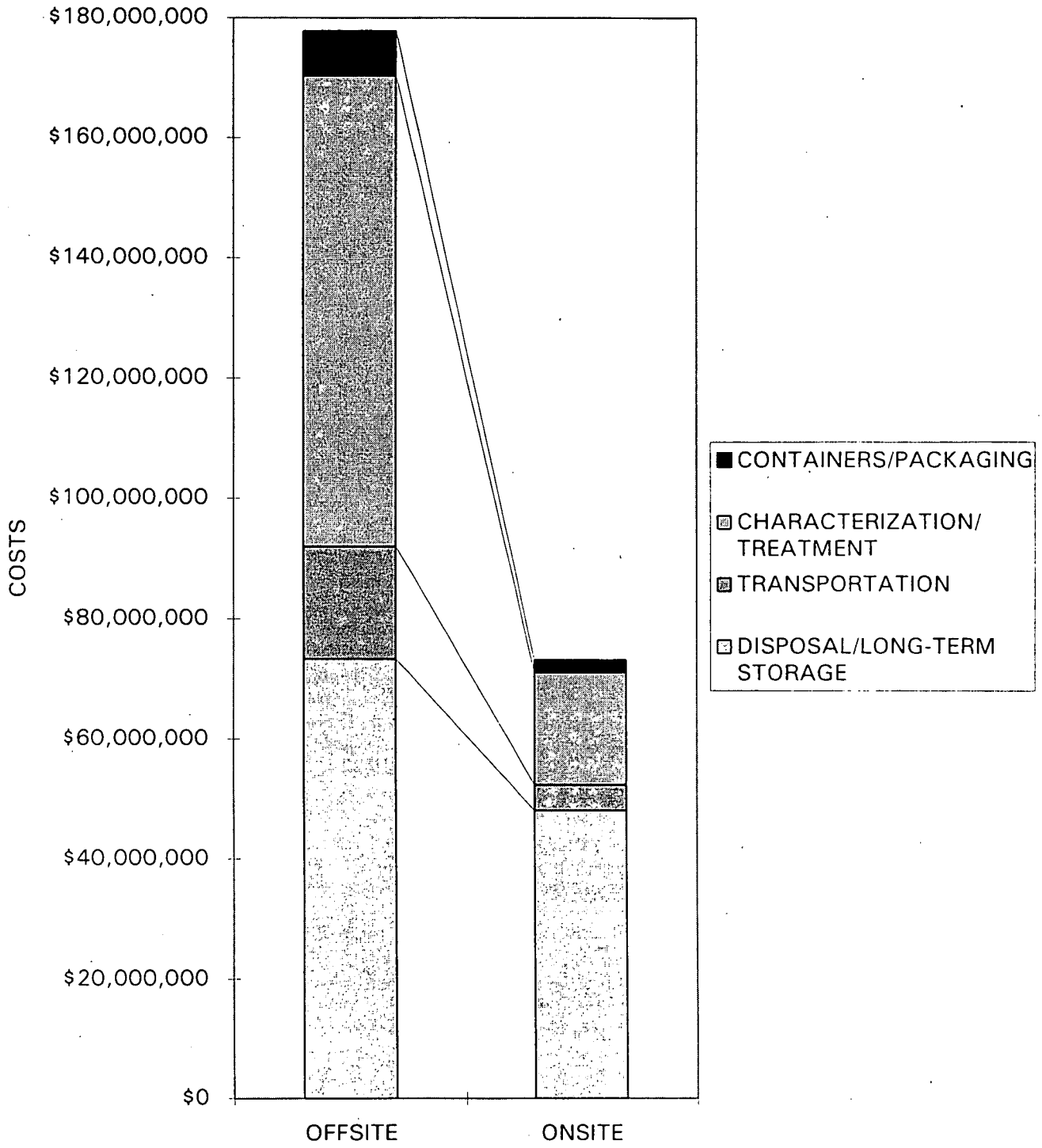
Table B-2 Onsite Vs. Offsite Disposal Costs

	Offsite Disposal		Onsite Management			
Activity	Total Cost	Cost/ cy			Total Cost	Cost/ cy
Containers	$4,643,000	$46			-0-	-0-
Packaging	$2,855,000	$29			$2,100,000	$21
Treatment/Characterization	$78,352,000	$784			$18,722,000	$187
Transportation	$18,647,000	$186			$4,309,000	$43
Disposal	$73,322,000	$733	**Onsite Management**			
			- Design	$1,235,000		
			- Permitting	$300,000		
			- Cell Construction	$20,777,000		
			- Operations	$11,604,000		
			- Cell Closure	$796,000		
			- Post Closure Care	$13,378,000		
			Subtotal	$48,090,000	$48,090,000	$481
Total Costs	$177,819,000	$1,778			$73,222,000	$732
Contingency	$52,332,000	$523			$21,549,000	$215
Total Cost with Contingency	$230,151,000	$2,302			$94,771,000	$948

Note: All costs are in 1996 Dollars without contingency, except as noted. All are based on a waste volume of 100,000 cy managed or disposed.
Note: LAC updated the Offsite costs from the "new" Summary Tables E1-11 on 4/16/96 Specifically the No Action Table E-11
Note: LAC updated the Onsite costs from the CLC-B Summary Table E-2 on 4/3/96

FIGURE B-1: ONSITE WASTE MANAGEMENT VS. OFFSITE DISPOSAL COST COMPARISON

(Based on a 100,000 cy scenario)



A big discrepancy in the treatment and characterization costs between the two options is shown in Table B-2 and Figure B-1. Under the Corrective Action Management Unit (CAMU) guidelines, the waste does not have to be treated to meet the Land Disposal Restrictions (LDR), however the waste must comply with onsite WAC. The treatment costs were developed from the actual costs for thermal desorption at the Site and the estimates for the Solar Pond sludge solidification process. Attachment 2 explains how the characterization costs were developed for the two options. Treatment costs were one of the major differences between the two options. This was mainly due to the expected costs of having to solidify some of the waste to meet the LDRS.

The total volume of remediation waste was another factor added to the cost difference between onsite and offsite options. If the total volume of remediation waste was sufficiently small, it would be less expensive to ship waste offsite; however, the projected total waste volume is approximately five times greater than that volume. The break-even point for managing waste onsite is 12,750 cy.

B.6 SCHEDULE ANALYSIS

One of the key factors for the comparative analysis of onsite waste management versus offsite disposal is schedule limitations. Cost and schedule are inseparable because one affects the other. Because of budget and schedule constraints, the concept of reducing overall risk to the public and the environment in less time, at a lower total cost, is more attractive than an extended waste removal process using offsite disposal. In the future, project expediency will become a significant factor in getting funding from Congress.

The no action alternative will obviously delay cleanup. The risk to the public and the environment will continue and will likely increase because of open pathways for contaminant migration. Schedule delays will not only impact the risk but will increase future costs when escalation of remedial actions is implemented.

Offsite disposal will require more time to disposition remediation waste than onsite waste management. The remediation waste at the Site is primarily LLMW and under the offsite disposal option most of the waste would go to the Envirocare facility, which currently is the only facility in the nation licensed to receive LLMW. As shown in the process flow diagram of Figure B-2, a long, arduous process is required before waste can be shipped offsite and accepted. Envirocare facility requirements that impact the schedule include:

- Documentation requirements that are more extensive for disposal at Envirocare than for onsite waste management. Most of the documentation is required prior to shipment. For any given wastestream, the documentation requirements are greatly reduced after the first shipment. An estimate of the waste volume must be submitted to Envirocare a full year prior to shipment.
- Waste acceptance contingent on the submittal of sampling and characterization data. The remediation waste must be sampled and analyzed several times prior to placement in the disposal facility. The initial analysis must be completed before submittal of Envirocare forms.
- Remediation waste meeting LDRs. Delays and additional costs will be incurred in treating the waste.
- Time-consuming logistics of handling and shipping the waste. Mixed waste must be containerized.
- Interim staging requirements for large bulk media for storing the waste while awaiting approval for shipment from Envirocare.
- The completion of manifests/travelers and compliance with U.S. Department of Transportation (DOT) criteria (which specify weight restrictions and other criteria) which creates additional delays and costs.

Figure B-2 Process Flow Diagram for the Offsite Disposal Option

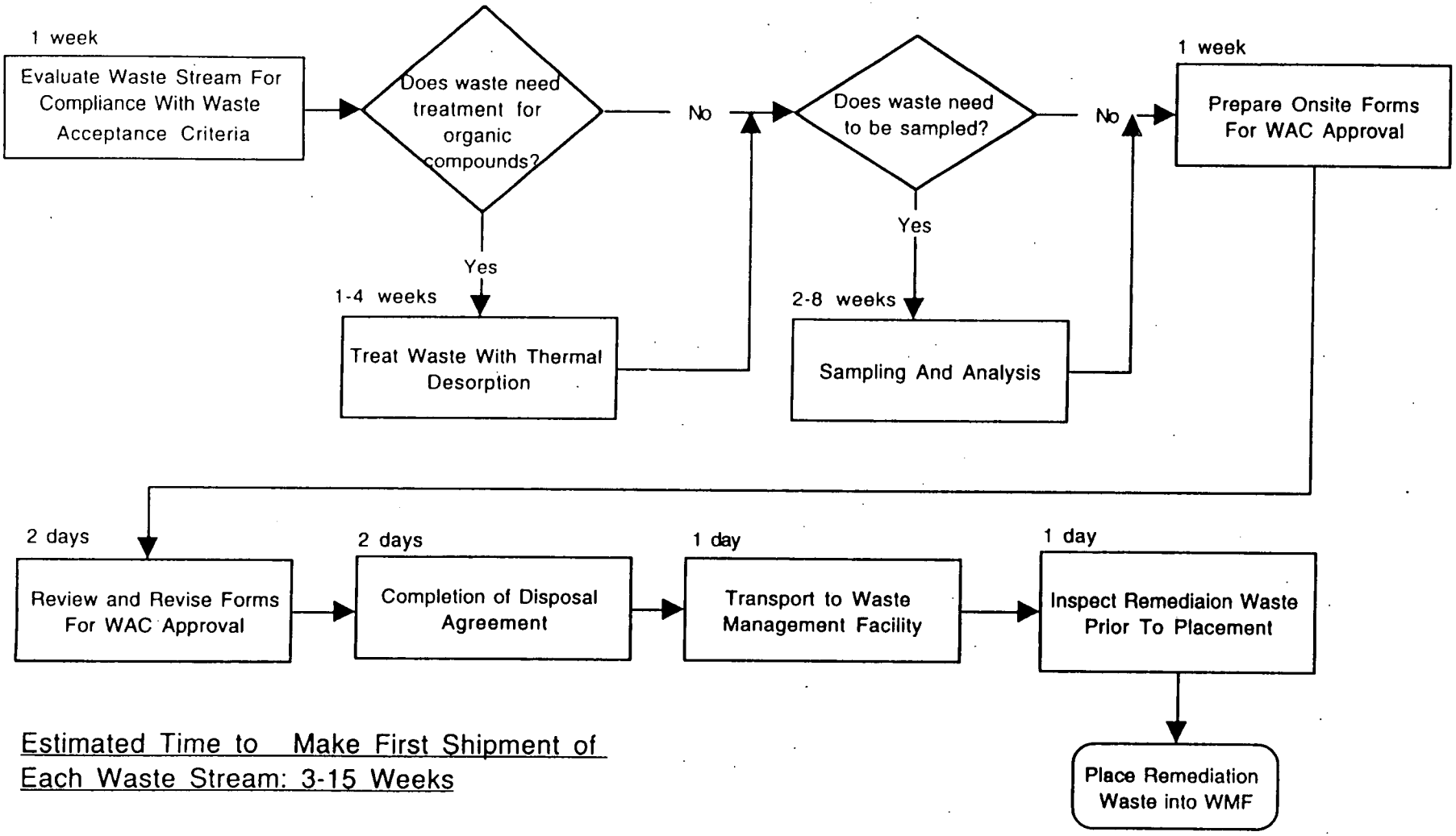
Onsite waste management has a shorter schedule than offsite disposal, once the WMF has been constructed. Like Envirocare, the onsite WMF would meet WAC; however, as shown in Figure B-3, the path from excavation to final placement would be less intensive and more expeditious. In general, only one sampling and analysis event would occur. The logistics of handling and disposal would be more straight forward because of the proximity of the disposal location. Likewise, DOT requirements would not be applicable because no state or interstate highways are traveled, and weight restrictions could be modified. Schedule problems that impact onsite disposal include:

- The placement of waste in an onsite WMF will be delayed until the facility is constructed. This is likely to cause handling problems for remediation waste excavated prior to the completion of an onsite facility.

- Additional security requirements could hamper the transport of remediation waste, although these requirements are insignificant compared to the packaging and manifesting requirements for offsite transport.

A schedule of the onsite waste management and offsite disposal options is shown in Figure B-4 for comparison.

Figure B-3 Process Flow Diagram For Onsite Waste Disposal Option



Estimated Time to Make First Shipment of Each Waste Stream: 3-15 Weeks

Estimated Time to Make Each Additional Shipment of Each Waste Stream: 3-15 Weeks

Figure B-4: Onsite and Offsite Approval Schedules

ID	Task Name	Dur
1	ONSITE WASTE MANAGMENT FACILITY	51d
2	Evaluate Waste Stream for Compliance with WAC	5d
3	Decision Point - Does waste need treatment for organic compounds	0d
4	Treat Waste With Thermal Desorption	10d
5	Decision Point - Does waste need to be sampled	0d
6	Sampling and Analysis	25d
7	Prepare Onsite Forms for WAC Approval	5d
8	Review and Revise Forms	2d
9	Completion of Disposal Agreement	2d
10	Transport to WMF	1d
11	Inspect Remediation Waste Prior to Placement	1d
12	OFFSITE DISPOSAL	195d
13	Envirocare sends Instructions and forms to the Site	0d
14	Evaluate Waste Stream for Compliance with WAC	5d
15	Decision Point - Is treatment required to meet LDR's	0d
16	Sample waste stream	3d
17	Treat to meet LDR's	25d
18	Representative Samples are analyzed at Lab (use Utah Certified Labs)	40d

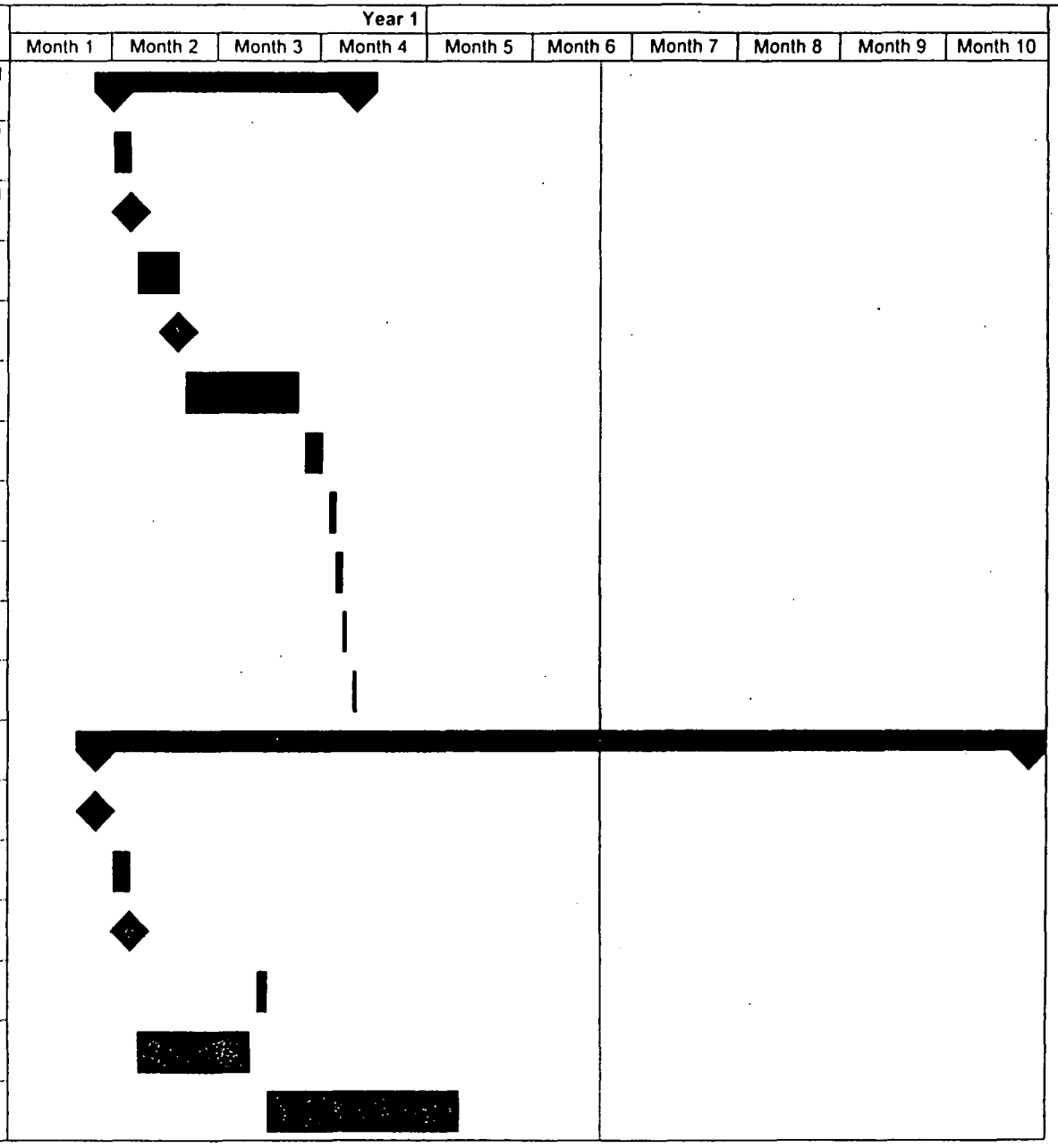


Figure B-4: Onsite and Offsite Approval Schedules

ID	Task Name	Dur
19	Decision point - Does waste meet LDR's	0d
20	Site completes Envirocare Profile Forms	5d
21	Site Reviews and Revises Forms	2d
22	Submit Lab Analysis, Forms and Pre-Shipment Samples to Envirocare	3d
23	Envirocare Evaluates Material for acceptability and approves waste profile forms	10d
24	Envirocare Analysis of Pre-Shipment Samples & establishes "Fingerprint" Acceptance Parameters	20d
25	Completion of Disposal Agreement	5d
26	Prep and Submit Radioactive Waste Shipment & Disposal Record, Manifest, and Transportation Plan	5d
27	Evirocare Approval of Disposal Record and manifest	0d
28	Envirocare Signs and Sends Notice to Transport and Pre-Shipment Sample Lab Results	5d
29	Site sends 3-day shipment notification	1d
30	Make First Shipment of a single half-crate	10d
31	Envirocare inspects incoming shipment and takes samples for fingerprinting and independent analysis	2d
32	Fingerprint parameters verified to allow unloading of waste	0d
33	Acceptable independent third-party analysis confirms shipment compliance	5d
34	Envirocare sends confirmation of disposal to the Site	0d
35	Decsion Point - Does Waste meet LDRs	0d
36	Treat to Meet LDRs	25d

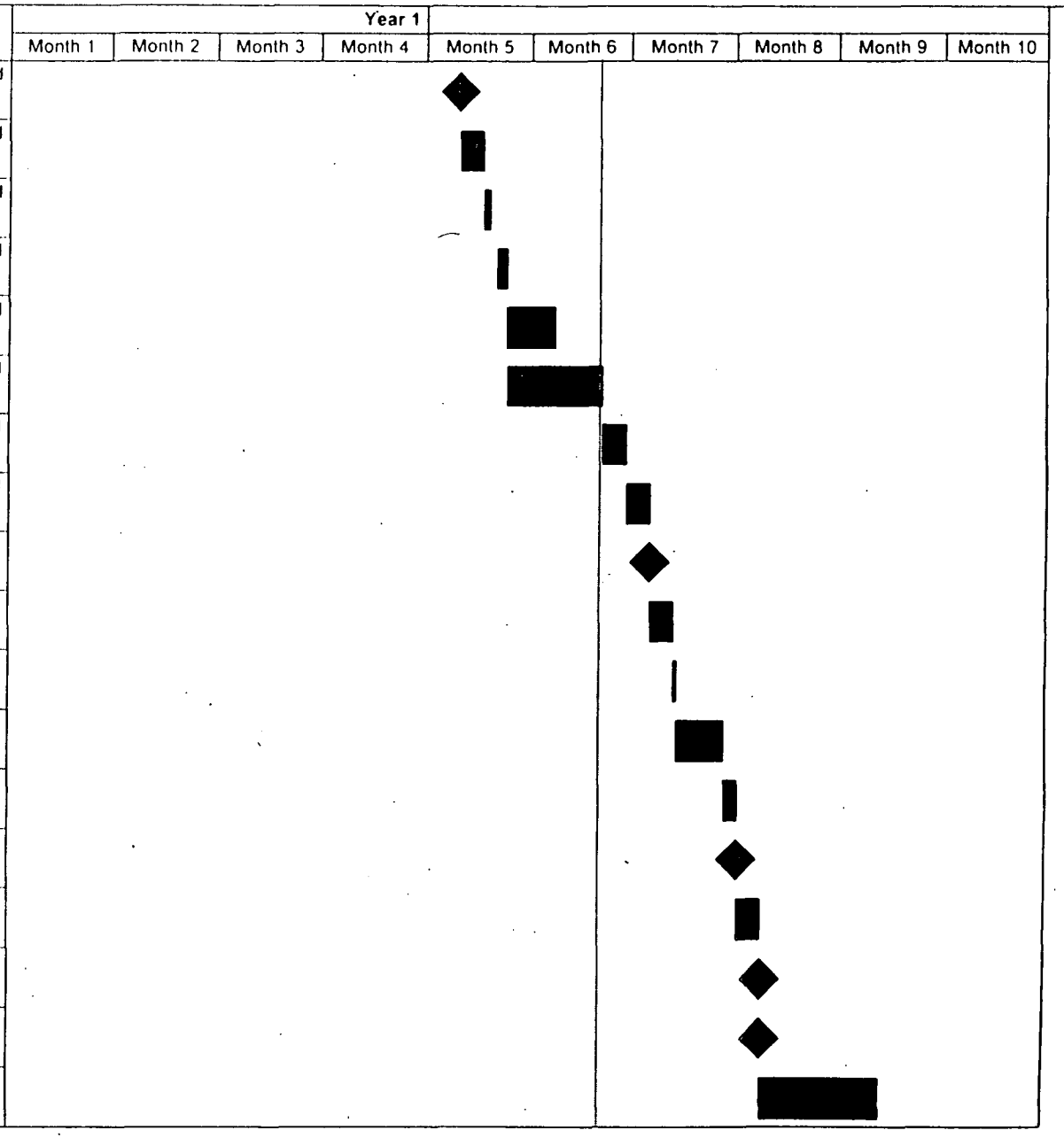
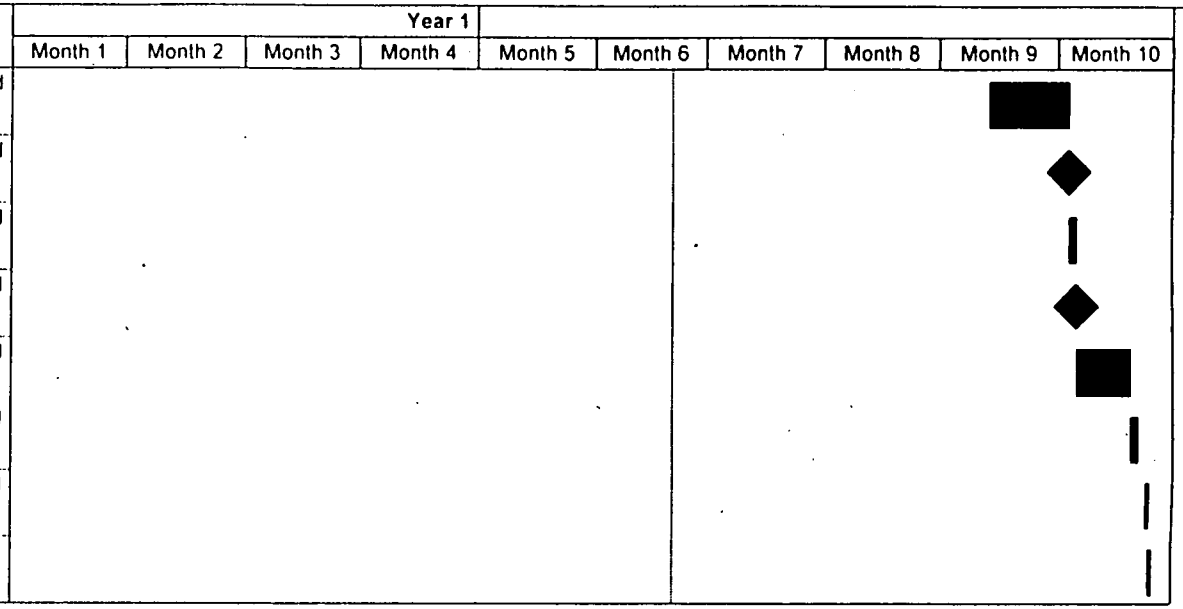


Figure B-4: Onsite and Offsite Approval Schedules

ID	Task Name	Dur
37	Take Composite Samples And Analyze	15d
38	Decision Point - Does Waste Meet LDRs	0d
39	Prepare Envirocare Forms	2d
40	Site sends 3-day Shipment Notification	0d
41	Regular Shipment of Containerized Waste	10d
42	Envirocare inspects incoming shipment and takes samples for fingerprinting and independent analysis	2d
43	Envirocare sends confirmation of disposal to the Site	1d
44	Fingerprint parameters verified to allow unloading of waste	1d



B.7 RISK ANALYSIS

The risk analysis evaluated three types of risks: human health risk, liability risk, and risks to the environment.

B.7.1 HUMAN HEALTH RISKS TO THE SITE WORKERS AND THE PUBLIC

For the purposes of this evaluation, human health risk or hazard resulting from exposure to chemicals in the soil or water is defined as the increased chance or probability of developing cancer or other adverse health effects as a result of that exposure. Exposure may occur through ingestion of soils or waters, absorption of chemicals through the skin, or by inhalation of airborne particulates or vapors. The health effects from these exposures could vary from minor skin irritations to cancer, depending on the chemical, the concentration, the exposure pathway, the length of the exposure, and the susceptibility of the receptor.

The nature of the health risks to individuals can be classified as involuntary or voluntary, and as uncontrolled or controlled. Acceptability of a risk depends on its nature. Health risks to hazardous waste/remediation workers at the Site is minimized by compliance with the Occupational Safety and Health Act (OSHA) and DOE orders. Health risks are controlled through safety and awareness training, use of personal protective equipment, and monitoring systems. The risk is voluntary because the worker has the option to either accept or decline the task. Furthermore, the risk is clearly communicated, controlled, and accepted by the worker. Risks to the community from future land uses at the location or from remedial activities are generally involuntary and cannot be controlled to the same extent as risk to a worker. If the decision is made to take no action or to transport wastes offsite, the ability to minimize human health risks to the community is greatly diminished.

For the three options, the human health risk evaluation must consider very different ways in which people could be exposed to radiological or hazardous contaminants (exposure scenarios). Worker safety is a factor for both onsite and offsite disposal. Risks to public safety due to accidents in transportation and handling of the waste is a factor for the offsite disposal option. Public safety risks include transportation- and construction-related injuries and fatalities, in addition to accidental radiological or hazardous releases.

Of the three options, the no action alternative could present the greatest human health risk to the community in the long term and least risk in the short term. The magnitude of the risk depends upon the types of exposures to the public, the concentrations, and types of chemicals present. This is dependent on the actions taken to prevent offsite migration and on the future land use permitted at the Site.

Risk assessments have been completed on areas in the buffer zone that initially were thought to be contaminated. The human health risks for OU 1 and the former OUs 2, 5, and 6 have been

characterized as part of the RCRA Facility Investigation/Remedial Investigation process. These assessments characterize the human health risks of the no action alternative.

Exposures to a potential office worker and to an open-space recreational user present the highest risk estimates. Cancer risks for office workers from contaminant exposure in buildings projected for the above OUs varied from 2 in 10,000 in OU 1, to 5 in 100,000 in the Walnut Creek area. This means that if 10,000 office workers worked in the highest risk area for 25 years, not more than 2 workers would be expected to develop cancer due to exposure to chemicals or radionuclides. The estimated risks to open space users were even lower, varying from 1 in 100,000 to less than 1 in 1,000,000. This means that for every person who uses the buffer zone for open-space recreation for 10 hours a month over
a 25-year period 1 in 100,000 might develop cancer due to contaminant exposure. These risks are very low when compared to the background rates of 25 to 30 people out of 100 who develop cancer during their lifetimes.

Risks have also been calculated for the exposure of offsite residents to contaminants in 903 Pad Mound and East Trenches. The risk of cancer to a resident living near the location due to offsite migration of 903 Pad Mound and East Trenches contaminants is much less than 1 in 1,000,000, varying from 1 in 10,000,000 to 1 in 100,000,000,000. These risks are considered too low to be of consequence. Data from recent accelerated actions indicate that 903 Pad Mound and East Trenches subsurface contaminant concentrations could be significantly higher than originally estimated and likewise the human health risks to construction workers could be higher if the no action alternative were implemented.

Risk assessments for the IA have not been conducted. It is expected that the human health risks will be higher than in the buffer zone because of the intense industrial activity that has taken place there for the last 50 years. Investigation data suggest that contaminant concentrations are significantly higher than levels in the buffer zone, and therefore, if no action is taken, the risks to Site workers would be higher. Without source removal, there is also a greater potential for release to the community following Site closure.

The remaining two options are onsite waste management and offsite disposal of remediation wastes. After the remediation waste has been placed in a WMF, the risks associated with these options should not be significantly different. However, the risks to both the Site workers and the public are expected to vary greatly in the handling and the movement of wastes to a facility. The differences in risks are due to uncertainties associated with transportation of the wastes.

Onsite transportation involves the movement of wastes by truck for a distance of less than 3 miles, through a controlled environment (the site). Risks associated with this movement can be tightly controlled, especially with respect to the community and worker exposure. Offsite transportation involves the movement of LLW, LLMW, and HW for distances of approximately 700 miles by rail and/or trucking. It is estimated that during the disposal effort, over 2.5 million miles would be logged

by trucks offsite. For the total waste volume, national statistics in Accident Facts from the National Safety Council published in 1994, suggest that five accidents would occur during transportation to the offsite repository. These accidents would not necessarily be fatalities but could result in personal injuries, property damage, or an accidental spill. As a result of these accidents, communities along the route from the Site to the disposal cell could be exposed to both chemical and radiological contamination. The magnitude of these risks are difficult to quantify; however, these exposures would be both involuntary and uncontrolled and, as such, may not be acceptable to potentially exposed communities (but probable low, given the nature of the waste).

Human health risks from onsite construction and transportation are much lower. Only about 6,000 miles would be logged by trucks onsite. The risk of uncontrolled releases of toxic substances will be greatly reduced. The risk to the public will be negligible and Site worker risk is controlled. Risks will also be controlled through dust suppression, personal protective equipment, training, continuous monitoring, and other safety measures.

In summation, onsite waste management is the best option in terms of human health risks for the following reasons:

- The no action alternative would provide no risk reduction.
- Additional handling and transportation to the offsite facility increases the likelihood of accidents resulting in injuries or spills.
- The offsite disposal alternative creates involuntary and uncontrolled risks to the public.
- The onsite waste management option is more amenable to risk management because risks can be tightly managed and controlled. Health risks to the workers would be better known and more risks would be voluntary.
- Finally, fewer overall risk reduction activities (including source removal) would be able to occur when using offsite disposal because less funding would be available.

The onsite waste management option offers the greatest overall risk reduction. Risk management could be conducted in a tightly controlled manner. Remediation waste would not be moved through communities where the public could be involuntarily subjected to accidental spills. Additional risk reduction could occur sooner and at a lower cost reducing exposure pathways through the air, surface waters, and groundwater.

B.7.2 LIABILITY RISKS

In evaluating liability, both near-term and long-term liability risks were analyzed. Near-term risks include the liability from spills that could occur in handling, storing, and transporting the remediation waste. Long-term liability risks include the ability to manage materials safely over time and long-term fiscal liability. These long-term risks could exist because some contaminants present in the remediation waste are resistant to natural degradation processes.

The liabilities involved with the no action alternative present the greatest risk because of the potential that contaminants could migrate offsite as airborne particulates or through surface waters to private and public lands, and bodies of water. Potential costs for cleanup of larger areas of contamination and possible payments for damage to human health and the environment are significant. The increased number of potential exposure pathways create a greater possibility for contamination of offsite lands, thus creating more liability from lawsuits for damage of property than either onsite waste management or offsite disposal of remediation waste. There could be additional exposure to the public if future land uses of the Site allow greater public access. Without some removal of contaminants, the Site cannot be released for other uses.

If remediation waste is disposed of offsite, it reduces no-action risks but there are the increased liabilities. The offsite disposal option could cause spills that could occur during transportation because of the additional mileage to offsite facilities, including damage caused by contaminated media being spread on uncontaminated roads and offsite property. The costs for offsite spills could be greater because there is a greater potential of larger and more pristine areas to become contaminated. Additionally, physical damage could occur to people, vehicles, and property.

Long-term waste management options, both onsite and offsite, were deemed to be equally effective in containing contaminants because of similar design and similar regulatory requirements. The Site and NTS are both DOE facilities. Other facilities are under private ownership. NTS cannot accept RCRA-listed waste, which severely limits the volume of waste that NTS can accept from the Site. For the offsite disposal option, most of the remediation waste would have to be managed in facilities that rely on the viability of a private firm to ensure continued operation. For the DOE, this reliance on a private firm is a risk in terms of liability, because there is no guarantee of continued effective operation. There is also no guarantee that the facility will remain effective over the hundreds or even thousands of years that the waste will pose a risk. Under CERCLA liability, waste remains the responsibility of the generator forever. A comparison of liability risks is presented in Table B-3.

Table B-3 Comparison of Liability Between Onsite Waste Management and Offsite Disposal Options

Liability	No Action Alternative	Onsite Waste Management Option	Offsite Disposal Option
Transportation Risks	Not Applicable	Reduced mileage to WMF would reduce likelihood of a spill. If a spill did occur it would be on DOE property, and therefore, would not affect private or public property.	Increased risk due to additional distance to WMF. Spill or accident could threaten public health or damage public or private property.
Handling Risks	Not Applicable	Less handling prior to shipment would reduce worker exposure and accidents.	Additional handling prior to shipment could increase liability risk from worker exposure and accidents.
Long-Term Fiscal Liability	Liability risk due to potential migration of contaminants via groundwater, surface water, and airborne particulates.	Liability due to leaks and spills.	Liability due to leaks and spills.
Fiscal Risk	Mitigation costs of offsite land and surface water.	Reduced fiscal risk-WMF remains on government property. DOE retains better control of costs in the event of a spill.	Possibility that operator might not exist in future. Liability for remediation waste could fall back to DOE based on CERCLA, or if trusts are consumed.
Long-Term Effectiveness	Not effective - Contaminated materials continue to be exposed to the environment. Cleanup costs increase because of the increase in areas of contamination.	Because of similar engineering design requirements, onsite and offsite are approximately the same.	Because of similar engineering design requirements, onsite and offsite are approximately the same.

B.7.3 IMPACT TO THE ENVIRONMENT

Environmental impacts to air quality, surface water, groundwater, soils, and ecosystems were considered for the three options. Impacts due to construction and/or expansion of offsite facilities were not considered because it was assumed that these impacts had already occurred. Environmental impacts from source removals were assumed to be similar between the onsite and offsite options. Dust suppression, erosional control, and other efforts will be used to minimize the impact. Because of regulatory requirements, both onsite and offsite options were assumed to be adequately designed to protect the environment once the remediation waste had been placed in the WMF.

B.7.3.1 No Action Alternative

The no action alternative would have the most detrimental impacts to the environment because the least amount of effort would be put into restricting the migration of contaminants.

Impact to Air Quality

There could be local air quality impacts due to the dispersion of contaminated soils which were not remediated. Emission rates of volatiles in subsurface soils will be dependent upon future activities at the location. Potential exposures or releases could result from future events, such as construction or erosion.

Ecological Impact

Impacts to ecosystems are not expected to be significant. Minor impacts to plants and wildlife could slowly increase as contaminants migrate. Contaminants could move from sources to groundwater and from groundwater to surficial waters which, in turn, increases exposure to surficial ecosystems; however, many of these contaminants will be destroyed, volatilized, or adsorbed by the soil prior to exposure by this pathway.

Impact to Soils And Sediments

The volume of contaminated subsurface soil will increase slowly as free-phase solvents and contaminated groundwater spread out. Sediments could be impacted as airborne contaminants settle in drainages, seeps bring contaminants to the surface, and/or erosion occurs. This is not consistent with intent of Rocky Flats Cleanup Agreement (RFCA).

Impact to Water Quality

Groundwater plumes will continue to spread due to diffusion and advection. Additional contaminants will leach into groundwater and surface waters because the sources of contaminants have not been removed.

B.7.3.2 Offsite Disposal

Impact to Air Quality

Direct environmental impacts include vehicle exhaust during excavation and transportation of the excavated materials and particulates from excavation, placement of contaminated media, and transportation over dirt roads. There is a potential for a spill to occur during handling and transportation, resulting in the dispersion of contaminated dust or vapors. Dust control during the spill cleanup should reduce this impact.

Ecological Impact

No direct impact to the ecosystem is anticipated, except if a spill were to occur during handling or transportation. If excavation of a spill were required, plants and/or habitats could be destroyed and irreversible harm could occur, if the replacement of these plants and/or habitats were not successful.

Impact to Soils And Sediments

As with the other environmental impacts, if a spill occurred during handling or transportation, there could be a direct impact to soils. Excavation of the contaminated soil would be required and, based on the characterization of the spill area, a greater volume of contaminated soil could require remediation.

Impact to Water Quality

No direct environmental impact is anticipated, except if a spill occurs during handling or transportation. Contamination of the surface water is possible depending on the location of the spill.

B.7.3.3 Onsite Waste Management Option

This option assumes that the location of a WMF will be at the Site (see Appendix C, Onsite Waste Management Facility Siting Study). Environmental impacts are location-specific and this evaluation could change based on the selected location.

Impact to Air Quality

Direct environmental impacts include vehicle exhaust during excavation and transportation of the excavated materials and particulates from excavation, placement of contaminated media, and transportation over dirt roads. There is a potential for a spill to occur during handling and transportation, resulting in the dispersion of contaminated dust or vapors. Impacts would be controlled by operational control of particulate and airborne contaminants.

Ecological Impact

Impacts to plant communities, wetlands, and other habitats will be minimized at the selected location. Likewise, the impact to threatened and endangered species is also expected to be minimal.

Impact to Soils and Sediments

Minimal damage will occur to the top soil at the selected location of the WMF. A higher erosional impact could also occur particularly if the WMF is situated close to areas with high natural erosion rates, such as drainage basins and slopes; however, through siting and erosional controls this effect will be minimized. Spills or leakage through the cell liner could also occur that could impacts surficial soils.

Impact to Water Quality

Based on the siting requirements in 6 CCR 1007-2, the WMF would be designed to isolate wastes for a thousand years from natural environmental pathways that could expose the public. Therefore, no impact on water quality is anticipated for the onsite option. An onsite WMF would include a postclosure (30 years) groundwater monitoring system for early detection of contaminant migration. There is a possibility of spills during transportation and handling; however, this risk is much less than the offsite option because of the close proximity of the WMF and fewer labor-intensive handling requirements prior to placement of the remediation waste. A summary of potential environmental impacts is given in Table B-4.

Table B-4 Summary of Environmental Impacts

Option	Air Quality Impact	Ecological Impacts	Soil and Sediment Impacts	Water Quality Impacts
No Action Alternative	Airborne dispersal of contaminants in soils.	Damage to local ecology due to unchecked migration of contaminants.	Increase in contaminated areas due to unchecked migration of contaminants.	Increase in plume size and increased transport of contaminants to surface water.
Offsite Disposal Option	Possible impact due to spills, otherwise minimal.	Possible impact due to spills, otherwise minimal.	Possible impact due to spills, otherwise minimal.	Possible impact due to spills, otherwise minimal.
Onsite Waste Management Option	Possible airborne particulates/ contaminants generated during construction depending on location. Possible impact due to spills.	Dependent on location. Impacts to plants, animal habitat, and threatened and endangered species can be minimized through location selection process.	Dependent on location. Possible impact to the topsoil. Erosional impacts are also possible.	Minimal impact.

B.8 CAPACITY AND AVAILABILITY

The capacity and availability for accepting remediation waste of the three different remediation waste management options are significant factors in the decision-making process. As a permitted treatment and storage facility (e.g. existing RCRA Permit #91-09-30-01 for storage), the Site has temporarily stored waste for the short and the long term until offsite disposal could occur. The cost impacts have been enormous in providing capital investment for storage facilities, and the required routine maintenance and scheduled walkdowns of waste inventories.

As mentioned previously, the majority of ER remedial waste media is projected to be contaminated soils and designated as LLMW. The most cost-effective and efficient manner in handling this waste media is in bulk (e.g., tandem dump trucks or large roll-off containers) versus drums or crates. The Site has a permitted storage capacity of 23,700 cy for LLMW. An inventory of LLMW, as of January 1995, accounts for 19,300 cy, which leaves 4,400 cy of usable storage space (see Table B-5, Permitted and Interim Status Storage Units). The permitted capacity of several of the RCRA units is larger than the available physical capacity of the unit. The permitted capacity can never be realized because of the physical limitations of the facility. A majority of the permitted facilities are structured for the storage of drums and crates and not for roll-off containers used for bulk ER waste material. As shown in Table B-1, the ER waste generation rate would surpass the existing available onsite storage space before offsite shipment could occur. Common sense dictates that waste should not be generated unless the material can be immediately disposed of offsite or managed onsite.

For the no action alternative, there is no driving factor because no removal action will take place. The waste material would remain as is with a higher level of risk to the public and the environment; therefore, capacity and availability have no significant impact.

For the offsite disposal option, capacity and availability are significant factors. Oak Ridge National Laboratory (ORNL) is the DOE facility that has contracted collectively on behalf of all DOE facilities with Envirocare of Utah for waste disposal. The contractual maximum waste limit which in all DOE facilities collectively can ship to Envirocare is 350,000 cy over the entire contract life (e.g., 5 years). A further breakdown of this value is 70,000 cy/year by all combined facilities. However, the WAC imposed by Envirocare to waste generators requires a rigorous process of verification and assurance for compliance with the LDR. A process flow diagram that outlines the duration of these requirements is shown in Figure B-2 and illustrates that waste generated cannot be shipped offsite until approval is granted from the disposal location (Envirocare).

Table B-5 Permitted and Interim Status Storage Units (Reference: 1995 Comprehensive Waste Management Plan)

Unit	Unit Name	Waste Type	Permitted/Interim Status Storage Capacity		Physical Capacity (m3)		On-Hand Inventory (m3)		Remaining Capacity (m3)			Comment
			Liquid	Total	Liquid	Solid	Liquid	Solid	Liquid	Solid	Total	
1	Main Hazardous Waste Storage Area	LLM	466.85	466.85	313.93	313.93	12.83	0.00	301.10	301.10	301.10	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity.
		HAZ	466.85	466.85	152.92	152.92	79.19	49.23	24.50	24.50	24.50	
		Total	466.85	466.85	466.85		92.20	49.23	374.65	325.60	325.60	Administrative limit of 200 cu yd for HAZ waste.
6	Chip Drum Storage Area: Building	LLM	4.43	4.43	4.43	4.43	0.00	0.63	3.80	3.80	3.80	
		Total	4.43	4.43	4.43		0.00	0.63	3.80	3.80	3.80	
10	Drum Storage Area: Building 561	LLM	78.74	78.74	78.74	78.78	61.92	0.00	15.43	15.43	15.43	Total on-hand inventory includes nonhazardous waste stored in this unit.
		Total	78.74	78.74	78.74		63.31	0.00	15.43	15.43	15.43	
11 (Includes Units 61 & 62)	Container Storage Area Building 776, Room 134	LLM	0.00	255.88	4.78	14.34	0.00	39.36	4.78	20.08	24.86	Total on-hand inventory includes nonhazardous waste stored in this unit.
		TRM	0.00	113.93	0.00	113.93	0.00	39.06	0.00	24.86	24.86	
		Total	0.00	255.88	133.05		0.00	108.19	0.00	24.86	24.86	Twenty five percent of LLM physical capacity reserved for repacking
12	Drum Storage Area: Building 776, Room 237	LLM	37.89	37.89	35.17	35.17	0.00	29.13	0.17	0.17	0.17	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity. Total on-hand inventory includes nonhazardous waste stored in this unit.
		Total	37.89	37.89	35.17		0.61	34.39	0.17	0.17	0.17	
13	Mixed Waste Storage: Building 884	LLM	139.91	209.86	194.82	194.82	0.42	168.78	20.10	20.10	20.10	Total on-hand inventory includes nonhazardous waste stored in this unit.
		Total	139.91	209.86	194.82		0.42	174.30	20.10	20.10	20.10	
14	Centralized Waste Storage Facility: Building 906	LLM	0.00	3975.92	0.00	2857.70	0.00	0.00	0.00	2857.70	2857.70	Liquid storage not allowed.
		HAZ	0.00	3975.92	0.00	2857.70	0.00	0.00	0.00	2857.70	2857.70	Physical capacity assumes 1:1 ratio of crates to 55 gallon drums.
		Total	0.00	3975.92	2857.70		0.00	0.00	0.00	2857.70	2857.70	
15A	904 Pad and Cargo Containers	LLM	60.31	844.28	60.31	478.18	0.84	383.81	59.47	94.37	153.84	Physical capacity limited due to stacking and large container constraints.
		Total	60.31	844.06	538.49		0.84	383.81	59.47	94.37	153.84	
15B	Mixed Waste Storage Area: 904 Pad	LLM	8181.22	8181.22	8181.22	8181.22	0.00	5041.73	3139.49	3139.49	3139.49	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity.
		HAZ	8181.22	8181.22	8181.22	8181.22	0.00	0.00	3139.49	3139.49	3139.49	
		Total	8181.22	8181.22	8181.22		0.00	5041.73	3139.49	3139.49	3139.49	
17	Mixed Waste Storage: Building 777, Room 423C	LLM	0.00	1.25	0.00	0.84	0.00	0.84	0.00	0.00	0.00	Liquid storage not allowed.
		Total	0.00	1.25	0.84		0.00	0.84	0.00	0.00	0.00	
18.03	Environmental Waste Drum Storage, Tent 1	LLM	718.74	718.74	718.74	718.74	0.00	8.40	472.34	472.34	472.34	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity.
		HAZ	718.74	718.74	718.74	718.74	0.00	238.00	472.34	472.34	472.34	
		Total	718.74	718.74	718.74		0.00	8.40	710.34	710.34	710.34	
18.04	Environmental Waste Drum Storage Unit	LLM	416.30	416.30	416.30	416.30	0.00	76.27	340.03	340.03	340.03	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity.
		HAZ	416.30	416.30	416.30	416.30	0.00	0.00	340.03	340.03	340.03	
		Total	416.30	416.30	416.30		0.00	76.27	340.03	340.03	340.03	
19	Mixed Waste Storage Area: Building 374, Room 3813	LLM	180.45	180.45	135.49	135.49	0.00	49.12	0.00	0.00	0.00	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity. Total on-hand inventory includes nonhazardous waste stored in this unit.
		TRM	105.51	105.51	105.51	105.51	0.00	45.99	0.00	0.00	0.00	
		Total	180.45	180.45	135.49		0.00	135.49	0.00	0.00	0.00	
20	Shipping Storage Area: Building 664	LLM	1911.50	1911.50	601.74	601.74	0.00	80.36	70.83	70.83	70.83	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity. Total on-hand inventory includes nonhazardous waste stored in this unit.
		HAZ	1911.50	1911.50	601.74	601.74	0.00	1.05	70.83	70.83	70.83	
		TRM	448.82	448.82	448.82	448.84	0.00	183.77	70.83	70.83	70.83	
		Total	1911.50	1911.50	601.74		0.00	530.91	70.83	70.83	70.83	
24	Mixed Waste Storage: Building 964	LLM	0.00	466.36	0.00	442.93	0.00	438.69	0.00	4.24	4.24	
		Total	0.00	466.36	442.93		0.00	438.69	0.00	4.24	4.24	
25	Mixed Waste Storage	LLM	10704.40	10704.40	10704.40	10704.40	0.00	5753.80	4950.60	4950.60	4950.60	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity.
		HAZ	10704.40	10704.40	10704.40	10704.40	0.00	0.00	4950.60	4950.60	4950.60	
		Total	10704.40	10704.40	10704.40		0.00	5753.80	4950.60	4950.60	4950.60	
27	Mixed Waste Storage: Building 776	LLM	10.41	10.41	10.09	10.09	7.56	0.84	0.43	0.43	0.43	Liquid permitted/Interim status capacity equals total permitted/Interim status capacity. Total on-hand inventory includes nonhazardous waste stored in this unit.
		Total	10.41	10.41	10.09		7.56	2.10	0.43	0.43	0.43	

The requirement that all waste characterization be conducted by certified State of Utah laboratories further restricts the availability of resources. Additionally, the assumption of transporting the majority of waste by rail to Envirocare would have both substantial cost and time savings versus waste shipment by trucking. DOT imposes restrictions on trucking for maximum load capacities on federal and state highways, which ultimately reduces the volume of waste per shipment. However, the logistics of handling and shipping waste by rail car are presently not available at the Site. A loading facility would be required to handle the shipments by rail.

Capacity and availability appear more attractive for onsite waste management. The waste disposal cell would be designed and constructed for a net volume of 100,000 cy. No restriction on the annual volume of waste would be imposed on the generator. In fact, the operations onsite could probably accept up to 500 cy/day. It is unlikely that the rate of removal and treatment of remediation waste could exceed the acceptance rate. In other words, removal actions would not be impeded by utilization of an onsite WMF. The WAC required for the onsite WMF unit would be less complicated than the offsite option and would be the process shown on Figure B-3, not become the lengthy process shown in Figure B-2. Characterization and certification could be obtained through a quality controlled program maximizing the use of field instrumentation techniques that could significantly reduce costs and schedules. Also, DOT load capacity requirements are not as stringent because state or interstate highways are not used. As a summary of comparisons, Table B-6 summarizes the capacity and availability of each option.

Table B-6 Comparison of Capacity and Availability of Waste Management Options

Options	Maximum Capacity (Volume)	Availability	Advantages/ Restrictions
No Action Alternative	4,425 cy *	No impact	Capacity is restricted by the current Site capability to store waste.
Onsite Waste Management	100,000 cy	Readily available (once constructed) and limited by maximum capacity.	1. No restrictions on the volume accepted except total capacity. 2. The WAC is not as stringent. 3. DOT requirements are not applicable.
Offsite Disposal	70,000 cy**	5 years***	1. Approval granted by Envirocare. 2. Waste characterization done by certified State of Utah laboratories. 3. DOT requirements for trucking on highways.

Notes:

* Remainder of the space available at the Site for the storage of LLMW (based on the inventory as of January 1995).

** Maximum waste limit that can be shipped to Envirocare per year for 5 years from all DOE facilities according to the contract with the DOE. The maximum waste capacity for all DOE facilities for Envirocare during the life of the contract is 350,000 cy.

*** Based on the current contract expiration with Envirocare. Conditionally, contract may be approved for extension after 5 years.

B.9 RECOMMENDATIONS

Overall the evaluation indicates that the onsite management of remediation waste is the best option. The main advantages are:

- Cost-effectiveness
- The possibility of offsite spills is negated
- There is better support of the Site mission as embodied in the Site Vision
- Greater support for the reduction of risks to the public and the environment is provided

The main cost benefit for onsite waste management is that under a CAMU designation, remediation waste would not have to be treated to meet the LDR; it would only need to be treated to ensure that the contaminants are immobile.

This evaluation was based on the assumption that an onsite CAMU would be operated for an indefinite period of time. Should the CAMU serve only as a temporary unit, then final action costs could warrant the consideration of offsite facilities. Although an onsite facility is designed for retrievability, should the remediation waste need to be removed or it becomes economically or technologically feasible to treat the contamination, the intention is that it be managed as any other CAMU, and like other CAMUs, it is intended to be the final action for most of the waste placed into it.

To compare the effects of onsite waste management versus offsite disposal, a hypothetical model (see Table B-7) was developed that tied in costs, waste volumes, and accelerated actions. The accelerated actions and waste volumes in Table B-7 were evaluated under a fixed budget of $20M per year until all of the actions were completed. Waste minimization of remediation waste by thermal desorption treatment was incorporated into the model. These soils were assumed to be returned to their source areas and were not placed in a WMF. As shown in Figures B-5 and B-6, an equal volume of remedial waste is dispositioned in 5 years with onsite waste management versus 16 years under the offsite disposal option. A description of the hypothetical cost model is presented in Attachment 3.

The onsite waste management option not only manages the waste in a more expeditious time frame and reduces risk to the environment and the public, but total costs expenditures are reduced significantly. As mentioned earlier, funding from Congress for future environmental cleanup is being reduced and will become more difficult to justify. Onsite waste management is less expensive than offsite disposal, and would enable an expedient reduction of environmental risks at the Site because the annual budget would not be consumed by offsite disposal costs. This, in turn, would result in greater overall risk reduction and long-term protectiveness of human health and the environment.

The primary challenge associated with an onsite WMF will be to obtain approval for an onsite CAMU, and obtaining public approval. Offsite facilities are currently permitted and are ready to accept waste for disposal despite problems with logistics and higher costs than onsite facilities.

Clearly, onsite waste management is the most cost-effective and viable option for the management of remediation waste at the Site.

Table B-7 Remediation Waste (cy) Treated By Fiscal Year

Fiscal Year	Onsite Option Waste Management (cy)	Onsite Option Thermal Desorption Treated Soil (cy)	Onsite Option Total Waste Volume (cy)	Offsite Option Waste Disposal (cy)	Offsite Option Therm Desorption Treated Soil (cy)	Offsite Option Total Waste Volume (cy)
Year 1	0	6,800	6,800	0	6,800	6,800
Year 2	12,348	0	12,348	7200	0	7,200
Year 3	6,032	4,090	10,122	7,034	144	7,179
Year 4	6,104	4,020	10,124	4,016	3,686	7,702
Year 5	11,946	0	11,946	3,519	4,280	7,799
Year 6	11,946	0	11,946	7,059	0	7,059
Year 7	11,946	0	11,946	7,059	0	7,059
Year 8	11,946	0	11,946	7,059	0	7,059
Year 9	3,352	6,170	9,522	7,059	0	7,059
Year 10	730	2,470	3,200	7,059	0	7,059
Year 11				7,059	0	7,059
Year 12				7,059	0	7,059
Year 13				3,958	3,770	7,728
Year 14				1,210	4,870	6,080
Total	76,350	23,550	99,900	76,350	23,550	99,900

Figure B-5 Remediation Waste Disposal Versus Fiscal Year

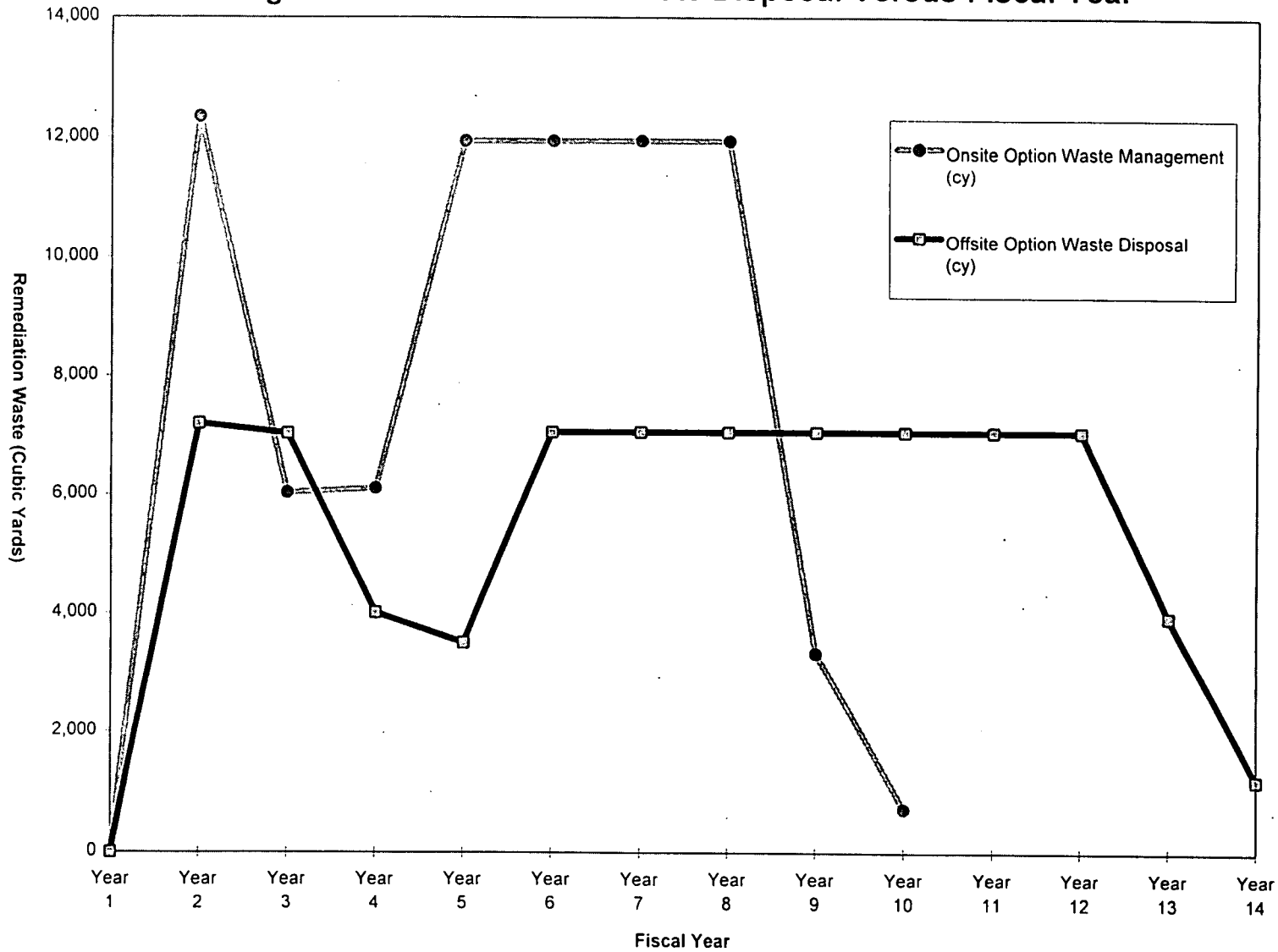
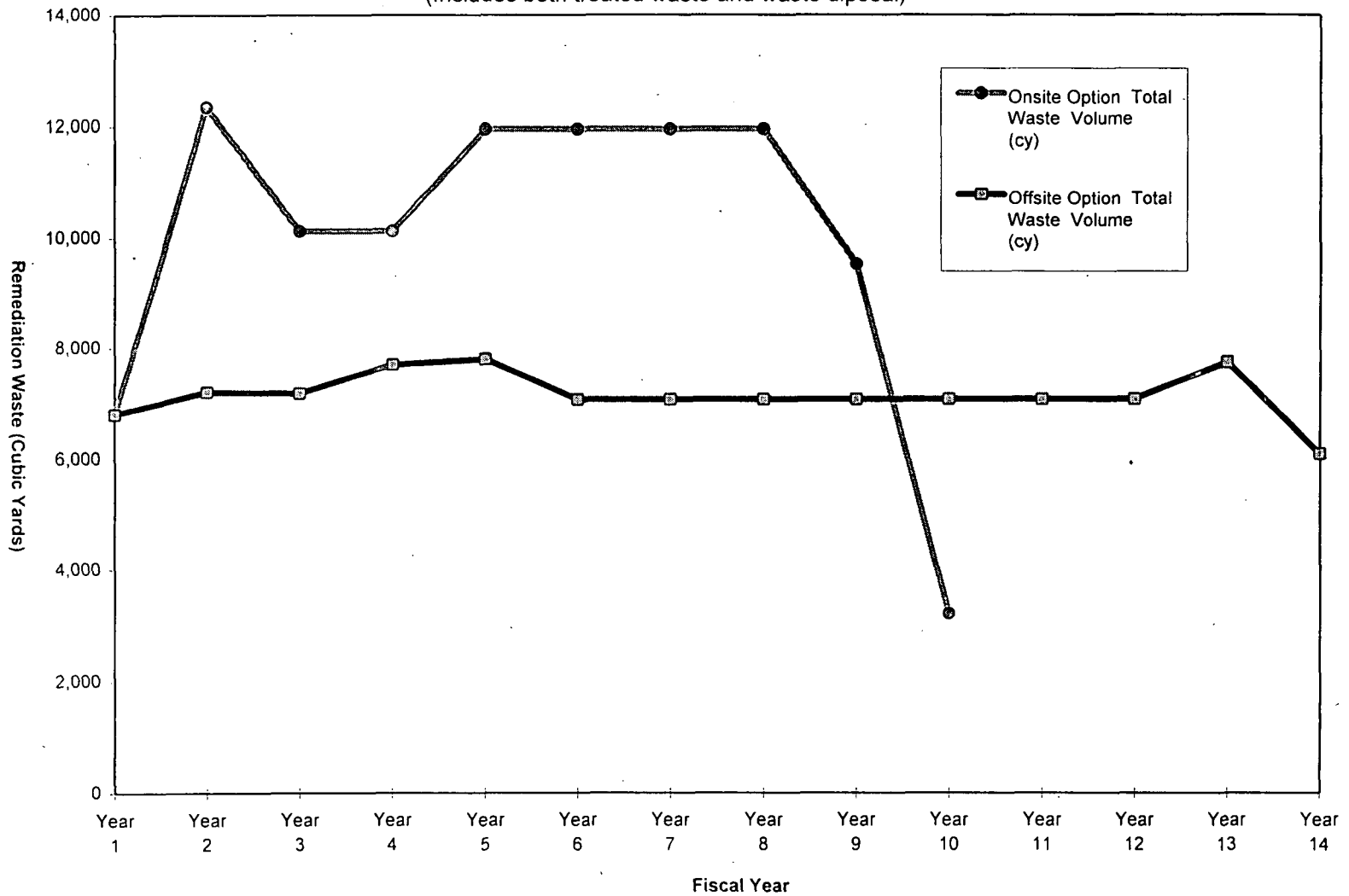


Figure B-6 Total Waste Dispositioned From Accelerated Actions Versus Time

(Includes both treated waste and waste diposal)



Attachment 1

Assumptions

General Assumptions

1. Assume that onsite waste management would be conducted under CAMU guidance (Subpart S, Corrective Action, Section 264.552 of 6 CCR 1007-3).

2. Assume that the onsite WMF would be designed to not pose a risk to the public or the environment for a thousand years in accordance with 6-CCR 1007-2, Part 2, Requirements For Siting of Hazardous Waste Disposal Sites.

3. Assume that high-level volatile and semivolatile organic constituents in the remediation waste would be treated using thermal desorption. Assume that contaminated soils would be treated; if PPRGs are met, the soils would be returned to their original point of excavation; if PPRGs are not met, the soils would be managed in the WMF.

4. No new interim storage facilities will be planned or budgeted for future storage of waste.

5. A limited budget in FY96 exists for the ER program. Outyear budgets have not been confirmed, however, a reduced budget for FY97 and outyears is assumed.

6. The use of railway shipment for bulk waste offsite would require upgrades or modifications to the existing system and a new loading facility.

7. No TRU waste was evaluated.

8. Under all of the options, groundwater monitoring will be integrated into the existing sitewide monitoring program. For an onsite facility, it was assumed that some additional wells would be necessary and that existing wells could also be used.

9. For all of the options, it was assumed that the level of all monitoring currently used at the Site would be continued. For the onsite option, additional monitoring would be required during construction and operation for health and safety purposes.

Assumptions of the Waste Volume Estimate (as presented in Table B-1)

1. The total volume estimated for the Solar Ponds ranges from 10,700 to 160,000 cy as referred by the *OU 4 IM/IRA Decision Document.* The value chosen assumes the vadose and surficial soils will require minimal remedial action based on the risk to human health and the environment. Pondcrete and sludge will be accepted without further treatment for free liquids. Sludge and pondcrete waste forms can be intermixed with soils to meet moisture content requirements.

2. The waste types exhibited are LLMW, HW, and LLW.

3. Assume that approximately 60% of the IDM drums (3,000 drums) will be going to the WMF, the remaining 2,000 drums will be disposed of in the present sanitary landfill under 4-U50-REP-1006.

4. Potential Early Actions waste will be disposed of in the WMF if the treated waste cannot be returned to the source location.

5. Table B-1 does not include volumes for the remaining IHSSs in the Industrial Area. Because of budgetary constraints, insufficient sampling results are available to project potential remediation waste volumes. Remediation activities in OUs 1, 3, and Walnut Creek Area are not anticipated to generate significant waste volumes. IHSS 115 and OU 7 landfills are assumed to be capped.

6. The total estimate of 85,629 cy of remediation waste is based on a 15% fluff/expansion factor.

7. The schedule for accelerated actions is presently unknown because of potential budgetary constraints. The volumes of the accelerated action removals do not represent the total cleanup of the Site.

Cost-Analysis Assumptions

1. For offsite disposal, all LLMW and HW will go to Envirocare.

2. For offsite disposal only, small quantities of waste will be packaged in crates.

3. The remaining waste (approximately 98%), destined for offsite disposal, will be packaged in bulk in roll-offs. Roll-offs are large, rectangular containers constructed of steel which can be placed on tractor trailers or rail cars. The roll-offs were assumed to have a capacity of 20 cy.

4. All waste destined for offsite disposal will be packaged in roll-off containers.

5. No waste will be required to be packaged in crates for onsite waste management.

6. Envirocare will accept waste in roll-off containers and will allow the waste to be disposed of in bulk. They will proceed to decontaminate the roll-off containers allowing them to be used again. For this reason, no more than a two-month supply of roll-off containers will be needed. It is assumed that 500 cy (on average) will be shipped offsite every 2 months. Therefore, 34 roll-off containers will be procured (see Attachment 2 for the calculation).

7. The Site will have the capability to handle and manage the roll-offs. Currently the Site does not have the equipment or facilities to handle and manage large amounts of shipments via roll-offs.

8. Waste characterization costs will be similar to the actual costs of the OU 1 hot-spot removal.

9. The overhead costs at the Site and subcontractor costs will remain the same in the future.

10. Rail transportation will be available for LLMW shipments to Envirocare.

11. NTS does not currently have a rail spur and doesn't appear that one will be built in the near future. So all LLW being shipped to NTS will be done in roll-offs via truck (approximately 5% of the total waste volume estimate). All waste shipments are currently being shipped via truck, therefore, it is safe to assume that this practice will continue. Also, it was assumed that 25% of the total waste amounts will be shipped by truck and the remaining 75% of the total waste will be shipped by rail.

12. The NTS tipping fee will remain at $17/cubic foot.

13. The Site will be allowed to utilize the Envirocare"Above 25,000 Cubic Yard" price schedule (least expensive of three options).

14. Each of the roll-offs will be decontaminated for return to the Site by Envirocare and will not be disposed of in their cell.

15. Seventy percent of the waste will be shipped in the summer, and 30% of the waste will be shipped in the winter.

16. The Site will not ship any small waste streams (less than 4,000 cy).

17. No material will be shipped with dimensions greater than 10 inches (demolition debris is excluded from this analysis).

18. All treatment will be accomplished through thermal desorption and/or solidification.

19. Waste managed in the onsite cell will be managed under CAMU guidelines.

20. Postclosure care and monitoring will be done on a quarterly basis for the first ten years and semiannually for the remaining twenty years. This is for groundwater monitoring only. Cap maintenance will be conducted as needed.

21. Treatment and handling systems are not expected to produce emissions sufficient to require additional permitting. Air monitoring will be conducted via the existing Site monitoring system. Any additional air monitoring required for worker health and safety considerations will be conducted by the appropriate oversight organization.

Schedule Assumptions

1. The use of laboratories in the State of Colorado which are certified by the State of Utah will not cause schedule impacts.

2. Assume 25% of the total waste (e.g., 25,000 cy) was shipped offsite in bulk via truck, using the 20 cy roll-off containers. This would become a lengthy process, (e.g., 8 years), based on shipping 500 cy every two months. This equates to 36 truckloads in a two-month period. This also assumes that there would not be delays in the waste characterization process.

Hypothetical Model for Waste Volume Cost Over Time Assumptions

1. The waste disposal and treatment options were based on an annual budget of $20M for ER activities, with the exception of a budget of $10M for FY96. This budget was used in planning for outyear activities as well.

2. The same costs for thermal desorption were used for both onsite and offsite options because it was a conservative estimate for both options.

3. The total volume does not include all of the high-risk removal actions because areas in the IA have not been totally characterized. However, it does represent the majority high-risk waste volumes outside of demolition activities.

4. No waste will be disposed of until FY97.

Attachment 2

Basis of Estimates for Onsite Waste Management and Offsite Disposal Cost

WASTE CONTAINERS

ASSUMPTIONS:

1) No waste will be packaged in drums due the higher cost per unit volume of waste.

2) Due to the small quantities of some of the waste streams and the fact that RFETS is currently packaging off-site waste in half crates, it was assumed that 2% (2,000 cy) of the projected waste volume will be packaged and transported in half-crates. Half crates are not re-usable.

3) The remainder of the remediation waste will be packaged in re-usable roll-off containers (98,000 cy) for offsite disposal.

4) Roll-offs will be cleaned/decontaminated and returned for re-use after waste disposal.
The cycle time for a rolloff is two months.
5) Rate of disposal. The cost estimate rate for off-site disposal at Envirocare is 3 years. This number averages to 5,444 cy per two months. Therefore the amount of roll-offs that need to be procured is 372. See detailed BOE below).

6)It was assumed that only 20 C.Y. roll-offs or containers would be used.

7) All waste (98,000 C.Y.) will be generated and disposed within a three year period.

COST CALCULATIONS AND BASIS OF ESTIMATE:

HALFCRATES		QTY	UNIT	BASIS OF ESTIMATE
External volume of a half crate		56	c.f.	(standard volume)
Cubic yards of waste per half crate - loss due to packaging		38	c.f.	Internal volume calculation based on Specification Drawing dimensions.
Volume of waste to be disposed in half crates (cubic yards)		2,000	c.y.	Assumption #2 above.
Volume of waste to be disposed in half crates (cubic feet)		54,000	c.f.	Assumption #2 above. 2,000 c.y. X 27 c.f./c.y.
Number of crates required		1,421	crates	(54,000 c.f.)/(38 c. f./Hcrate)
Cost per crate		$500	dollars each	Recent procurement
Total cost of Halfcrates, Offsite Options.	$	710,500		1,421 crates X $500/crate

ROLL-OFFS, by Rail to Offsite Disposal	QTY	UNIT	BASIS OF ESTIMATE
Capacity in Cubic yards per roll-off	20	c.y.	Basic Assumption
Usable Capacity in Tons per Rolloff	24	tons, net	Capacity of RailCar = 75 TONS. 1 Rolloff @ 0.75 Tons empty + 24 tons of waste = 25 Tons .. 3 Rolloffs at 25 tons gross wt. each = 75 Ton Capacity of railcar.
Density of soils at RFETS	1.62	tons/c.y.	Merrick Conceptual Design Document for the New Sanitary Landfill
Volume of waste allowed on each railcar	44.4	C.Y.	3 X 24 tons / 1.62 T/CY = 44.4 C.Y.
Number of Rolloffs per railcar - Maximum/not full	3.0	Rolloffs/car	44.4 C.Y. /20 C.Y. = 2.22 Rolloffs
Usable volume capacity per rolloff	14.8	C.Y.	44.4 C.Y./ 3 Rolloffs=14.8 C.Y. Rolloff
Number of roll-offs needed to achieve 5444 c.y. shipments every 2 months	372	roll-offs	(98000CY /36 months X 2 months /Roundtrip X 1 Car/44CY X 3 Rolloffs/Car = 372 rolloffs/ Roundtrip.)
Cost to procure one roll-off	$10,570	each	Actuals from Trench T-3 and T-4 Removal Project
Total cost for roll-offs, offsite disposal option.	$3,932,040		$10570 X 372 roll-offs

Containers, Rolloffs onsite storage. (Metal Buildings, Slab on Grade).			
Rolloffs/ Containers, onsite storage options	QTY	UNIT	BASIS OF ESTIMATE
Volume of Waste to be stored	100,000	C.Y.	Basic assumption
Usable capacity of container	20	C.Y.	Basic assumption
Number of containers required	5000		100,000/20 = 5,000
Cost to procure one rolloff/container	$10,570	each	Actuals from Trench T-3 and T-4 Removal Project
Total Cost to procure 5,000 container/rolloffs, onsite storage options. (100,000 C.Y.)	$52,850,000		5,000 X $10,570 each.

CONTAINER COST SUMMARY:

Total half-crate cost (2% of Waste Volume)	$710,500
Total roll-off cost (offsite transport & Disposal)	$3,932,040
TOTAL CONTAINER COST (Offsite disposal options)	$4,642,540

TOTAL CONTAINER COST (Onsite storage options)	$52,850,000

Note 1.
End dump trucks operating and acquisition costs were placed into the Transportation BOE
Note 2.
Note these costs are, UNescalated.

PACKAGING

CRATE PACKAGING AND PREPARATION

1) For the purposes of this estimate it was assumed that the waste would not be packaged in drums because of the higher costs.

2) Due to their small quantities, the following wastes likely will be packaged in half-crates see Table 5-1):

OU-2 Trench T-2	0 cu. yd.
OU-4 Debris	700 cu. yd.
OU-9 Tank 40	130 cu. yd.
OU-6 B-1 Dam	8 cu. yd.
Hot Spot Removal	50 cu. yd.
IDM	180 cu. yd.
TOTAL	1,068 cu. yd.

3) Approximately 1421 Halfcrates will be required to contain 2,000 C.Y.Waste.

4) Packaging refers only to the cost of labor and labor supplies necessary to prepare, fill, label, and certify containers of waste for transportation. Packaging costs here exclude cost of containers , transportation, and characterization.

CRATE PACKAGING	QTY	UNITS	BASIS OF ESTIMATE
Crates packaged per hour, including documentation	0.2	crates/hr	Experience on 750 Pad.
Number of crates	1,421	crates	(From "Waste Containers" BOE)
Total hours to fill, seal, glue and nail lids, provide and attach documentation on Loaded Crates	7,105	hours	(1421 crates)/(0.2 crates/hr)
Cost per labor hour	$85	/hr	Assumed base rate including labor burden. From FY 96 Budget Call Book.
Total cost to Package Halfcrates	$603,925		$85/hr X 7,105 hours

ROLL-OFF PACKAGING AND PREPARATION

6) Assume that all waste stored or disposed of on-site not "in bulk" will be packaged in roll-offs.
   6a) Assume that all waste destined for "immediate" offsite disposal will be packaged in rolloffs.
   6b) Assume that all waste stored or disposed on site, "in bulk" will be packaged and transported in End Dump Trucks.

7) Assume that the packaging time for end dump trucks and rolloffs are equal, regardless of destination.

8) Personal Protective Equipment (PPE) is assumed to be no greater than level D (gray coveralls) for estimating purposes. Costs of Level D PPE is considered minimal. Actual PPE will be prescribed by site HS &R personnel.

ROLL-OFF PACKAGING		QTY	UNIT	BASIS OF ESTIMATE
Person-hours to package one container		4	hours	Actuals from Trench T-3 and T-4 Removal Project
Cost per labor hour		$85	/hour	Approximate average labor rate
Labor cost per container	$	340		4 Hours X $85
Amount of waste in roll offs (off-site)		98,000	c.y.	100,000 cy - 2,000 cy (in crates)
Amount of waste in roll-offs (on-site)		100,000	c.y.	Ground Rule from Section 7.0 of this document
Volume of waste allowed in one rolloff. (offsite)		14.8	c.y.	From "Waste Container" BOE
Volume of waste allowed in one rolloff. (onsite)		20.0	c.y.	From "Waste Container" BOE
Number of times the roll-offs need to be packaged (off-site rail transportation)		6,622	times	98,000CY / 14.8 CY/Rolloff = 6622
Number of times the roll-offs need to be packaged (on-site storage options)		5,000	times	100,000Cy / 20 CY = 5000
Total cost for roll-off packaging (off-site)	$2,251,480			6622 X $340
Total cost for roll-off packaging (on-site)	$1,700,000			5,000 X $340

DUMP TRUCK PACKAGING	QTY	UNIT	BASIS OF ESTIMATE
Person-hours to package/load one dump truck, including loading, documentation, placarding, and smear testing. (excludes excavation, crushing, grinding or treatment time and costs.) (Assumes clock time = 2 hours)	4	hours	Assumed based on actuals from Trench T-3 and T-4 Removal Project
Amount of waste in dump trucks (on-site)	100,000	c.y.	From 'Waste Container' BOE
Volume of waste allowed in one dump truck	16.0	c.y.	From 'Transportation' BOE
Number of times the dump trucks need to be packaged (on-site)	6,250	times	(100,000C.Y.) / (16 C.Y. per truck)
Total hours to place waste in dump trucks. Includes documentation, placarding, smear testing.	25,000	hours	4 Hours to package one dump truck X 6250 times
Cost per labor hour	$85	/hour	Base labor rate from FY96 Budget Call
Cost to package dump trucks w/o contingency	$2,125,000		Total hours X labor rate
Total cost for dump truck packaging	$2,125,000		Total cost w/o contingency

PACKAGING COST SUMMARY:

OFFSITE PACKAGING COSTS	
(2,000 CY) Total half-crate packaging cost	$603,925
(98,000 CY) Total roll-off packaging cost	$2,251,480
TOTAL **OFFSITE** PACKAGING COST W/O CONTINGENCY (100,000CY)	$2,855,405

65

ONSITE PACKAGING COSTS , Bulk storage	
Total half-crate packaging cost	$0
(100,000CY) Total dump truck packaging costs	$2,125,000

ONSITE PACKAGING COSTS, Container storage	
Total half-crate packaging cost	$0
(100,000 C.Y.) Total roll-off packaging costs	$1,700,000

Note: All costs on packaging BOE are UNescalated

TRANSPORTATION

ASSUMPTIONS:

1) No Drum Transportation is included in this estimate

2) Approximately 1421 Halfcrates are included in this transportation estimate for offsite disposal. All Halfcrates will be transported by truck to offsite disposal.

3) Approximately 4900 roll-off containers of waste will be transported off-site (98,000 C.Y. / 20 CY each).

4) For onsite disposal /placement in bulk calculations all waste will be transported in 16 C.Y end-dump trucks. The trucks will be weight rated to transport full loads.

5) For onsite storage and transportation in containers the volume per container is 20 C.Y., only one container per truckload.

6) All rolloffs for offsite disposal will be transported by rail.

7) Rail Transportation of rolloffs, maximum of 4 Roll-offs per railcar, (80 C.Y. volume capacity / railcar), for return transportation of used, clean, empty, rolloffs to site for reuse.

8) Rail Transportation, Maximum number of rolloffs per loaded car is 3 due to weight limit of 75 tons. (See Weight & Volume Calculation in this BOE).

9) The existing rail siding at RFETS is currently active, certified and considered adequate to support

10) Railcar loading equipment must be provided and included in this estimate.

11) Contingency will not be added to individual BOE's.

COST CALCULATIONS AND BASIS OF ESTIMATES:

Half-Crate transportation - OFFSITE DISPOSAL	QUANTITY	UNIT	BASIS OF ESTIMATE
Waste to be transported	1,421	Halfcrate	"Waste Containers" BOE
Weight Capacity of truckload	22.5	Tons	State/DOT Regs, Est. Vehicle net load
Weight per Halfcrate	2.45	Tons	38 Cu.Ft / 27 Cu Ft/YD X 1.62 Ton / Yd = 2.279 Tons soil/Hcrate +0.175 ton tare/crate = 2.45 tons /HCrate
Max Halfcrates per truckload	9	Halfcrate:	22.5 Tons/Truck / 2.45 Tons / Halfcrate = 9.18 Halfcrates / Truck
Truckloads required.	158	Trucks	1421 HCrates/ 9 halfcrates / truck = 157.89
Cost per truckload	4,800	Dollars	Existing contract.
Direct Cost of Transportation	758,000	Dollars	4800 X 158 =$758,400
Total Cost of halfcrate transportation offsite	$758,000		

Note: Two offsite transportation BOE's were prepared, one to determine the weight limit and one to determine the volume limit. The weight is the governing factor. The volume calculation is included here for reference only.

ROLL-OFF TRANSPORTATION - OFFSITE DISPOSAL	QTY	UNIT	BASIS OF ESTIMATE
Rail car transportation only, based on **weight**			
Amount of waste in roll offs (off-site)	98,000	c.y.	From 'Waste Container' BOE
Volume of waste allowed in one roll-off (max) (due to Weight limit)	14.8	c.y.	From 'Waste Container' BOE
Number of Rolloffs to be transported (recycled)	6,667		98,000 C.Y. / 14.8 C.Y. Rolloff
Number of loaded Rolloffs per railcar	3	Rolloffs	Assumption #8 (Above).
Number of Railcar trips required, loaded	2,223	Railcars	6667 rolloffs / 3 per car = 2223 railcar trips, loaded
Number of Railcar trips required, return empty	1,667		6667 Rolloffs / 4 per car =1667 railcar return "empties" trips.
Total Railcar trips required	3890		2223 + 1667 = 3890
Cost per railcar trip	$4,150	Dollars	RMRS Transportation Mgr. Pers Comm.
Total cost for rail transportation of rolloffs (98,000 C.Y.))	$16,143,500		$4150 X 3890 trips = $16,143,500

ROLL-OFF TRANSPORTATION - OFFSITE DISPOSAL	QTY	UNIT	BASIS OF ESTIMATE
Rail car transportation only, based on **volume**			
Amount of waste in roll offs (off-site)	98,000	c.y.	From 'Waste Container' BOE
Volume of waste allowed in one roll-off (max)	20.0	c.y.	From 'Waste Container' BOE
Number of Rolloffs to be transported (recycled)	4,900		98,000 C.Y. / 20 C.Y. Rolloff
Number of loaded Rolloffs per railcar	4	Rolloffs	Assumption #7 (Above).
Number of Railcar trips required, loaded	1,225	Railcars	4900 rolloffs /4 per car = 1225 railcar trips, loaded. *NOTE* : Four fully loaded Rolloffs exceed weight capacity of railcar by 25 Tons, per "Waste Container" BOE.
Number of Railcar trips required, return empty	1,225		4900 Rolloffs / 4 per car =1225 railcar return trips
Total Railcar trips required	2,450		1225 + 1225 = 2450
Cost per railcar trip	$4,150	Dollars	RMRS Transportation Mgr. Comm.
Total cost for rail transportation of fully loaded rolloffs, (4 rolloffs per railcar)	Not Achievable, **weight** restriction		$4150 X 2450 trips = $10,167,500

Waste Transportation to onsite storage or onsite disposal in bulk

TRANSPORTATION-ONSITE DISPOSAL/STORAGE		QTY	UNIT	BASIS OF ESTIMATE
Amount of waste in dump trucks		100,000	c.y.	Basic assumption
Volume of waste allowed in one truck		16.0	c.y.	Assumption #4 (above)
Number of Truckloads Required		6,250	Rtrips	100,000 C.Y. / 16 C.Y. Truck
Roundtrip Distance per Truckload		3	Miles	Base assumption
Miles traveled by Trucks		18,750	Miles	6250 Rtrips X 3 Miles/Trip
Roundtrip Truckloads/day		8.3	Round-trips	6250 Rtrips/3 years X 1 year/50 weeks X 1 week/5 days X 1 day / 6 hrs working = 8.3 RTrips/day
Loads per truck per day (6 Hours operating)		2	trips	Base assumption 3 hours/RoundTrip, load 1 hour, travel 1 hour, unload 1 hour. (See Packaging BOE)
Trucks required each day		5	Trucks	8.3 RTrips/day X 1 day / 2 Rtrips/ truck = 4.15 Trucks, use 5 trucks, incl spares.
Labor, Drivers required to drive trucks		5	Drivers	Base assumption, 1 driver per truck per day
Labor Cost to drive trucks (Pay at 8 hrs/day, work at 6 hours/day)	$	2,550,000	Dollars	$85/hr X 8 hr/day X 5 drivers/day X 5 days/week X 50 weeks/yr X 3 years. Cost Basis - FY 96 Work Package Guidance)
Fuel Cost for trucks	$	9,375	dollars	18750 miles X 50 cents/mile Assumption
Procurement cost of 5 16 yd end-dump trucks	$	1,250,000	dollars	5 Trucks X $250K each, Rough Estimate, based on prior purchases
Maintenance of Trucks	$	500,000	Dollars	Rough Estimate
Total cost for onsite "Bulk" transportation	$	4,309,375		SUM of Labor, Fuel, Procurement, Maintenance

Onsite Transportation of Rolloffs/Sealand Containers

TRANSPORTATION -ONSITE DISPOSAL/STORAGE IN CONTAINERS		QTY	UNIT	BASIS OF ESTIMATE
Amount of waste in containers		100,000	c.y.	Basic assumption
Volume of waste allowed in one truck/container		20.0	c.y.	Assumption #5 (above)
Number of Truckloads Required		5,000	Rtrips	100,000 C.Y. / 20 C.Y. Truck
Roundtrip Distance per Truckload		3	Miles	Base assumption
Miles traveled by Trucks		15,000	Miles	5000 Rtrips X 3 Miles/Trip
Roundtrip Truckloads/day		7.0	Round-trips	5000 Rtrips/3 years X 1 year/50 weeks X 1 week/5 days X 1 day / 6 hrs working =7 RTrips/day
Loads per truck per day (6 Hours operating)		2	trips	Base assumption 3 hours/RoundTrip, load 1 hour, travel 1 hour, unload 1 hour. (See Packaging BOE)
Trucks required each day		4	Trucks	7 RTrips/day X 1 day / 2 Rtrips/ truck = 3.5 Trucks, use 4 trucks, incl spares.
Labor, Drivers required to drive trucks		4	Drivers	Base assumption, 1 driver per truck per day
Labor Cost to drive trucks (Pay at 8 hrs/day, work at 6 hours/day)	$	2,040,000	Dollars	$85/hr X 8 hr/day X 4 drivers/day X 5 days/week X 50 weeks/yr X 3 years. Cost Basis - FY 96 Work Package Guidance)
Fuel Cost for trucks	$	7,500	dollars	15000 miles X 50 cents/mile Assumption
Procurement cost of 4 container-hauling trucks	$	1,000,000	dollars	4 Trucks X $250K each, Rough Estimate, based on prior purchases
Maintenance of Trucks	$	500,000	Dollars	Rough Estimate
Total cost for onsite "container" transportation	$	3,547,500		SUM of Labor, Fuel, Procurement, Maintenance

Railcar Loading Equipment for Rolloffs.

Forklift 25 ton Capacity 20 foot lift	$250,000		Cap Cost. Quote FOB RFETS
Forklift operating cost @ $50/hr =	$225,000		3 years X 50 Weeks/year X 5 days/week X 6 hours/day =
Forklift operator and spotter- labor	$1,020,000	Dollars	3 years X 50 weeks year X 40 hrs week X $85 Hour X 2 people
Site-prep and maintenance of loading area	$250,000	Dollars	Rough Estimate
Upgrade of rails (not required)	-0-		Assumptions #8 and 9 Above.
Total of rail car loading facility equipment and maintenance of site.	$1,745,000	dollars	Sum of above costs

SUMMARY OF TRANSPORTATION COSTS

Onsite Transportation, bulk storage, via dump trucks	$	4,309,375

Onsite Transportation of Containers to Storage Facility	$	3,547,500

Off site transportation.		
Rail loading facility equipment and operation	$	1,745,000
Rolloff Transportation with recycling	$	16,143,500
Trucking of halfcrates	$	758,000
TOTAL	$	18,646,500

Characterization Costs For Onsite Management and Offsite Disposal

Assumptions

1) Although there is a wide variation in potential sampling costs for various facilities, by making the costs identical, the playing field was leveled in terms of sampling and analysis. This allows the cost analysis to focus on other factors. Most of the variation between facilities can be attributed to the number of different analyses required and analytical methods used. In reality, the sampling and analysis costs would be expected to be higher for offsite facilities and lower for an onsite facility. This is generally true for any offsite facility and is driven by various permit requirements, waste acceptance criteria, RCRA, and other factors.

2) Laboratory analysis were estimated based on past laboratory costs. The costs are estimates and as such differ from any proprietary information that might be in current analytical contracts. For required sample methods that currently was not available through the Rocky Flats Sample Management Office, it was assumed that the required sampling methods (8000 series) would be available and the cost would be similar to similar existing methods currently in use.

3) It was assumed that all of the samples would be analyzed at laboratories. For onsite management, it might be possible to use field methods which could further reduce the costs.

4) Assume that on the average, one sample would be taken for every 75 cubic yards to meet the waste acceptance criteria. This sampling amount was increased by 100% to cover the following:

1) Quality Assurance Samples - 25%
2) Post-treatment Sampling - 75%

Assume that for a baseline each sample would be analyzed using the paint filter test, gamma spectroscopy, and TCLP for metals and volatiles. Additional miscellaneous analysis could include additional samples for Hydrogen Cyanide, Hydrogen Sulfide, Uranium Isotopic Analysis, Thorium Isotopic Analysis, Plutonium 239/240, Gross Alpha/Beta, Proctor Testing, and others.

5) Assume that the cost for sample containers were included in the analytical costs.

6) Assume that sampling would be performed on-site by plant personnel. A burdened cost of $85/hour was assumed for both monitoring and sampling personnel. Assume that sampling crews would consist of two individuals with full-time radiation monitoring support.

7 Assume that most of the sampling would be done in Level D personal protective

equipment and that on occasion this would be upgraded to Level C.

8) Assume that samples would be tracked through the Rocky Flats Environmental Database System.

9) Assume that transportation costs would be minimal since most of the samples would be analyzed on plant site. Assume that some samples would go off-site due to capacity or analytical method.

Cost Calculations

Laboratory Analysis:

Paint Filter Test (estimate)	$100.00
TCLP (metals)	$550.00
TCLP (organics)	$550.00
Gamma Spectroscopy	$200.00
Total Cost	$1,400

$1,400

Possible Additional Sample Costs

Any of the analytes below could be included depending on the waste acceptance
All sample costs are estimates and have not been escalated.

Analysis	Cost
pH	$ 15.00
Hydrogen Cyanide	$ 65.00
Hydrogen Sulfide	$ 50.00
Heavy Metal Analysis* (CLP and Non-CLP)	$600.00
Hexavalent Chromium	$ 60.00
Volatiles (Method - CLP)*	$340.00
Semivolatiles (Polynuclear Aromatics)**	$310.00
TCLP (Metals)	$550.00
TCLP (Organic Volatiles)	$550.00
TCLP (Semivolatiles)	$800.00
Gamma Spectroscopy	$200.00
Uranium Isotopic Analysis	$280.00
Thorium Isotopic Analysis	$240.00
Plutonium 239/240	$280.00
Gross Alpha/Beta	$180.00
Proctor Test	$260.00
Total Organic Halides (TOX)	$150.00

Pesticides and PCBs	$260.00
Herbicides	$310.00
Petroleum Hydrocarbons	$180.00

* Substituted other methods to estimate cost
** Substituted EPA Method 610 for 8100

Labor (Cost per Sample):

Presampling Preparation and Sampling Forms	-	**0.75 Hours**
Donning Personal Protective Equipment	-	**0.5 Hours**
Sampling	-	**1.25 Hours**
Safety Monitoring	-	**2 Hours**
Data Entry and Sample Tracking	-	**0.75 Hours**
Sample Packaging and Shipping	-	**0.75 Hours**
Management Oversight	-	**0.25 Hours**
Total	-	**6.25 hours**
Labor Rate		**$85/hour**
Labor Cost		**$530**

Materials & Equipment (Not Including Sample Bottles)

Coolers and Sampling Supplies	$ 40	
Protective Equipment (Level C &D)	$ 70	
Monitoring Equipment and Supplies	$ 70	
Equipment Total	$180	$ 180
Transportation (on-site/off-site)	$ 40	$ 40
Total Cost Per Sample		$2,150

Number of samples:

(100,000/75) x 2 = 2680 samples

Total Characterization Cost

2680 samples x $2150/sample = (without contingency)	**$5,762,000**
Total Characterization Cost (Contingency not included)	**$5,762,000**

Treatment Costs for Off-Site Disposal

Assumptions:

1) Assume that only the waste that needs to be treated to meet Land Disposal Restrictions will be treated and that treatment will consist of either solidification or thermal desorption. Assume that none of the waste needs volume reduction. Assume that soils that do not need to be treated to meet Land Disposal Restrictions (LDRs), do not need any additional treatment including dewatering or drying.

2) Cost for solidification of Solar Ponds sludge was based on Solar Ponds' estimates in the "Operable Unit 4 IM/IRA Decision Document". The estimate was for Pondcrete and Sludge combined. Volumetrically, the sludge represented roughly half of the total volume so the cost estimate was approximated by taking half of the total cost or $21 million. This cost is fully burdened but does not include escalation. The volume of sludge at the Solar Ponds is 6,000 cubic yards.

3) Cost of solidification of soils was modified from on pondcrete treatment costs in the from "Pondcrete Processing Conceptual Design", Haliburton NUS Corporation, January 6, 1995. Capital Costs are based on facility designed to treat approximately 12,000 cubic yards of pondcrete. Soil solidification costs could be reduced by approximately $11.6 million if the equipment fro pondcrete processing can be utilized for soil solidification.

Capital Cost	$11,600,000
Unit Operating Cost	$5,500,000/5,600 yd^3 = $980/$yd^3$

The total volume of remediation requiring solidification is approximately 41,100 yd^3 of which 6,000 yd^3 is sludge (see attached Table B-8) so

42,300 yd^3 - 6,000 yd^3 = 36,300 yd^3 of soils

4) A cost of $1300 per cubic yard for thermal desorption was based on the estimate for the remediation of the East Trenches (Trenches T-3/T-4). The volume requiring thermal desorption treatment is approximately 3400 yd^3 (see Table B-8).

5) Unit costs were assumed to be all inclusive. This included all transportation, health and safety, documentation, oversight, etc.

6) Costs for treatment of the liners was not included in the estimate. It was assumed that contamination on the liners would be less difficult to remove and that the costs would not be high. This assumption would need to be revised if the contamination has been absorbed into the asphalt as opposed to removable surficial contamination.

Cost Calculations

Thermal Desorption:

3400 cubic yards x $1300/cubic yard	= $4,420,000	≈	**$ 4,420,000**
Solidification of Sludge:	= $21,000,000		**$ 21,000,000**

Solidification of Soils:

Capital Cost	= $11,600,000	
Operating Cost:		
36,300 cubic yards x $980/cubic yard	= $35,570,000	
	$47,170,000	**$ 47,170,000**

Total Treatment Cost **$ 72,590,000**
(Contingency not included)

Treatment Costs for Onsite Management

Assumptions:

1) Assume that all of the soils removed from the trenches, IHSS 119.1, some soils from 903 Pad and some soils removed from Original Process Waste Line Tanks T-2, T-3, T-9, T-10, T-14, T-16 and T-40 will require treatment by thermal desorption.

	Cubic Yards
Trench T-1	1000
Trench T-3	300
Trench T-4	300
Trenches T-5 through T-11	1000
Mound Area	1500
903 Pad (IHSS 112 and 140)	1400
Tanks T2 and T-3	500
Tanks 9 & 10	500
Tanks T-14 and T-16	3,340
Tank T-40	130
Total	9,970

2) Assume a unit cost of $1300 per cubic yard for thermal desorption was based on the Operable Unit 2 estimate for the remediation of the East Trenches.

Cost Calculations:

$1300 x 9,970 = **$12,960,000**

Total Treatment Cost (Contingency not included) **$12,960,000**

Attachment 3

Description of Hypothetical Cost Model for Accelerated Actions at the Rocky Flats Environmental Technology Site

The purpose of the hypothetical cost model for accelerated actions was to compare the cost and schedule impacts of the onsite waste management option versus the offsite option, given a fixed budget. Unit costs were developed based on actuals and the estimates described in Attachment 2 as follows:

Unit Cost for Onsite Waste Management (includes Excavation)	$2,128/cy
Unit Cost for Offsite Disposal (includes Excavation)	$3,482/cy
Unit Cost for Thermal Desorption	$2,970/cy

Based on the above unit costs, the cost of thermal desorption used for onsite management and offsite disposal were calculated for each accelerated action. Ten million dollars were allocated for the first year, based on the actual FY96 budget. It was assumed that the budget for each following year would increase to $25M. All of the accelerated actions were prioritized based on risk. The cost model was set up as follows:

1. Starting with Year 1, the cost of both thermal desorption and disposition for the highest priority accelerated action was allocated to that year, followed by the next highest priority accelerated action and so on until the $10M budget was consumed.

2. This was repeated again for Year 2 for a $25M budget and again for the next year until there were no more accelerated actions to allocate. Both the onsite and offsite options were allocated in this manner.

3. Based on the costs allocated for each accelerated action in each fiscal year, the volume of soils treated with thermal desorption and the volume of soil dispositioned were determined.

4. These volumes were then plotted versus fiscal year as shown in Figures B-5 and B-6.

Appendix C

Onsite Remediation Waste Storage Facility Siting Study

TABLE OF CONTENTS

ABBREVIATIONS, ACRONYMS, AND INITIALISMS v

EXECUTIVE SUMMARY ES-1

C.1 OBJECTIVES C-1

C.2 COMPARATIVE ANALYSIS OF SITE LOCATIONS (ALTERNATIVES) C-3

C.2.1 SCREENING CRITERIA DEFINED C-3

C.2.1.1 Category 1: Corrective Action Management Unit (CAMU) Criteria C-3
C.2.1.2 Category 2: Public Protection (Geotechnical and Hydrological Criteria) C-4
C.2.1.3 Category 3: Site Special Issues C-5
C.2.1.4 Category 4: Cost Criteria C-5
C.2.1.5 Category 5: Regulatory Support C-6
C.2.1.6 Category 6: Other Stakeholder Concerns C-6

C.2.2 METHODOLOGY C-7

C.2.3 SCREENING PROCESS C-14

C.2.4 ANALYSIS C-17

C.2.4.1 Corrective Action Management Unit (CAMU) Criteria C-17
C.2.4.2 Public Protection (Geotechnical and Hydrological) Criteria C-19
C.2.4.3 Site Special Issues C-25
C.2.4.4 Cost Criteria C-31
C.2.4.5 Regulatory Support C-31
C.2.4.6 Other Stakeholder Concerns C-32

C.2.5 RESULTS FOR SELECTED LOCATIONS C-33

C.2.6 REFERENCES C-34

FIGURES

1 Location Map
2 Hydrogeological Conditions
3 Geological and Geotechnical Conditions
4 Structure Base of Alluvium
5 Thickness of Alluvium
6 Ecology and NEPA Map
7 Adverse (for RWSF siting) Conditions Map
8 Mineral Ownership

TABLES

C-1 Criteria Comparison C-6
C-2 RWSF Location Criteria Detail C-7
C-3 Criteria Issues C-12
C-4 Criteria Points C-13
C-5 RWSF Siting Location Summary C-14
C-6 In-place Infrastructure C-24
C-7 Order-of-Magnitude Costs for Site Preparation C-25

ABBREVIATIONS AND ACRONYMS

Am	americium
CAMU	Corrective Action Management Unit
CCR	Code of Colorado Regulations
CDPHE	Colorado Department of Public Health and Environment
CHWA	Colorado Hazardous Waste Act
cm/sec	centimeters per second
cy	cubic yards
D&D	deactivation and decontamination
DOE	United States Department of Energy
ESF	East Spray Fields (IHSS 216.2 and 216.3)
FY	fiscal year
HW	hazardous waste
IA	Industrial Area
IA-East	Industrial Area-East
IA-West	Industrial Area-West
IDM	Investigation-Derived Material
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
ITS	Interceptor Trench System
NEPA	National Environmental Policy Act
NSL	New Sanitary Landfill
PA	Protected Area
PAC	potential areas of concern
PCB	polychlorinated biphenyls
Pu	plutonium
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RWSF	Remediation Waste Storage Facility
SME	Subject Matter Expert
SE Quad	Southeast Quadrant
Site	Rocky Flats Environmental Technology Site
Site Vision	Rocky Flats Conceptual Vision
SW Quad	Southwest Quadrant
TSCA	Toxic Substance Control Act
WMF	waste management facility

EXECUTIVE SUMMARY

A Remediation Waste Storage facility (RWSF) has been envisioned to store remediation waste at the Rocky Flats Environmental Technology Site (Site). The objectives of this siting study are to identify and rank criteria to be used to select a location, develop a methodology for comparative analysis of different locations, and select location(s) that would be suitable for a RWSF within the boundaries of the Site, using the identified criteria and methodology for comparative analysis.

The location would be for a RWSF that accepts remediation wastes with low-level radioactive and/or hazardous constituents but would not preclude the shipment of remediation waste that could be more effectively and economically managed offsite. The facility would be designed and constructed to meet all of the applicable federal, state, and local regulatory requirements.

Seven onsite locations were identified and carried through the location selection process. The three locations in the Industrial Area (IA) are the IA-West, IA-East, and the area adjacent and to the east of the Solar Ponds. The four locations in the buffer zone are the New Sanitary Landfill (NSL), the East Spray Fields (ESF), the Southeast Quadrant (SE Quad), and the Southwest Quadrant (SW Quad).

Six categories were considered in developing the comparative analysis. These criteria include regulatory requirements and guidelines that have been discussed during various stakeholder meetings regarding a RWSF at the Site. These criteria have been placed into six general categories, and further divided into 35 specific subdivisions.

The following general criteria categories were assigned a weighting factor (%) totaling 100%:

Category 1, Corrective Action Management Unit (CAMU) Criteria - 20%

Category 2, Public Protection (Geotechnical and Hydrological Criteria) - 20%

Category 3, Site Special Issues - 15%

Category 4, Cost Criteria - 15%

Category 5, Regulatory Support - 15%

Category 6, Other Stakeholder Concerns - 15%

The following locations were evaluated against the criteria and given an overall ranking between 0 and 100%, with 100% being the most favorable location for the siting of a RWSF.

Solar Ponds location, IA	68.3%
IA-West location, IA	67.6%
New Sanitary Landfill, buffer zone	67.4%
SE Quad location, buffer zone	66.4%
ESF location, buffer zone	66.1%
SW Quad location, buffer zone	63.4%
IA-East location, IA	62.5%

Overall, the Solar Ponds location was ranked slightly higher than the IA-West location and the NSL as a place to locate a RWSF at the Site. The results of this study are detailed and summarized herein.

Category 1, CAMU, favored the IA locations, with the designation of the location as a CAMU. The ability to reduce the areal extent of contamination without contaminating clean areas weighed heavily in favor of the IA locations.

Category 2, Public Protection, ranked three of the buffer zone locations the highest. The primary concern with the locations in the IA is the elevated groundwater table. This concern is somewhat mitigated, however, by the fact that all viable design alternatives envisioned are above-grade facilities.

Category 3, Site Special Issues, ranked the SE Quad location the highest, followed by the Solar Ponds, and ESF location. The three locations in the IA all received high ranking for the ability to support the Rocky Flats Conceptual Vision (Site Vision) in terms of future land use. Nevertheless, the existing infrastructures lowered the overall scores in this category. There are extensive underground and overhead utilities encountered within most of the IA, as well as other building and waste storage facilities, that would have to be removed or re-routed.

Category 4, Cost Criteria, favored the buffer zone locations. The main consideration of the locations within the IA is the cost associated with removing, re-routing, or replacing building and underground and overhead utilities in the IA. An additoinal consideration to The Solar Pond location is the burden of constructing a portal through the Protected Area (PA) security fence, constructing a fence surrounding the location, and providing a security staff during construction and operation of the facility.

Category 5, Regulatory Support, showed support clearly in favor of a location in the IA. The Solar Ponds location was ranked highest followed by IA-East and IA-West.

Category 6, Other Concerns, ranked the IA locations the highest. The general public would probably be receptive to placing environmental waste in areas that already contain some contamination rather than siting a RWSF in an area that has no history of contamination. Also, the Jefferson County, Colorado Board of Commissioners stated their desire to maintain the buffer zone around the IA as undeveloped open space (Resolution No. CC94-654).

C.1 OBJECTIVES

For this project, the reduction of environmental risk is dependent on the ability to disposition and manage remediation waste. As part of risk reduction at the Rocky Flats Environmental Technology Site (the Site), it is currently projected that there is 123,000 cubic yards [cy] (95,000 cubic meters [m^3]) of remediation waste to be excavated and appropriately managed. Approximately 9,000 cubic yds can be treated by thermal desorption treatment and returned to where it came from, leaving 114,000 cy that will need to be stored and managed See Table 3-1 Waste Identification and Volumes for a Remediation Waste Storage Facility, in the IM/IRA Decision Document for the RWSF for a break down of volumes by source and waste type. This waste will come from soils excavated from Individual Hazardous Substance Sites (IHSSs), accelerated actions, D&D waste and investigative derived waste (IDM). This waste consists of media with hazardous constituents or with mixed hazardous/low-level radioactive constituents. The waste streams will include, but are not limited to (approximate percentage of waste is in parentheses):

- Debris from decontamination and decommissioning activities (57%)
- Contaminated soil and debris collected from accelerated actions and hot spots removals (30%)
- Pond sludge (9%)
- Asphaltic materials and pondcrete (less than 1%)
- Investigation-Derived Material (IDM) from characterization (not suitable for disposal in the sanitary landfill) and intrusive investigation activities (less than 1%)
- Toxic Substance Control Act (TSCA) waste such as asbestos and polychlorinated biphenyls (PCBs) (less than 1%)
- Treatment by-products from groundwater, surface water, and/or soil remediation actions (less than 1%)

To store this remediation waste, a RWSF has been proposed to be located within the boundaries of the Site. This task was undertaken to identify the optimal location for the facility. The three objectives of this task are to:

1. Identify and rank criteria to be used for location selection.
2. Develop a methodology for comparative analysis of different locations.
3. Select a suitable location for construction of a facility with the capacity to accommodate 114,000 cy of environmental waste (using the identified criteria and methodology for comparative analysis).

C.2 COMPARATIVE ANALYSIS OF SITE LOCATIONS (ALTERNATIVES)

C.2.1 SCREENING CRITERIA DEFINED

The location must accommodate a facility that would accept (for storage) remediation waste with low-level radioactive and/or hazardous constituents. The facility would be designed and constructed to substantively comply with all applicable federal, state, and local regulatory requirements.

A number of categories were considered in developing the location criteria matrix. The criteria included requirements and guidelines that have been discussed during various stakeholder meetings regarding RWSF at the Site. These criteria can be placed into six major categories: (1) *Corrective Action Management Unit (CAMU) Criteria*, adherence to the key points of this category is fundamental if the RWSF is to designated a CAMU, (2) *Public Protection*, this geological and geotechnical criteria is being considered and would be relevant and appropriate if at some later date, the decision is made to close the RWSF in-place, (3) *Site Special Issues*, these are issues that are unique to RFETS that require consideration in the selection of a location for a RWSF, (4) *Cost Criteria*, (5) *Regulatory Support*, and (6) *Other Stakeholder Concerns* which generally deals with community acceptance. Each of these categories is further divided into specific issues. These categories and specific issues are discussed in the following subsections.

C.2.1.1 Category 1: Corrective Action Management Unit (CAMU) Criteria

Category 1, CAMU, focuses on the designation of the RWSF as a CAMU, per 6 CCR 1007-3, 264.522 (c), and is a critical factor in locating the facility at the Site, with the following key points:

1. The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies.

2. Waste management activities associated with the CAMU shall not create unacceptable risks to humans or the environment resulting from exposures to hazardous waste or hazardous constituents.

3. The CAMU shall include uncontaminated areas of the facility only if the inclusion of such areas for the purpose of managing remediation waste is more protective than management of wastes at contaminated areas of the facility.

4. Areas within the CAMU where remediation wastes remain in place after closure of the CAMU shall be managed and contained to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment. (The above key point of the CAMU regulation is not applicable to this siting study because there will be no waste left in place.)

5. The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 6 CCR 1007-3, 264.552(c)(1) or (c)(2).

6. The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU, unless to do so would be inconsistent with 6 CCR 1007-3, 264.522 (c)(1) or (c)(2). (The above key point of the CAMU regulation is not applicable to this siting study because there will be no waste left in place.)

7. The CAMU shall enable the use, when appropriate, of treatment technologies, including innovative technologies, to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remedial waste.

C.2.1.2 Category 2: Public Protection (Geotechnical and Hydrological Criteria)

Category 2, Public Protection, consists of geological, geotechnical and hydrological considerations to ensure the protection of the public should the decision be made in the future to close the RWSF in-place. These considerations are summarized below:

1. The geological and hydrogeologic conditions of a location in which hazardous waste is to be stored should be such that reasonable assurance is provided that the wastes are isolated within the storage area away from pathways to the public.

2. Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree, which can be accommodated in the facility design.

3. Structural-related issues include slope and geotechnical stability.

4. The immediate area of the location should be in strata of minimal groundwater flow.

5. Geological strata combined with engineering barriers shall provide minimum permeability.

6. Siting consideration should include bedrock and surface integration including the nature and extent of bedrock material.

7. Siting consideration should include minimal relative presence of fractures or faults.

8. Consideration should be given to the relative depth to bedrock and groundwater, including seasonal fluctuations for groundwater.

9. The Site will not impact nor be impacted by surface water.

10. Relative distance to nearest discharge area shall include consideration of groundwater flow direction and travel time.

11. The terrain is such that good drainage exists for movement of precipitation away from the storage area, and such that water and wind erosion will be minimal.

C.2.1.3 Category 3: Site Special Issues

Category 3, Site Special Issues, supports the timely construction of a facility and integration with other Site programs, including the Site Vision to occur, and includes:

1. Support from the proposed CAMU of the Site Vision objectives
2. Impacts from existing utility, sewer, process waste, or communications lines
3. Impacts from security
4. Impacts from plutonium (Pu) consolidation or residue stabilization activities
5. Impacts from decommissioning activities
6. Impacts from current RCRA units
7. Impacts from mineral rights issues or other easements
8. Ability to collocate additional RWSFs in the same vicinity

C.2.1.4 Category 4: Cost Criteria

Category 4, Cost Criteria, presents cost considerations assigned as two separate criteria:

1. Cost of engineering and construction of protective measures

2. Cost of location preparation including building demolition, subsurface utility line removal and rerouting, access requirements, and power/facility requirements above the basic RWSF

C.2.1.5 Category 5: Regulatory Support

Category 5, Regulatory Support, focuses on using the State principles for onsite waste management of contaminated materials, per the February 27, 1995 letter from Tom Looby (CDPHE) to Jack McGraw (EPA) and Mark Silverman (DOE). The following principles have been evaluated in this study to ensure consistency with EPA and CDHPE desires, but because the RWSF being proposed is for storage, not disposal, some of these criteria may not be appropriate for siting a storage facility.

1. The number of disposal locations must be minimized. "We (CDPHE) suggest one centralized location be chosen for consolidation of contaminated materials."

2. "Every effort should be made to locate a centralized disposal facility in an area of optimal geologic parameters preferably within or close to the Industrial Area (IA)."

3. "Any disposal facility must be designed and built as a state-of-the-art disposal facility that meets or exceeds all permitting and regulatory requirements. This includes (but not limited to) siting, design, long-term protection, and performance requirements."

4. "A permitted facility would provide DOE the greatest degree of future applicability and utility. The facility should be designated with the intent to permit under RCRA/CHWA."

5. "Any disposal location at RFETS should be located in areas that have limited future land use potential and will be controlled by DOE until the interred waste no longer presents a risk to human health or the environment."

C.2.1.6 Category 6: Other Stakeholder Concerns

Category 6, Other Stakeholder Concerns, lists the following stakeholder concerns that have been factored into the analysis:

1. General public perception and acceptance

2. Municipal or County acceptance

3. Department of Energy (DOE) Orders

4. National Environmental Policy Act (NEPA)

C.2.2 METHODOLOGY

A weighting system (modified from Dawson, G. W. and Mercer, B.W., Hazardous Waste Management, 1986) was used to develop the ranking system.

First, a subjective weighting factor (%) was assigned to each of the six general categories of criteria, totaling 100%, as shown in Table C-1, Criteria Comparison.

Table C-1 Criteria Comparison

Category	Criteria	Weighting Factor (%)
1	Corrective Action Management Unit (CAMU) Criteria	20
2	Public Protection (Geotechnical and Hydrological Criteria)	20
3	Site Special Issues	15
4	Cost Criteria	15
5	Regulatory Support	15
6	Other Stakeholder Concerns	15
	Total	**100**

Second, each of the six general categories was divided into specific issues as shown in Table C-2, RWSF Location Criteria Detail, and each specific issue was subjectively assigned a value between 1 and 3, with 3 being more important criteria, and 1 being less important criteria.

Third, each of the locations (e.g., Industrial Area-West [IA-West] and Industrial Area-East [IA-East]) was compared to the specific issue, as well as the relativity to one another, and a calculated value between 0 and 1 was determined; 1 would be very favorable, and a value of 0 would indicate a fatal flaw resulting in removing that location from further consideration for a RWSF, as shown in Table C-2.

This matrix form was developed showing location versus specific issues, as shown in Table C-2. This form was distributed to Subject Matter Experts (SMEs) for scoring. The scores were averaged, and average values were used to complete the ranking. If there was a major difference between SMEs, discussions were held to resolve those differences.

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 1, CAMU Criteria - Ability to designate as CAMU. Per 6 CCR 1007-3 264.552 (c)	20															
1	The CAMU shall facilitate the implementation of reliable, effective, protective, and cost effective remedies.		3	1.8	0.6	1.5	0.5	2.1	0.7	3.0	1	2.7	0.9	2.7	0.9	2.7	0.9
2	Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposures to HW or HW constituents.		3	2.4	0.8	2.4	0.8	2.4	0.8	2.1	0.7	2.1	0.7	2.1	0.7	2.1	0.7
3	The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purposes of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.		2	1.4	0.7	1.4	0.7	1.6	0.8	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6
4	The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2).		3	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8
5	The CAMU shall enable the use when appropriate of treatment technologies to enhance long term effectiveness of remedial actions by reducing the toxicity, mobility or volume of remedial waste.		2	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9
CAMU Criteria			13.0	9.8		9.5		10.3		10.5		10.2		10.2		10.2	

	SITING CRITERIA			Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 2, Public Protection - Geological, Geotechnical and Hydrological Criteria	20															
1	The geological and hydrological conditions of a site in which HW are to be stored should be such that there is reasonable assurance that the wastes are isolated within the storage area away from pathways to the public.		3	0.6	0.2	0.6	0.2	0.9	0.3	1.2	0.4	1.5	0.5	2.1	0.7	0.3	0.1
2	Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree which can be accommodated in the facility design.		2	1.6	0.8	1.6	0.8	1.6	0.8	1.8	0.9	1.8	0.9	1.4	0.7	1.8	0.9
3	Structure related issues to include: Slope and geotechnical stability		3	2.7	0.9	2.7	0.9	2.7	0.9	2.7	0.9	2.7	0.9	2.4	0.8	2.7	0.9
4	The immediate area of the site is in strata of minimal groundwater flow.		3	0.9	0.3	0.9	0.3	0.9	0.3	0.9	0.3	0.6	0.2	1.5	0.5	0.9	0.3
5	Geological strata combined with engineering barriers shall provide a minimum permeability for aquifer protection.		3	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8
6	Bedrock/surface integration including the nature and extent of bedrock material.		2	1.6	0.8	1.2	0.6	1.2	0.6	1.8	0.9	1.4	0.7	2.0	1	1.8	0.9
7	Minimal relative presence of fractures or faults.		2	1.2	0.6	1.2	0.6	1.2	0.6	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8
8	Relative depth to bedrock/groundwater including seasonal fluctuations for groundwater.		3	0.9	0.3	0.6	0.2	0.3	0.1	1.5	0.5	1.5	0.5	0.3	0.1	0.6	0.2
9	The site will not impact nor be impacted by surface water.		2	2.0	1	2.0	1	2.0	1	1.8	0.9	1.8	0.9	1.8	0.9	1.8	0.9
10	Relative distance to nearest discharge area to include consideration of groundwater flow direction and travel time.		3	0.6	0.2	0.6	0.2	0.6	0.2	0.9	0.3	0.6	0.2	1.5	0.5	0.6	0.2
11	The terrain is such that good drainage exists for movement of precipitation away from the storage area.		1	1.0	1	1.0	1	1.0	1	1.0	1	1.0	1	0.9	0.9	1.0	1
	Public Protection		27.0	15.5		14.8		14.8		17.6		16.9		17.9		15.5	

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 3, Site Special Issues - Ability of the candidate site to provide a "footprint" that allows timely construction of a facility to occur. (schedule criteria)	15															
1	Ability of the site to support the Rocky Flats Conceptual Vision (Vision) objectives.		3	2.1	0.7	2.4	0.8	3.0	1	0.3	0.1	0.3	0.1	0.3	0.1	0.3	0.1
2	Impacts from existing utility, sewer, process waste, or communications lines.		2	1.2	0.6	0.4	0.2	0.8	0.4	1.8	0.9	1.6	0.8	2.0	1	2.0	1
3	Impacts from security.		1	0.9	0.9	0.9	0.9	`0.4	0.4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	Impacts from Pu consolidation or residue stabilization activities.		1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
5	Impacts from D&D activities.		2	1.2	0.6	1.0	0.5	1.4	0.7	1.6	0.8	1.8	0.9	1.8	0.9	1.8	0.9
6	Impacts from current RCRA units.		2	1.8	0.9	0.4	0.2	1.4	0.7	2.0	1	2.0	1	2.0	1	2.0	1
7	Impacts from mineral rights issues or other easements.		2	1.2	0.6	1.8	0.9	1.8	0.9	0.8	0.4	1.8	0.9	2.0	1	1.2	0.6
8	Ability to co-locate additional waste management cells in the same vicinity.		2	1.6	0.8	1.2	0.6	1.6	0.8	2.0	1	2.0	1	2.0	1	1.6	0.8
	Site Special Issues		15.0	10.8		8.9		11.2		10.2		11.2		11.8		10.6	
	Category 4, Cost Criteria	15															
1	Cost of engineering and construction of protective measures.		3	2.1	0.7	1.5	0.5	1.5	0.5	2.4	0.8	2.1	0.7	2.1	0.7	2.1	0.7
2	Cost of site preparation including building demolition, subsurface line removal and re-routing, access requirements, and power/facility requirements		3	2.1	0.7	1.5	0.5	1.8	0.6	2.4	0.8	2.4	0.8	2.4	0.8	2.4	0.8
	Cost Criteria		6	4.2		3.0		3.3		4.8		4.5		4.5		4.5	

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 5, Regulatory Support State Principles for On-Site Disposal of Contaminated Materials (27-February-95 letter from Tom Looby to Jack McGraw and Mark Silverman)	15															
1	"The number of disposal sites must be minimized. We (CDPHE) suggest one centralized site be chosen for consolidation of contaminated materials."		2	1.6	0.8	1.4	0.7	1.8	0.9	1.4	0.7	1.2	0.6	1.2	0.6	1.2	0.6
2	"Every effort should be made to site a centralized disposal facility in an area of optimal geologic parameters preferably within, or close to the IA."		3	2.1	0.7	2.1	0.7	2.1	0.7	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6
3	"Any disposal facility must be designed and built as a state of the art disposal facility that meets or exceeds all permitting and regulatory requirements. This includes siting, design, long term protection, and performance requirements."		3	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6
4	'A permitted facility would provide DOE the greatest degree of future applicability and utility. ....the facility should be designed with the intent to permit under RCRA/CHWA"		2	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8	1.6	0.8
5	"Any disposal site at RFETS should be located in areas that have limited future land use potential and will be controlled by DOE until the interred waste no longer presents a risk to human health or the environment."		3	1.5	0.5	2.1	0.7	2.7	0.9	1.2	0.4	1.2	0.4	0.9	0.3	0.9	0.3
Regulatory Support			13.0	8.6		9.0		10.0		7.8		7.6		7.3		7.3	

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1	Points Scored	multi factor 0-1
	Category 6, Other Stakeholder Concerns	15															
1	General public perception/acceptance		2	1.4	0.7	1.4	0.7	1.6	0.8	0.8	0.4	0.6	0.3	0.4	0.2	0.4	0.2
2	Municipal or County acceptance.		2	1.2	0.6	1.4	0.7	1.4	0.7	0.4	0.2	0.4	0.2	0.2	0.1	0.2	0.1
3	DOE Orders		2	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6	1.2	0.6
4	NEPA		3	2.1	0.7	2.1	0.7	2.1	0.7	1.8	0.6	1.8	0.6	1.8	0.6	1.8	0.6
	Other Stakeholder Concerns		9.0	5.9		6.1		6.3		4.2		4.0		3.6		3.6	

Evaluate the seven locations (e.g., IA-East, IA-West) against the specific issues (for location, see Figure 1). The evaluation of the seven locations against Category 2 was accomplished with a series of maps displaying geologic, geomorphology, and hydrogeologic conditions (see Figures 2 through 7).

1. Evaluate and assign a number between 0-1 for each location on the matrix (e.g., IA-West, IA-East) against each specific issue with 0 being a fatal flaw that would preclude the location from being selected to 1 being the most favorable circumstance for that criteria (see Table C-2 for assigned numbers).

2. Multiply the score assigned to the specific issue in step 1 above (0 to 1) by the value assigned to the specific issue (between 1 and 3).

3. Sum the above products within each of the specific issues, as shown in Table C-2. There is a total of 35 specific issues illustrated in Table C-3, Criteria Issues:

Table C-3 Criteria Issues

Category	Criteria	Issues
1	Corrective Action Management Unit (CAMU) Criteria	5
2	Public Protection (Geotechnical and Hydrological Criteria)	11
3	Site Special Issues	8
4	Cost Criteria	2
5	Regulatory Support	5
6	Other Stakeholder Concerns	4
	Total	**35**

4. Divide the above sums by the total points and multiply by the weighting factor of that category, which in all cases is either 15 or 20%. The total available points assigned are 83, and are distributed as illustrated in Table C-4, Criteria Points.

Table C-4 Criteria Points

Category	Name	Points
1	Corrective Action Unit (CAMU) Criteria	13
2	Public Protection (Geotechnical and Hydrological Criteria)	27
3	Site Special Issues	15
4	Cost Criteria	6
5	Regulatory Support	13
6	Other Stakeholder Concerns	9
	Total	**83**

5. Sum the weighting factor of the six categories for the final ranking of the location. The overall ranking is summarized in Table C-5, RWSF Location Criteria Summary.

Each location was thus given an overall ranking between 0 and a 100%, with 100% being the most favorable location for the siting of a RWSF.

C.2.3 SCREENING PROCESS

A basic assumption made was that the entire Site as shown in Figure 1 would be included in the siting study. Category 2 includes the geologic, hydrogeologic, and geomorphologic aspects of the siting study. A series of maps were produced to assist in this evaluation. Additionally a map addressing ecology issues was included because these issues are best illustrated on a map. There are seven:

- Figure 1, Site Location Map, shows the location of building, roads, and the seven locations carried through in this evaluation.

- Figure 2, Hydrogeological Conditions, includes the depth to the water table and the area encompassed by 100-year flood plain.

SITING CRITERIA				Alternative Sites													
				Industrial Area						Buffer Zone							
				IA - West		IA - East		Solar Ponds		NSL		ESF		SE Quad		SW Quad	
		Weight %	Total Available Points	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored	Partial %	Points Scored
1	CAMU CRITERIA	20	13.0	15.1	9.8	14.6	9.5	15.8	10.3	16.2	10.5	15.7	10.2	15.7	10.2	15.7	10.2
2	PUBLIC PROTECTION	20	27.0	11.5	15.5	11.0	14.8	11.0	14.8	13.0	17.6	12.5	16.9	13.3	17.9	11.5	15.5
3	SITE SPECIAL ISSUES	15	15.0	10.8	10.8	8.9	8.9	11.2	11.2	10.2	10.2	11.2	11.2	11.8	11.8	10.6	10.6
4	COST CRITERIA	15	6.0	10.5	4.2	7.5	3.0	8.3	3.3	12.0	4.8	11.3	4.5	11.3	4.5	11.3	4.5
5	REGULATORY SUPPORT	15	13.0	9.9	8.6	10.4	9.0	11.5	10.0	9.0	7.8	8.8	7.6	8.4	7.3	8.4	7.3
6	OTHER STAKEHOLDER CONCERNS	15	9.0	9.8	5.9	10.2	6.1	10.5	6.3	7.0	4.2	6.7	4.0	6.0	3.6	6.0	3.6
	TOTALS	100%	83.0	67.6%	54.8	62.5%	51.3	68.3%	55.9	67.4%	55.1	66.1%	54.4	66.4%	55.3	63.4%	51.7

- Figure 3, Geological and Geotechnical Conditions, includes steep, color-coded slope areas for slopes 15-20%, 20-30%, and greater than 30% and inferred faults traces.

- Figure 4, Structure Base of Alluvium, drawn on the base of the alluvium (top of bedrock).

- Figure 5, Thickness of Alluvium, show the thickness of the Rocky Flats Alluvium.

- Figure 6, Ecology and NEPA, shows the location of seeps, wetlands, and Preble's Meadow Jumping Mouse probable habitat, a wildlife species that is being considered for listing as a species of concern, or a threatened and endangered species.

- Figure 7 Adverse Conditions (a combination of figures 2, 3, and 6 for a RWSF location) delineates three of the major potentially limiting criteria, the 100-year floodplain, steep slopes and the location of wetlands, seeps, and the Preble's Meadow Jumping Mouse habitat. Areas highlighted on this map have been removed from future consideration in this siting study because the presence of one or more of these aspects presents a major obstacle for locating a RWSF.

This initial screening of the Site reduced the number of locations being addressed. Seven locations are being carried forward in this study, four in the buffer zone and three located within the IA of the Site, as shown in Figure 1.

The four areas in the buffer zone are:

- The New Sanitary Landfill (NSL)

- An area near the East Spray Fields (ESF)

- An area in the Southwest Quadrant (SW Quad) of the buffer zone

- An area in the Southeast Quadrant (SE Quad) of the buffer zone

The three areas in the IA are:

- An area on the west side of the Industrial Area - (IA-West)

- An area on the southeast side of the Industrial Area - (IA-East)

- An area including the Solar Ponds 207B (North, Central, and South) and the land immediately adjacent and to the east (IHSS 165 and IHSS 176)

These seven locations are then carried on through the study and evaluated against the six general criteria categories. The scored matrix of location versus criteria and the values associated with the different combinations are shown in Table C-2.

C.2.4 ANALYSIS

The summary of the criteria evaluation is presented in Table C-5.

C.2.4.1 Corrective Action Management Unit (CAMU) Criteria

"The CAMU will facilitate the implementation of a reliable, effective, protective, and cost-effective remedy."

- A reliable, effective, and protective facility can be engineered at any of the locations being considered. The cost-effective component of this criteria ranges significantly from location to location, and is partially dependent on the RWSF design alternative selected. Locating any of the design alternatives within the IA is less cost-effective because of the infrastructure currently in place, such as building and buried and overhead utilities, that would have to be removed, rebuilt at another location, or re-routed.

- IA-West, IA-East, and Solar Ponds, all located within the IA, would be the less cost-effective options.

- NSL, ESF, SE Quad, and SW Quad locations located in the buffer zone would be the more cost-effective options.

"Remediation waste management activities associated with CAMU cannot create unacceptable risks to human health or the environment from exposure to hazardous waste or hazardous constituents."

- the locations within the IA would have a slight advantage in terms of transporting waste. Most of the waste that is being targeted for the RWSF would originate in the IA, and haul distances to a facility in the IA would be less than to a facility outside the IA.

"The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purpose of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility."

- NSL, SW Quad, and SE Quad locations are not in IHSSs or potential areas of concern (PAC). The designation of a CAMU to any of these locations would not be more protective than construction of the same facility within the IA on an IHSS.

- IA-West and IA-East locations are not within IHSSs or PACs; they are, however, located in the IA, adjacent to known contamination, or adjacent to, or within areas of, the location that have been subject to significant industrial uses, such as office buildings, waste storage buildings, production buildings, parking lots, paved roads, and buried and overhead utilities.

- The Solar Ponds and ESF are located within areas that have, in part, been designated IHSSs. The Solar Ponds location overlaps the Triangle Area, IHSS 165; the Contractor Storage Yard, IHSS 176; and the Solar Ponds, IHSS 207B. Managing remediation waste in this area has the advantage of managing waste in a secure area and reducing the size of the overall footprint of contamination at the Site.

- The ESF location overlaps IHSSs 216.2 and 216.3; however, these IHSSs have been identified as having no risk associated with them and have been recommended to go to no further action.

"The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 6 CCR 1007-3, 264.552(c)(1) or (c)(2)."

- The timing of remedial activity implementation is more dependent on the RWSF design alternative selected and the permitting process than on the location selected. This criteria is approximately the same for all locations being considered.

The CAMU shall enable the use, "as appropriate, treatment technologies (including innovative technologies) to enhance long-term effectiveness of remedial actions at the facility by reducing the toxicity, mobility, or volume of wastes that will remain in place after closure."

- The ability of the CAMU to use these treatment technologies, when appropriate, is more or less independent of the location selected and is approximately the same for all locations in the study.

C.2.4.2 Public Protection (Geotechnical and Hydrological Criteria)

"The geological and hydrogeologic conditions of a location in which hazardous waste is stored should provide reasonable assurance that the wastes are isolated within the storage area away from pathways to the public."

- Hydraulic conductivities of foundation soil materials (Rocky Flats Alluvium) typically occur in the 10^{-3} to 10^{-5} cm/sec range. Lower hydraulic conductivity values in the range of 10^{-6} to 10^{-7} cm/sec have been measured for the underlying weathered claystone bedrock. All of the locations are located in recharge areas associated with the Rocky Flats Alluvium and colluvial deposits, and many are located near discharge areas. The depth to the Fox Hills aquifer is greater than 500 feet over most of the Site and this interval consists mainly of low permeability claystones with hydraulic conductivities in the range of 10^{-6} to 10^{-7} cm/sec.

- The estimates of lateral groundwater flow travel times in the underlying surficial materials from the proposed waste locations to their nearest discharge points are well below a 1,000 years for all of the locations under consideration. The calculated travel times typically range from several years to several decades. The presence of significant groundwater discharge points (springs and seeps) in hydraulically downgradient areas of the SW Quad (Antelope Springs), NSL (Lindsey Ranch Springs), and potentially the ESF location, tend to reduce the suitability of these locations because of the potential ecological impacts associated with sensitive habitats issues. The location least affected by short groundwater travel times is the SW Quad location because groundwater is assumed to flow through bedrock materials (hydraulic conductivities 10^{-6}-10^{-7} cm/sec) rather than the more permeable alluvium.

- Water losses from location operations via leaking pipes and general housekeeping practices are currently believed to contribute an unknown but potentially significant amount of recharge to the groundwater in the Site IA. It is expected that the elimination of anthropogenic recharge sources related to cessation of location operations and building closures under the Site Vision will result in a lowering of water levels in the IA similar to that observed in many IA well hydrographs following the termination of plant production operations in 1990.

"Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree which can be accommodated in the facility design."

- This is not a major factor in the overall siting study; all locations have approximately the same geomorphic conditions with the degree of erosion occurring at a predictable rate and can be accommodated in the facility design. The SE Quad location is rated lower in this category because the protective cover of the Rocky Flats Alluvium has been removed by erosion and escarpment retreat.

"Structural-related issues include slope and geotechnical stability, as shown in Figures 3 and 7."

- Areas with steep slopes (slopes greater than 15%) have been eliminated from the siting study. There is a steep slope to the north of the Solar Ponds location; the footprint to the facility would be positioned, however, as far south of the slope as the design would allow and is not considered to be a limiting siting factor. Geotechnical stability of foundation soils is not expected to be a problem at any of the locations. This consideration will be addressed by a field geotechnical investigation performed at the selected location during the feasibility-assessment phase of the program.

"The immediate area of the location should be in strata of minimal groundwater flow."

- All of the locations have minimal groundwater flow, however, the SE Quad location is situated in an area considered more suitable compared to the other locations. At the SE Quad location, the RWSF would be built on weathered bedrock materials that have a significantly lower permeability than either the surrounding thin, colluvial soil veneer or Rocky Flats Alluvium.

"Geological strata combined with engineering barriers shall provide a minimum permeability."

- The design of the facility at any of the candidate locations would incorporate an engineered barrier that would provide a minimum permeability of 10^{-7} cm/sec for protection of domestic or agriculture aquifers. Additional protection of the regionally important Laramie/Fox Hills aquifer is provided by several hundred feet of intervening, low-permeability claystone aquitard materials comprising the upper Laramie and Arapahoe formations. Downward migration from the unconfined aquifer is thought to be nonexistent based on existing data (EG&G, 1995a).

Siting consideration should include "bedrock and surface integration including the nature and extent of bedrock material."

- The upper Laramie Formation is an extensive aquitard beneath all locations under consideration (maximum thickness beneath the Site is greater than 500 feet) and forms an effective and continuous low-permeability barrier to downward vertical groundwater flow. Local variations in shallow bedrock lithology caused by the presence of small, discontinuous bodies of subcropping Arapahoe formation sandstones are observed in the IA, notably at the Solar Ponds and IA-East locations. These sandstones are capable of both vertical and lateral groundwater transport, but vertical flow to deeper sandstones and the Laramie/Fox Hills aquifer is thought to be nonexistent. Sites with thinly saturated alluvium and subcropping sandstones, such as those found at the Solar Ponds and IA-East areas, have the greatest potential for groundwater interchange between alluvial

and bedrock units. The sandstones from the Arapahoe and Laramie formations, however, are discontinuous and isolated, with fewer sandstone lens present in the lower part of the formation.

"Siting consideration should include minimal relative presence of fractures or faults."

- Bedrock fracturing is potentially important in areas of thinly saturated alluvium (Solar Ponds, ESF, and IA-East locations), where a significant portion of alluvial groundwater may recharge the bedrock, or at the SE Quad location, where liner materials would be in direct contact with bedrock. Groundwater flow in fractured claystone bedrock is thought to be minimal because of limited fracture densities and small fracture apertures observed in core samples across the location. Fracture densities are observed to decrease with depth.

- The inferred bedrock faults at the Site, as shown in Figures 3 and 4, are not considered to pose a seismic risk (EG&G, 1995b), according to the Nuclear Regulatory Commission definition (10 CFR Part 100, Appendix A) (NRC, 1990 and 1991), because the Rocky Flats Alluvium is not deformed over the intensely fractured areas of the Laramie Formation at the Site.

  - Solar Ponds and IA-East. There is an inferred north-to-south-orientated bedrock fault through the Solar Ponds that continues south through the IA-East location (EG&G 1995a). The inferred fault appears to be located hydraulically upgradient from the Solar Ponds location which would remove it as a potential groundwater pathway. The trace of this inferred fault also bisects the IA-East location from north to south.

  - IA-West. There is an inferred northeast-to-southwest trending bedrock fault through the IA-West location. This fault is located hydraulically downgradient from the IA-West location and represents a potential groundwater pathway to deeper sections of the Laramie Formation.

  - ESF. There is an inferred northeast-to-southwest bedrock fault trending fault through the ESF location. The fault is located hydraulically upgradient from the location and removes it as a potential groundwater pathway.

  - NSL, SE Quad, and SW Quad. There are no mapped or inferred faults in these areas.

  - A preliminary evaluation of potential vertical groundwater movement along fault zones at the Site using environmental isotopes as hydrologic tracers has indicated that fault zones probably transmit little, if any, groundwater preferentially downward relative to flow in undisturbed, unweathered bedrock zones (memorandum to A. Primrose from R. Smith dated November 22, 1995).

Consideration should be given to the "relative depth to bedrock/groundwater, including seasonal fluctuations for groundwater."

- Bedrock depths range from less than an estimated 5 feet at the SE Quad location to over 40 feet at the NSL, ESF, and SW Quad locations. Saturated alluvial thicknesses at the candidate locations vary as a function of distance from drainages, configuration of bedrock topography, and seasonal recharge. Generally, saturated thicknesses are greatest in the spring (April, May, and June) and

may fluctuate anywhere from a few feet to as much as 20 feet depending on local hydrologic and seasonal recharge conditions.

- Precipitation for the spring of 1995 has been estimated to be the greatest in a 102-year period based on precipitation records from Boulder, Colorado. Seasonally high water tables, in some cases within a foot of ground level, were measured or estimated at many of the locations in 1995. The locations with the deepest water tables (seasonal peaks greater than 10 feet below ground level) include ESF and the NSL.

- IA-West, IA-East, and Solar Ponds. As shown in Figure 2, the average water table in the IA is +/- 10 feet from the surface (Ref.: EG&G, Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site, April 1995). At the IA-West location, the minimum depth to groundwater (historical highs) was recorded or estimated during 1995 and ranged from 0.0 to 8.7 feet below ground level in the six monitoring wells in and around the location. In this same timeframe at the Solar Ponds location, the depth to groundwater ranged from 1.0 to 4.8 feet. Well coverage at the IA-East location is less extensive compared to the other IA locations, and it is assumed that water-level conditions were similarly shallow based on historical water-level records and location-specific hydrologic conditions.

  - NSL. The concerns related to water-table depth at the NSL are less than those associated with the IA. The minimum depth to groundwater at the NSL location was measured at 26 feet (well 0190) in 1995, which makes this the most favorable location in terms of the seasonal fluctuation criteria. The water table typically occurs in the 30- to 50-foot below grade range under normal (nonpeak) hydrologic conditions.

  - ESF. Water level records of four wells at the ESF location indicate that the minimum depth to water expected in this area is about 20 feet, with an average depth of between 25 to 30 feet. The alluvium at this location generally has a saturated thickness of less than 5 feet, with significant unsaturated areas occurring during seasonal watertable lows.

  - SE Quad. There is a paucity of water-level data in this area because of the lack of monitoring well coverage. The majority of the surficial deposits in this area most likely exist in a largely unsaturated condition. A shallow water table in the underlying weathered bedrock material, however, may exist and cannot be ruled out without more information.

  - SW Quad. Depth to groundwater at the SW Quad location is 0 to 20 feet with a saturated thickness of between 30 and 40 feet. Groundwater in this area becomes more shallow in an eastward direction toward Antelope Springs, as indicated by monitoring well data. The minimum water-table depth in areas west of Antelope Springs is estimated to be less than 5 feet.

"The site will not impact nor be impacted by surface water."

- None of the locations are located in areas that will be impacted by surface water. The locations are not expected to have a significant impact on surface water, although slight reductions in flow at nearby springs and seeps may be experienced because of a loss of recharge area. This situation might exist at the SW Quad, NSL, and ESF locations where free-flowing springs

contribute directly to stream flow.

"Relative distance to the nearest discharge area should include consideration of groundwater flow direction and travel time."

- The relative distance to the nearest discharge areas is relatively short for most of the locations being considered.

  - IA-West and IA-East. These locations lie astride the subsurface drainage divide between the ephemeral Woman and Walnut Creeks. The nearest point of discharge are the seeps that are expressed near the base of the alluvium on the south-facing slopes of the Woman Creek Drainage. These wetlands areas are approximately 250 feet south of the IA-West location. Groundwater flow from the IA-East location south of the drainage divide would flow toward Woman Creek but is captured by the French Drain along the 881 Hillside.

  - Solar Ponds. This location lies astride the subsurface drainage divide between the North and South Walnut Creeks. The Interceptor Trench System (ITS) adjacent to, and north of, the Solar Ponds captures part of the groundwater flow to the north. The flow to the north not captured by ITS moves toward South Walnut Creek and eventually enters the groundwater system associated with this drainage. The nearest point of discharge to South Walnut Creek is approximately 250 feet south of the Solar Ponds location.

  - NSL. This location lies astride the subsurface drainage divide between the ephemeral Rock Creek to the north and North Walnut Creek to the south. Surface expressions of groundwater in the forms of seeps are evident along the base of the alluvium in the Rock Creek Drainage about 1500 feet to the northeast. On the south side of the drainage divide the nearest discharge to surface water would be about 500 feet south to the upper reaches of North Walnut Creek.

  - ESF. This location lies on the subsurface drainage divide between Woman and Walnut Creeks. The part of this candidate area that lies on the Woman Creek side of the watershed is unsaturated, which would indicate that groundwater from this location in all likelihood does not flow into Woman Creek. The part of the location on the Walnut Creek side of the location discharges into a series of seeps located 200 to 1000 feet north of the location (depending on the location of the facility) at the base of the alluvium that discharges through surface flow into Walnut Creek.

  - SW Quad. The groundwater direction of flow from this location is to the northeast and discharges into Antelope Springs, which is adjacent to the location. The location is within the Woman Creek drainage basin.

  - SE Quad. This candidate is located on the north side of the Woman Creek drainage. Subsurface data are sparse in this area, but the area is not located on the Rocky Flats Alluvium. The surficial geology of this location is weathered claystones, siltstones, and sandstones of the Arapahoe and the underlying Laramie Formations (EG&G, 1995a). The location potentially has no saturated unconsolidated surficial deposits.

"The terrain is such that good drainage exists for movement of precipitation away from the storage area, and such that water and wind erosion will be minimal."

- This criteria is essentially the same for all locations, either good drainage already exists or a drainage system can be engineered to accommodate the needs of this requirement. The SW Quad has a slightly poorer drainage system than the other locations.

C.2.4.3 Site Special Issues

The ability of the location to support the Site Vision objectives: Under the Site Vision, all nuclear materials will be removed from the Site and the DOE will remediate the Site in a manner consistent with reasonably foreseeable future projected land (see Figure 8, Conceptual Site Land Uses) and water uses.

- The reasonably foreseeable future land use of the buffer zone varies from unrestricted to restricted open space, whereas the IA is projected as either an industrial use area or as a capped area.
  - Solar Ponds would be an ideal candidate to support the Site Vision because of the future land use of the IA and its location within the footprint of the capped area.
  - IA-East and IA-West could, with extensive modification to the footprint of the capped area, support the RFCA. The IA-West location is in a noncontaminated area in the IA.
  - The candidate locations, NSL, ESF, SW Quad, and SE Quad, do not support the Site Vision because utilization of these locations would involve placing contamination in previously uncontaminated areas.
- Impacts from existing utility, sewer, process waste, or communications line:
  - IA-West, IA-East, and Solar Ponds. The three locations within the IA all have significant amounts of utility lines, sewer lines, and other infrastructure, either buried or above ground, that would require removal or replacement. (listed in Table C-6, "In-place Infrastructure"). Impacts would also include demolition of buildings within the footprint, storage of RCRA waste currently located in buildings at these locations (IA-East and the Solar Ponds), and construction of a portal and security fence for the Solar Ponds location. The order-of-magnitude costs generated for the preparation of a location are in Table C-7.

Table C-6 In-place Infrastructure

Location	Area	Infrastructure
New Sanitary Landfill	Underground	Telephone main
		Electrical - 208V
		Water Line - 3@ (abandoned)
	Overhead	Electrical Utilities - 208V
	Miscellaneous	Live Firing Range - Range Fan Area
	Buildings	None
Solar Ponds	Underground	Process Waste Lines - 3" and 8"
		Raw Water Lines - 4." 6" and 8"
		Domestic Cold Water - 4"
		Sewer Lines - 4". 8" and 12"
		Process Drains - 3". 6" and 8"
		Water Valves
		Culverts
		Telephone Lines
	Overhead	Electrical Utilities - 110V. 440V. 480V and 2400kV
		Helicopter Deterrent
		Power Poles
	Buildings(1)	228A, 228B, 910, 928, 964, 965, 967, and 990
IA-East	Underground	Electrical Utilities - 480V and 13.8kV
		Water Pipelines - 3". 6". and 10"
		Steam - 6" and 8"
		Gas Lines - 3"
		Sewer Lines - 4" and 12"
		Telephone Lines
		Foundation Drains
		Tunnel
		Culverts
		Alarms and Data Systems
		Storm Drains
		Vaults
	Overhead	Electrical - 2400V and 13.8kV
		Alarms
		Steam and Condensate
		Natural Gas
	Buildings	T886B, T886C, T893B, 902 Tent, 906, and ER Contractor Yard
IA-West	Underground	Electrical Utilities - 15V, 110V, 120V, 120/240V, 277V. 2400V. and 13.8kV
		Domestic Cold Water Pipelines - 4". 6". and 12@
		Raw Water Pipelines - 2". 4". and 12"
		Water Valves
		Culverts - 12". 18". and 20"
		Alarms - 1". 2" and 4"
		Sewer Lines - 4" and 8"
		Catch Basins
		Storm Drains - 15"
		Scanner
	Overhead	Electrical - 480V. 2400V. 13.8kV and Parking
	Buildings	T124A

(1) Only Building 964 will need to be removed if any design alternative other than the Abovegrade Landfill is the preferred alternative.

Table C-7 Order-of-Magnitude Costs for Site Preparation

Location	Construction Cost
IA-East	$14,800,000
Solar Pond	$11,900,000
IA-West	$2,200,000
NSL	$100,000

- Costs were not generated for the ESF, SW Quad, or the SE Quad locations. The preparation for these areas would fall between the costs of the IA-West and NSL.

- Impacts from security:

  - Security impacts would be approximately the same for all locations, except for the Solar Ponds. That area would need an access portal to allow for construction materials and workers to enter the PA, a perimeter fence to isolate the discharge to surface water would be about 500 feet south to the upper reaches of RWSF during both construction and postconstruction activities, and a security staff during construction activities. The cost of the portal, fence, and security staff has been calculated as part of the preparation cost.

- Impacts from Pu consolidation or residue stabilization activities:

  - Impacts from Pu consolidation or residue stabilization activities are not a factor for the siting of a RWSF.

- Impacts from deactivation and decontamination (D&D) activities:

  - IA-West. Building T124A is located within the footprint and staging area (22 acres) of the abovegrade RWSF landfill and would require demolition if this design option was selected. This building is currently scheduled for removal in fiscal year 2000, but that could easily be accelerated if the location were selected. The other design alternatives for this location all have smaller footprint and staging areas (approximately 10 to 12 acres) and would not require demolition of this building.

  - IA-East. There are several buildings and a contractor yard that would be impacted from siting the RWSF at IA-East. Building 906, the centralized waste storage facility, is the newest building at the Site and was specifically built for waste storage. The decommissioning of this facility has not been scheduled, and the current working assumption is that it will remain, at least, for the near term. The 902 Pad facility is a tent and the possibility exists to move it to another location without losing storage capacity. The contractor yard has a number of trailers and government- and contractor-owned stored equipment. The decommissioning of this area has not yet been scheduled and the working assumption is that it would remain open beyond 2003.

- Solar Ponds. Building 964 is located within the footprint of all of the RWSF alternatives. It is a sheet metal building used as a RCRA storage facility. Demolition of the structure is straight forward and could be completed in 90 days assuming additional waste storage capacity becomes available. If the above-grade landfill alternative is selected the footprint would be larger and also require the demolition of Buildings 228A, 228B, 928, 965, 910, and 990.

- NSL, ESF, SW Quad, and SE Quad. There are no buildings associated with these candidate's locations.

- Impacts from current RCRA units:

  - IA-East. Building 906, the centralized waste storage facility, is a RCRA storage facility. The decommissioning of this facility has not been scheduled, and the current working assumption is that it will remain until no longer required.

  - Solar Ponds. Building 964 is a RCRA storage facility located within the footprint of the RWSF. Alternative storage capacity would have to be created before demolition of this structure.

  - IA-West, NSL, ESF, SW Quad, and SE Quad. There are no RCRA storage units located at these candidate locations.

- Impacts from mineral rights issues or other easements:

  - All mineral rights at the Site are either privately held, or, as with the NSL location, it is both privately and governmentally held (see Figure 9, Mineral Ownership). Alluvial thicknesses greater than 40 feet are potentially economic for the gravel resources.

  - NSL and SW Quad. Both locations have alluvial thicknesses greater than 40 feet.

  - IA-West. Alluvial thicknesses are 25 to 40 feet thick and do not constitute an economic resource.

  - ESF. Alluvial thicknesses are 10-30 feet thick and do not constitute an economic resource.

  - IA-East and Solar Ponds. Alluvial thicknesses are +/-10 feet thick and do not constitute an economic resource.

  - SE Quad. Located off the Rocky Flats Alluvium, there are no gravel deposits at this location.

- Ability to collocate additional RWSFs in the same vicinity:

  - IA-West, NSL, ESF, SW Quad, and SE Quad. All have adequate space to location additional RWSF cells if needed.

- Solar Ponds. The footprint shown can accommodate approximately 300,000 cy.

- The area around IA-East is restricted, with the 800 complex to the west, steep slopes to the south, and the security fence surrounding the PA to the north. Room for expansion would potentially be available to the east.

C.2.4.4 Cost Criteria

- The cost of engineering and construction of protective measures:

  - The cost of engineering and construction varies with the RWSF alternative selected. The cost of construction at the Solar Ponds would be greater than at other locations because of the additional requirements imposed by having to construct a materials and worker portal through the security fence into the PA, and the additional security that would be required.

- Cost of preparation of the location including building demolition, subsurface line removal and rerouting, access requirements and power/facility requirements above the basic RWSF:

  - The cost of preparation varies by location. The cost of preparation at the NSL location is approximately of $100,000. The preparation for the NSL location already under construction has mitigated the costs that would otherwise be associated with a RWSF at this location.

  - ESF, SW Quad, and SE Quad would require construction or upgrades to the roads leading to the locations; costs are estimated to be more than the NSL location ($100,000) but less than the costs of the IA-West location ($2.2 to $2.8 million).

  - The locations within the IA, IA-West, IA-East, and Solar Ponds have considerable costs associated with preparation including building demolitions, subsurface line removal and rerouting access requirements. Costs for preparation range from approximately $2.2 to $2.8 million for IA-West, $6.1 to $14.5 million for the Solar Ponds, and $15.2 to $18.1 million for IA-East.

C.2.4.5 Regulatory Support

"The number of disposal sites must be minimized. We (CDPHE) suggest one centralized site be chosen for consolidation of contaminated materials." The following concepts have been evaluated in this study to ensure consistency with EPA and CDHPE desires, but because the RWSF being proposed is for storage, not disposal, some of these criteria may not be appropriate for siting a storage facility.

- Locating the RWSF at the Solar Ponds location minimizes the number of locations by locating the facility in an area that coincides with, and would ultimately be incorporated into, the larger cap, and is a component of the Site Vision. The IA-West and the IA-East locations could, with

major revisions, support the Site Vision.

- The NSL, ESF, SE Quad, and the SW Quad locations would increase the overall areal extent of contamination by their location that is further away from the IA. The IA is where the bulk of the environmental waste at the Site is located.

"Every effort should be made to site a centralized disposal facility in an area of optimal geologic parameters preferably within or close to the Industrial Area (IA)."

- Optimal geological parameters at the Site reside in the locations outside of the IA. The NSL, ESF, and the SE Quad are preferred locations from an optimal geologic standpoint relative to the IA. However, all three locations are at a distance from the IA; the NSL is 2,000 feet northwest; ESF is 4,000 feet to the east; and the SE Quad is approximately 6,000 feet to the southeast of the PA.

- Optimal geological parameters do not exist within the IA, as discussed in Section 2.4.1, IA-West, IA-East, and the Solar Ponds are all within the IA.

"Any disposal facility must be designed and built as a state-of-the-art disposal facility that meets or exceeds all permitting and regulatory requirements. This includes (but not limited to) siting, design, long-term protection, and performance requirements."

- The alternatives considered will be built as a state-of-the-art storage facility and will meet or exceed all permitting and regulatory requirements. This criteria is the same for all locations being considered.

"A permitted facility would provide DOE the greatest degree of future applicability and utility. The facility should be designated with the intent to permit under RCRA/CHWA."

- This criteria is the same for all locations being considered.

C.2.4.6 Other Stakeholder Concerns

- General public perception and acceptance:

  - For onsite management of remediation waste, the locations within the IA, IA-West, IA-East and the Solar Ponds would in all likelihood be more readily acceptable to the general public than storage in the buffer zone. The locations in the IA reduce the footprint of contamination at the Site, and other than offsite disposal, storage of the environmental waste in the IA may well be the most acceptable alternative to the general public. Also, the Interim Measure/Interim Remedial Action (IM/IRA) for closure in place of Solar Ponds has already been accepted by the public.

- Municipal or County acceptance:

  - The Jefferson County, Colorado Board of Commissioners Resolution No. CC94-654 states, "maintaining, in perpetuity, the undeveloped buffer zone of open space around Rocky Flats is a critically important environmental, safety, and health constraint which

must be required as part of any and all alternatives actions proposed by the Department of Energy." The three locations within the IA, IA-West, IA-East and the Solar Ponds would support this resolution.

- NSL, ESF, SW Quad, and SE Quad locations are located within the buffer zone and as such, constructing a RWSF at any of these locations would be counter to the desires of Jefferson County.

- DOE Orders:
  - The same DOE orders would apply equally to all locations.
- NEPA:
  - NEPA issues would be addressed equally for all locations.

C.2.5 RESULTS FOR SELECTED LOCATIONS

The results of the above analysis are summarized in Table C-5. Overall, the Solar Ponds (68.3%) was ranked slightly higher then the IA-West (67.6%) location, and the NSL (67.4%) as a location for a RWSF at the Site.

In Category 1, CAMU, the ability to designate the location as a CAMU was in favor of the IA locations, in order: Solar Ponds; IA-East; and IA-West. The capacity to reduce the areal extent of contamination and not contaminate clean areas weighed heavily in favor of the IA locations. No fatal flaws were associated with this category at any of the seven locations carried through the evaluation.

In Category 2, Public Protection (Geotechnical and Hydrological Criteria), three of the buffer zone locations were ranked highest, in order: SE Quad; NSL; and ESF. The primary concern with the locations in the IA, (Solar Ponds, IA-West, and IA-East) is the elevated groundwater table; the concerns are somewhat mitigated, however, through the use of an above-grade design. No fatal flaws were associated with this category at any of the seven locations carried through the evaluation.

In Category 3, Site Special Issues, the SE Quad was evaluated as the highest, followed by Solar Ponds, and ESF locations. The three locations in the IA, IA-West, IA-East, and the Solar Ponds all received high ranking for the ability to support the Site Vision. However, the impacts of having to address issues with the existing infrastructure lowered the overall scores for the IA locations in this category. No fatal flaws were associated with this category at any of the seven locations carried through the evaluation.

In Category 4, Cost Criteria, the locations in the buffer zone are favored. All four buffer zone locations received higher ranking than the locations in the IA. The major factors were the costs associated with removing, rerouting, or replacing buildings and underground and overhead utilities in the IA. The Solar Ponds has the additional burden of having to construct a portal through the PA security fence, constructing a fence surrounding the location, and having a security staff available during construction and operation of the facility.

In Category 5, Regulatory Support, the support is clearly in favor of a location in the IA. The Solar Ponds location was ranked highest followed by IA-East and IA-West.

In Category 6, Other Stakeholder Concerns, the three locations within the IA, Solar Ponds, IA-East, and IA-West respectively, ranked the highest. The general public would likely be more receptive to placing remediation waste in areas that already contain some contamination rather than siting a RWSF at a location that has no history of contamination. The Jefferson County, Colorado Board of Commissioners, state their position in Resolution No. CC94-654 as "Maintaining in Perpetuity, the undeveloped buffer zone of 'Open Space' around Rocky Flats is a critically important environmental safety and health constrain which must be required as part on any and all alternative action proposed by the Department of Energy."

C.2.6 REFERENCES

Dawson, G.W. and Mercer, B.W., 1986, Hazardous Waste Management, Wiley-Interscience Chapter 5 Facility Siting.

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TABLE OF CONTENTS

D.1 SCREENING CRITERIA D-1

D.2 COMPARISON OF ALTERNATIVES CRITERIA D-5

TABLES

Table D-1 Screening Criteria for IM/IRA Remediation Waste Storage Facility D-1

D.1 SCREENING CRITERIA

The criteria used in the Onsite Remediation Waste Storage Facility Siting Study and the Draft Evaluation of Onsite Versus Offsite Remediation Waste Management Options is presented in Table D-1.

TABLE D-1 .....SCREENING CRITERIA FOR IM/IRA REMEDIATION WASTE STORAGE FACILITY

IM/IRA Selection Criteria	Siting Criteria	Design Criteria
1. CAMU CRITERIA - Ability to designate as CAMU per 6 CCR 1007-3 264.552 (c)		
(1.1) The CAMU shall facilitate the implementation of reliable, effective, protective, and cost effective remedies.	X	X
(1.2) Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposures to hazardous waste or hazardous waste constituents.	X	X
(1.3) The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purposes of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.	X	
(1.4) Areas within that CAMU, where remediation wastes remain in place after closure of the CAMU, shall be managed and contained so as to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment.	X	X
(1.5) The CAMU shall expedite the timing of remedial activity implementation, unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2).	X	X
(1.6) The CAMU shall enable the use, when appropriate of treatment technologies (including innovative techs.) to enhance long term effectiveness of remedial actions by reducing the toxicity, mobility or volume of remediation waste that will remain in place after closure.		X
(1.7) The CAMU shall minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU unless to do so would be inconsistent with 264.552 (c)(1) or (c)(2).	X	
2. PUBLIC PROTECTION (GEOTECHNICAL AND HYDROLOGICAL CRITERIA) - Ability to protect public per 6 CCR 1007-2 Part 2		
(2.1) The geol. and hydro. conditions of a site in which HW are to be disposed shall be such that reasonable assurance is provided that such wastes are isolated within the designated disposal area... away from ...pathways (to public) for 1000 yrs.	X	X
(2.2) Geomorphic conditions either will not vary significantly from the present state or will occur to a predictable degree which can be accommodated in the facility design.	X	
(2.3) Structure related issues to include: Slope and geotechnical stability	X	X
(2.4) The immediate area of the site is in strata of minimal groundwater flow.	X	
(2.5) ...geological strata combined with engineering barriers shall provide a minimum permeability of 10-7 cm/sec or equivalent...domestic or agr. aquifer protection.	X	X
(2.6) Bedrock/surface integration including the nature and extent of bedrock material.	X	

Table D-1 (continued)

IM/IRA Selection Criteria	Siting Criteria	Design Criteria
(2.7) Minimal relative presence of fractures or faults.	X	
(2.8) Relative depth to bedrock/groundwater including seasonal fluctuations for groundwater.	X	
(2.9) The juxtaposition of the site and any free flowing or standing natural surface waters shall be such that disposal location will not impact nor be impacted by surface water.	X	
(2.10) Relative distance to nearest discharge area to include consideration of groundwater flow direction and travel time.	X	
(2.11) The terrain is such that good drainage exists for movement of precipitation away from the disposal area, and such that water and wind erosion will be minimal.	X	
(2.12) The geochemical characteristics of the geological strata are compatible with the waste categories proposed to be disposed...provide high adsorption, absorption...fixation of any wastes that may migrate...	X	
3. SITE SPECIAL ISSUES - Ability of the candidate site to provide a "footprint" that allows timely construction of a facility to occur. (schedule criteria)		
(3.1) Ability of the site to support the Site Vision and RFCA objectives.	X	
(3.2) Impacts from existing utility, sewer, process waste, or communications lines.	X	
(3.3) Impacts from security.	X	
(3.4) Impacts from Pu consolidation or residue stabilization activities.	X	
(3.5) Impacts from building deactivation activities.	X	
(3.6) Impacts from D& D activities.	X	
(3.7) Impacts from current RCRA storage or other active RCRA units.	X	
(3.8) Impacts from mineral rights issues or other easements.	X	
(3.9) Ability to collcate additional waste management cells in the same vicinity.	X	
4. COST CRITERIA		
(4.1) Cost of construction, includes Construction, Preconstruction, and Design Costs	X	
(4.2) Cost of site preparation including building demolition, subsurface line removal an re-routing, access requirements, and power/facility requirements above basic cell Functional & Operational Requirements.	X	
(4.3) Cost of interim closure and monitoring after interim closure		
(4.4) Total Life-Cycle Cost		
5. REGULATORY SUPPORT - State Principles for On-Site Disposal of Contaminated Materials (27-February-95 letter from Tom Looby to Jack McGraw and Mark Silverman)		
(5.1) The number of disposal sites must be minimized. We (Colorado Department of Public Health and the Environment) suggest one centralized site be chosen for consolidation of contaminated materials.	X	

Table D-1 (continued)

(5.2) Every effort should be made to site a centralized disposal facility in an area of optimal geologic parameters preferably within, or close to the IA.	X	
(5.3) Any disposal facility must be designed and built as a state of the art disposal facility that meets or exceeds all permitting and regulatory reqmts. This includes (but not limited to) siting, design, long term protection, and performance reqmts.	X	X
(5.4) A permitted facility would provide DOE the greatest degree of future applicability and utility. ....the facility should be designed with the intent to permit under RCRA/CHWA...	X	X
(5.5) Levels of radioactive contamination in any materials disposed on-site will be limited....levels as yet undetermined...		X
(5.6) Any disposal site at the Site should be located in areas that have limited future land use potential and will be controlled by DOE until the interred waste no longer presents a risk to human health or the environment.	X	
6. OTHER STAKEHOLDER CONCERNS		
(6.1) General public perception/acceptance	X	X
(6.2) Municipal or County acceptance.	X	X
(6.3) DOE Orders	X	X
(6.4) NEPA	X	
(6.5) Air Impacts	X	X
(6.6) Compliance to ARARS	X	X
(6.7) Long Term Liability/Effectiveness		X
(6.8) Ability to Accept Waste		X
(6.9) Demo. performance/Useful Life		X
(6.10) Construction and Operation		X
(6.11) Schedule Requirements		X
(6.12) Availability of Technology		X
(6.13) Availability of Service and Materials		X

The stakeholder concerns criteria addresses impacts to parties affected by decisions at the Site and to the Site and the surrounding community, as follows:

6.1) General Public Perception/Acceptance - The public sentiment including the general public and concerned local communities is evaluated as an alternative.

6.2) Municipal and County Acceptance - The viewpoints of local government including Jefferson County and local municipal governments are reflected in this criteria.

6.3) DOE Orders - This criteria has the ability to meet the requirements of DOE orders, particularly orders that protect the safety of workers, the public, and the environment.

6.4) NEPA - This criteria contains NEPA compliance requirements including environmental impacts, socioeconomic impacts, and impacts to archeological, cultural, and historical locations.

6.5) Air Impacts - This criteria includes impacts to air quality—onsite, offsite and regionally, as well as air pollution prevention or mitigative measures.

6.6) Compliance to Performance Regulations - This criterion was used to evaluate the ability of any given alternative to meet existing and potential state and Federal performance requirements. This did not include any performance requirements specific to the cleanup of Individual Hazardous Substance Sites that are independent of any given alternative.

6.7) Long-Term Liability and Effectiveness - This criterion was employed to evaluate the ability to safely isolate, contain, and manage remediation waste with the passage of time. It also addressed the issues of long-term liability, particularly for alternatives whose ability to safely manage materials could be subject to change in the future.

6.8) Ability to Accept Waste - This criterion was utilized to evaluate the ability of an alternative to accept waste volumes and different types of waste that will result from environmental restoration activities. This included, at a minimum, the ability of various options to accept remediation waste at the same rate that it is generated and to have the overall capacity to be a viable solution for at least near-term activities.

6.9) Demonstrated Performance/Useful Life - This criterion was used to address the permanence of a selected alternative as well as whether the alternative is known through experience to be viable.

6.10) Construction and Operation - This criterion was used to evaluate a number of factors such as whether monitoring is feasible during operations and after closure, whether environmental and geological features would circumvent construction or the overall constructability, and whether transportation of remediation waste is feasible.

6.11) Schedule Requirements - This criterion was used to directly support one of the main objectives of this IM/IRA—can the alternative be ready to accept remediation waste and be fully operational when needed in the future.

6.12) Availability of Technology - This criterion was employed to evaluate whether the technologies exist and have been developed to the point where they would be available. This was primarily directed at design considerations; however, the availability of monitoring, transportation, handling, and safety technologies was also part of this consideration.

6.13) Availability of Services and Materials - This was an evaluation of the availability of construction materials, equipment, analytical support, construction labor, and support personnel over the entire life of any given alternative.

D.2 COMPARISON OF ALTERNATIVES CRITERIA

The final comparison of alternatives used the seven criteria (plus two additional criteria) defined in 40 CFR Part 300.430, that are summarized, as follows:

1) Protection of Public Health and the Environment - This criterion was used to evaluate the alternative's impacts to ground water, surface water, drainage pattern impact, soil, air, plants and animals for the life-cycle of the IM/IRA. Emphasis is placed on the ability of the alternative to control migration and leachability of contaminants and impact of any construction.

Impacts on erosion rate and loss of top soil were also examined including their offsite effects of erosion and wind blown soil. Alternatives were evaluated as to whether there were temporary or short-term changes to the soil and the erosion rate or whether these changes had lasting long-term impacts. The ability of an alternative to minimize and/or mitigate these erosional effects through erosion control or replacement of the topsoil was evaluated.

Each alternative was analyzed for biological impacts, direct and indirect impacts on critical habitat, wetlands, and vegetation. Analyzing biological effects included the cumulative effects of regionally important species, endangered species, and biodiversity. It also included the irreversible effects of permanent loss of habitat and permanent loss of species. The ability to restore biological habitat and wetlands or reduce the impact by the timing of the action was also evaluated.

Impact to air quality onsite, offsite, and regionally; and pollution prevention or mitigative measures were also considered.

The impact of the alternative on the safety of the surrounding community is evaluated. This includes not only disposal and storage of remediation waste but also the impact of transportation of remediation waste. Direct effects on water quality and water consumption are an important part of this criteria as well as airborne materials that could potentially impact public health.

2) Worker Safety - The health and safety of workers is evaluated. This includes all phases of the alternative from construction to all handling and operation to closure and surveillance.

3) Transportation - This includes all forms of transport associated with an alternative from any shipment of waste to the impacts that an alternative might have on existing traffic systems. Transportation had to be examined out of state also since the all of alternatives involve offsite shipment at some time..

4) Facility Design, Containment and Monitoring - This criterion was used to evaluate the design of each alternative in terms of implementability, efficiency safety, availability, and protectiveness. The ability of each alternative to effectively contain contaminants and the ability verify that containment through monitoring was also evaluated.

5) Institutional Controls - This criterion was used to evaluate institutional controls which limit human activities at or near the facility, protect health and environment, and assure continued effectiveness of the alternative.

6) Cost - The total cost of each alternative was evaluated, as were individual costs for design, site preparation, construction, operations, interim closure, and interim closure monitoring.

7) Community Acceptance - This criterion was used to evaluate the public sentiment concerning an alternative. It includes the general public as well as concerned local communities. This is a modifying criterion that will address public comments as part of the review

8) Short-Term Effectiveness - This is a gauge of the alternative's capability to support upcoming risk reduction efforts at the Site. These efforts are primarily early actions which could include hot-spot removal, tank removals, additional solar pond remediation, and PCB location remediation.

9) Long-Term Effectiveness and Permanence - This criterion was used to evaluate the ability to safely isolate, contain, and manage remediation waste with the passage of time. It also addressed the issues of long-term liability, particularly for alternatives whose ability to safely manage materials could be subject to change in the future.

Appendix E

Descriptions of Remediation Waste Storage Facility Design Alternatives

REMEDIATION WASTE STORAGE FACILITY (RWSF) DESIGN ALTERNATIVES

The alternative facility designs were all based on the need to accommodate 100,000 cubic yards (cy), with the ability to expand to 400,000 yd^3 if required, for Low Level Mixed Waste (LLMW), Low Level (LL), or Hazardous Wastes (HW) in a storage facility. None of the designs considered were tailored to a specific location on RFETS site. In general, bulk waste placement requires the smallest land area when compared to containerized waste placement.

Attributes common to alternative designs:

- 100,000 to 400,000 cy waste capacity if required for retrievable, monitored, storage.
- Each design considered would place the waste above the present grade.
- Each design was considered to be capable of waste retrieval, although the ease (and cost) of retrievability varied significantly among the designs.
- Conceptual design sketches (Figures) and cost estimates (Tables) follow the description of each design.
- Any leachate collected would be treated at another facility, and was not costed here.
- Groundwater Monitoring wells would be installed both up gradient and down gradient of the facility and operated from start of construction through the end of post closure monitoring.
- Costs were escalated to reflect estimated actuals at the time of expenditure , based on DOE guidance documented in RFETS 1996 Budget Call Manual.
- Construction periods were assumed to be of one year duration for all alternatives.
- Operations costs were defined as those activities directly related to placement of (prepared) waste into each alternative facility.
- Treatment and handling systems are not expected to produce emissions sufficient to require additional permitting. Air monitoring will be conducted vial the existing Site monitoring system. Any additional air monitoring required for worker Health and Safety consideration will be monitored by the appropriate oversight organizations.

AboveGrade Storage Cell

This RWSF is designed such that clean dirt (fill) would be used to construct the sides of the cell so that the entire facility would be above the present grade. The design is similar to a standard Subtitle "C" landfill in use throughout the United States. The whole cell is placed at a higher elevation to allow greater vertical separation between the bottom of the cell and the water table. The conceptual design cost estimate assumed that the remediation waste would be placed in the cell without containers (in bulk, compacted in place), however, some existing containerized waste could be placed. In addition, the placement of individual waste streams would be mapped and gridded to allow retrieval (by excavation) when desired.

- This waste cell design includes a double liner with leachate collection system. These features were used to develop the cost estimate and may change during detailed design (see Figures E-1 and E-2). Compliance with 6 CCR 1007-3, Part 264, Subpart N requirements is accomplished by the following provisions:

  — Interim cover system

  — Leachate collection layer consisting of one foot of drainage gravel

  — Primary liner would be composed of an 80 mil high density polyethylene (HDPE) geomembrane

  — Leak detection system includes a geocomposite, (e.g., A geonet with a geotextile on each side)

  •

  — Secondary liner would include three feet of compacted clay, overlain by a 80 mil HDPE geomembrane

This cell design cost estimate was based on cell dimensions of 440 feet long, 360 feet wide, and 30 feet deep. Table E-1 presents the cost estimate summary. The cost estimate included a clean dirt cover installed over exposed waste at the close of daily placement operations to prevent wind dispersion of the waste.

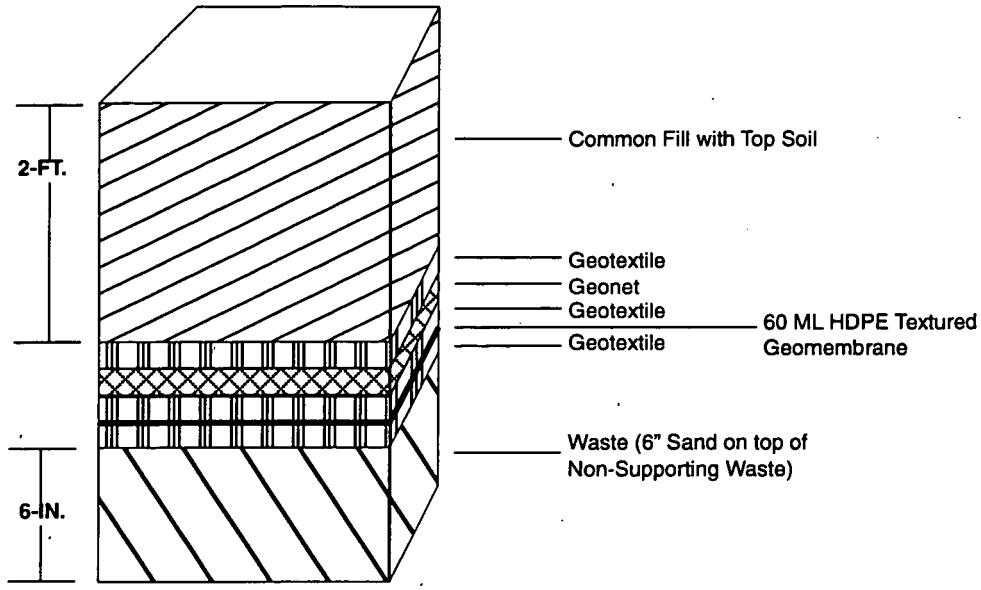
The entire footprint including sideslopes cover approximately 9 acres.

Cell Support Facilities include a lay down area for cell construction materials.

- Any leachate collected would be treated at another facility, and those costs were not included in this estimate.

- Groundwater Monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring.

INTERIM CELL COVER



CELL LINER

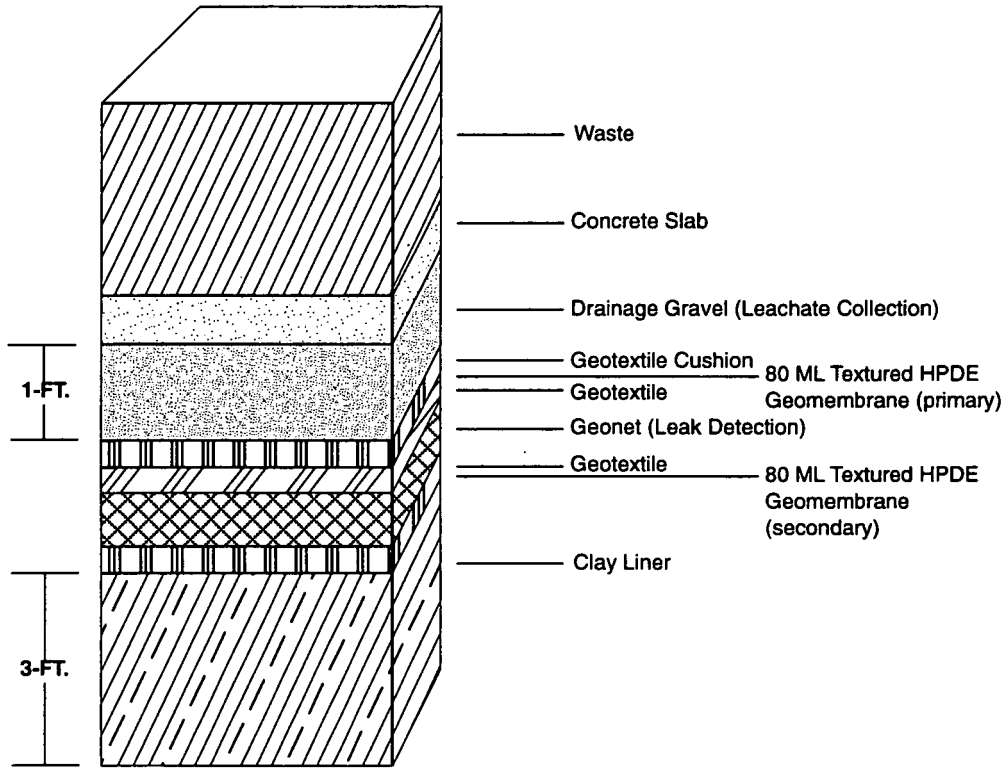


Figure E-1

ON-SITE FACILITY CROSS SECTION

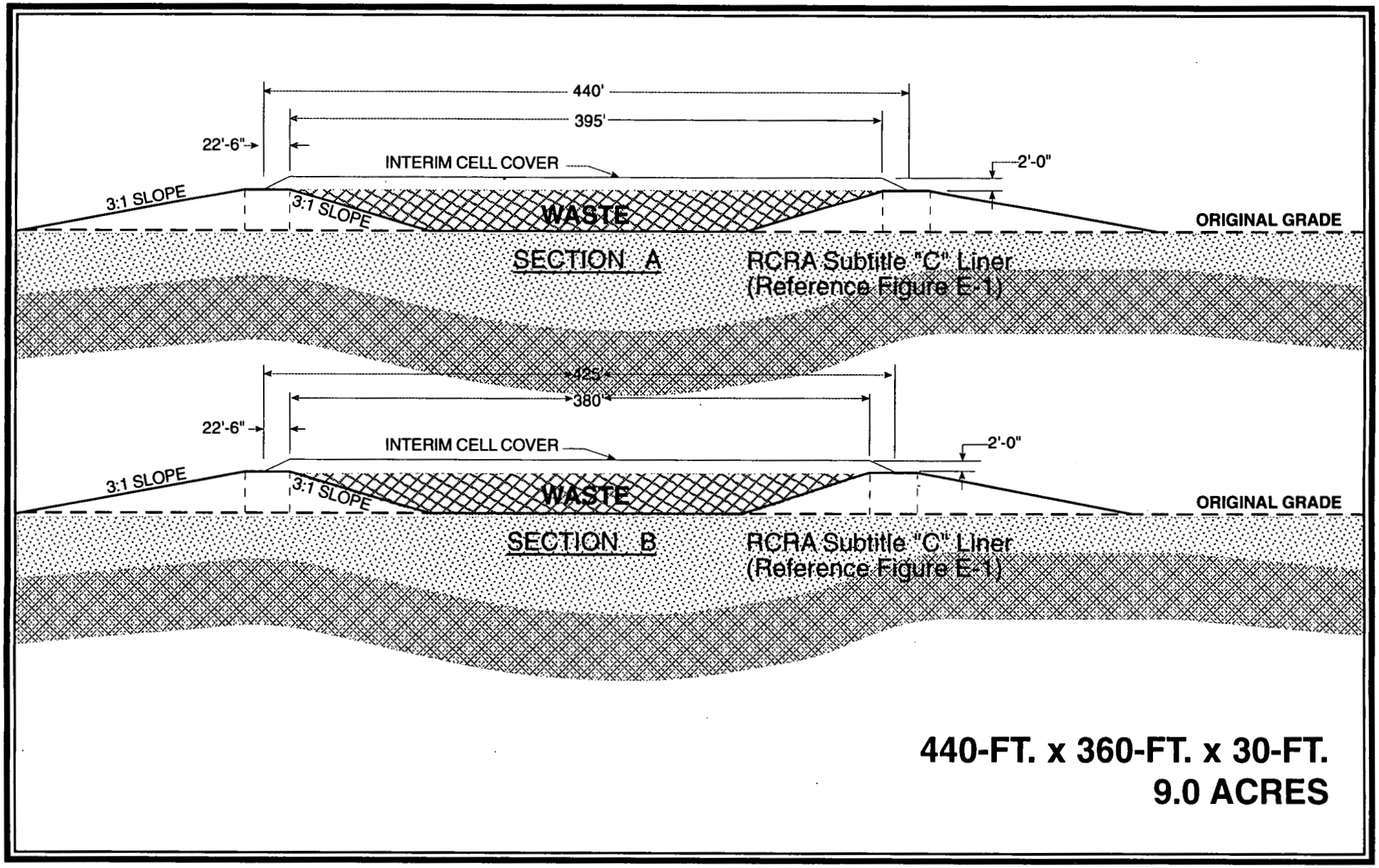


Figure E-2

CROSS-SECTION OF ABOVE-GRADE STORAGE CELL

TABLE E-1

Above-Grade Landfill

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,200,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$8,800,000
Construction	$41,700,000
Operations	$9,000,000
Interim Cap Installation	$5,300,000
Interim Closure Care and Monitoring	$13,900,000
Off-Site Disposal	N/A
Contingency	$27,000,000
Total Life Cycle Costs	***$118,800,000***

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

Concrete Lined Cell, with Bulk Placement

This alternative design consists of three adjacent open top concrete cell(s) placed over a (RCRA Subtitle 'C' landfill) double liner and leachate collection system (see Figure E-3A). When the cell(s) are filled with remediation waste an interim cover is placed over the facility. The conceptual design cost estimate assumed that the remediation waste would be placed in the cell without containers (in bulk, compacted in place), however, some of the waste could be placed in containers, in addition, the placement of individual waste streams would be mapped to allow retrieval (by excavation) when desired. The individual cells are modular and would be constructed as needed over the liner to allow flexibility in sizing the facility.

The concept for the design was modified from the BNFL Drigg Facility in the United Kingdom. The following features were used to develop the cost estimate and may change during detailed design.

- This waste cell design includes an interim cover (see Figure E-1). The surface slope of the finished cover would be approximately 4%.

- This waste cell design also includes a double liner with leachate collection system (see Figure E-1). Compliance with 6 CCR 1007-3 Part 264 Subpart N requirements is accomplished by the following provisions:

  — Interim cover system

  — Self supporting open top concrete shell with reinforced concrete walls and floor slab. The wall design incorporates integral water stops and the floor design incorporates cast-in-place drain channels and sumps

  — Leachate collection layer consisting of one foot of drainage gravel

  — Primary liner would be composed of an 80 mil HDPE geomembrane

  — Leak detection system includes a geocomposite, (e.g. A geonet with a geotextile on each side)

  — Secondary liner would include three feet of compacted clay, overlain by a 80 mil HDPE geomembrane

- The Concrete Lined Cell facility conceptual design includes the following features which were included in the cost estimate (see Table E-2 for the cost estimate summary).

- Facility size of 500 feet long by 360 feet wide by approximately 14 feet deep
- The temporary storage facility long term footprint would be approximately four acres
- The entire footprint during construction and placement operations would be approximately 10 acres (Cell area + Lay down areas + Operations areas = 10 acres)
- No aisles or corridors
- Three open top concrete modules
- A lay down area for cell construction materials
- Groundwater Monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring
- Any leachate collected would be treated at another facility, and those costs were not included in the estimate

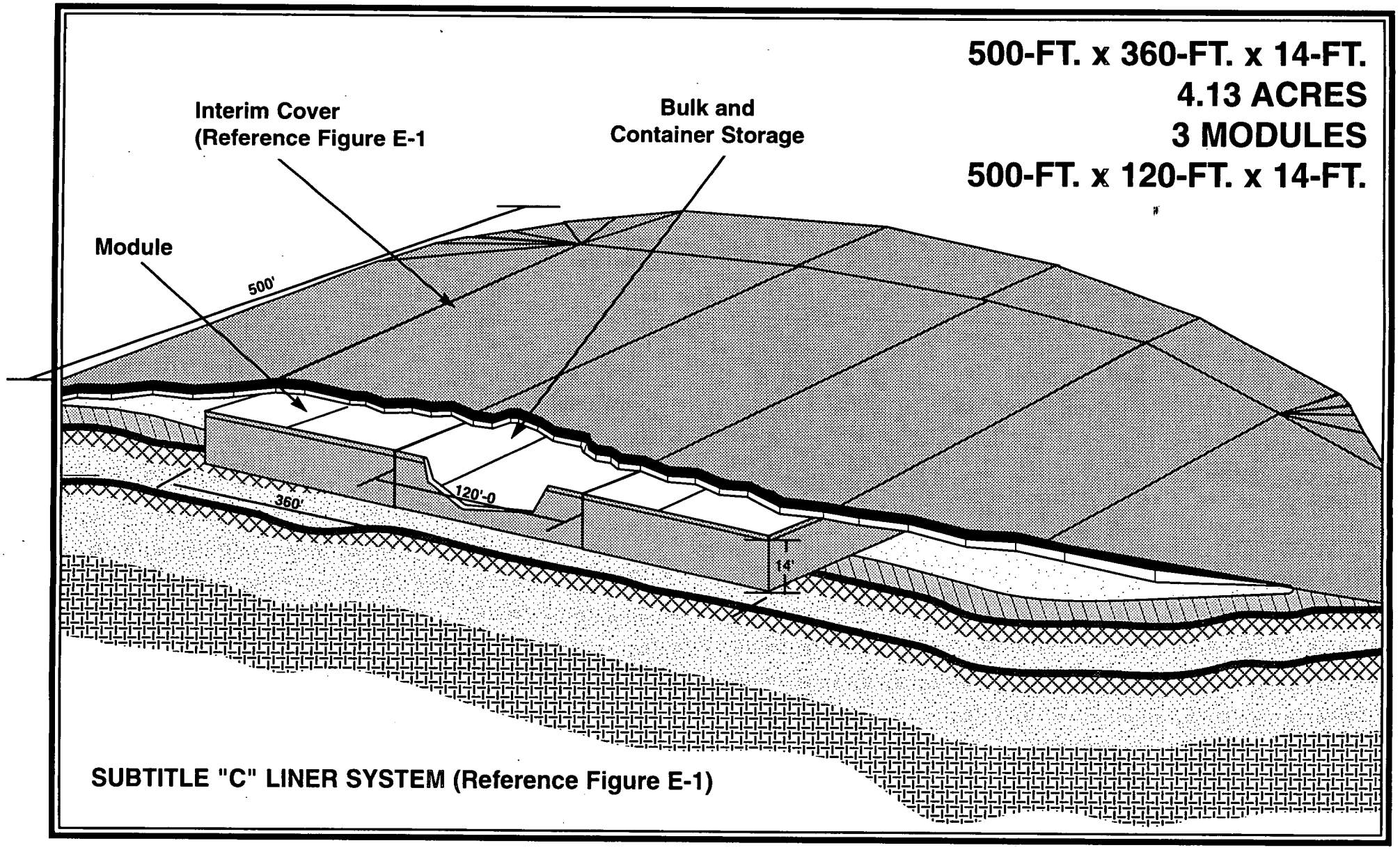


Figure E-3A

CONCRETE-LINED CELL WITH BULK WASTE PLACEMENT

TABLE E-2

Concrete Lined Cell with Bulk Waste Placement

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$1,600,000
Permitting	$300,000
Pre-Construction	$150,000
Site Preparation	$1,970,000
Construction	$18,600,000
Operations	$8,600,000
Interim Cap Installation	$5,300,000
Interim Closure Care and Monitoring	$13,000,000
Off-Site Disposal	N/A
Contingency	$17,600,000
Total Life Cycle Costs	*$77,320,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

Concrete Lined Cell In Containers

This alternative design consists of three adjacent open top concrete cell(s) placed over a (RCRA Subtitle 'C' landfill) double liner and leachate collection system (see Figure E-3B). When the cell(s) are filled with remediation waste an interim cover is placed over the facility. All of the remediation waste would be placed in containers (Cargo containers) which would then be placed into the cells. This aspect is the only significant difference from the previously described option "Concrete Lined Cell with Bulk Placement". Individual waste streams would be recorded and mapped to allow retrieval (by excavation) when required. The individual cells are modular and would be constructed as needed over the liner providing flexibility in sizing the facility. The concept for the design was modified from the Drigg Facility in the United Kingdom.

The following features were used to develop the cost estimate and may change during detailed design.

- This waste cell design includes an interim cover (see Figure E-1). The surface slope of the finished cover would be approximately 4%.

- This waste cell design also includes a double liner with leachate collection system (see Figure E-1). Compliance with 6 CCR 1007-3, Part 264, Subpart N requirements is accomplished by the following provisions:

  — Interim cover system

  — Self supporting open top concrete shell with reinforced concrete walls and floor slab. The wall design incorporates integral water stops and the floor design incorporates cast-in-place drain channels and sumps.

  — Leachate collection layer consisting of one foot of drainage gravel

  — Primary liner would be composed of 80 mil HDPE geomembrane

  — Leak detection system includes a geocomposite (e.g,. A geonet with a geotextile on each side)

  — Secondary liner would include three feet of compacted clay, overlain by a 80 mil HDPE geomembrane

- The Concrete Lined Cell facility conceptual design includes the following features which were included in the cost estimate (see Table E-3 for the cost estimate summary).

  — Facility size of 405 feet wide by 500 feet long by approximately 14 feet deep

  — The waste cell facility long term footprint would be approximately 4.6 acres

  — The entire footprint during construction and placement operations would be approximately 10 acres (Cell area + Lay down areas + Operations areas = 10 acres)

  — No aisles or corridors

  — Three open top concrete modules

  — A lay down area for cell construction materials

  — Groundwater Monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring

  — Any leachate collected would be treated at another facility, and those costs were not included in the estimate

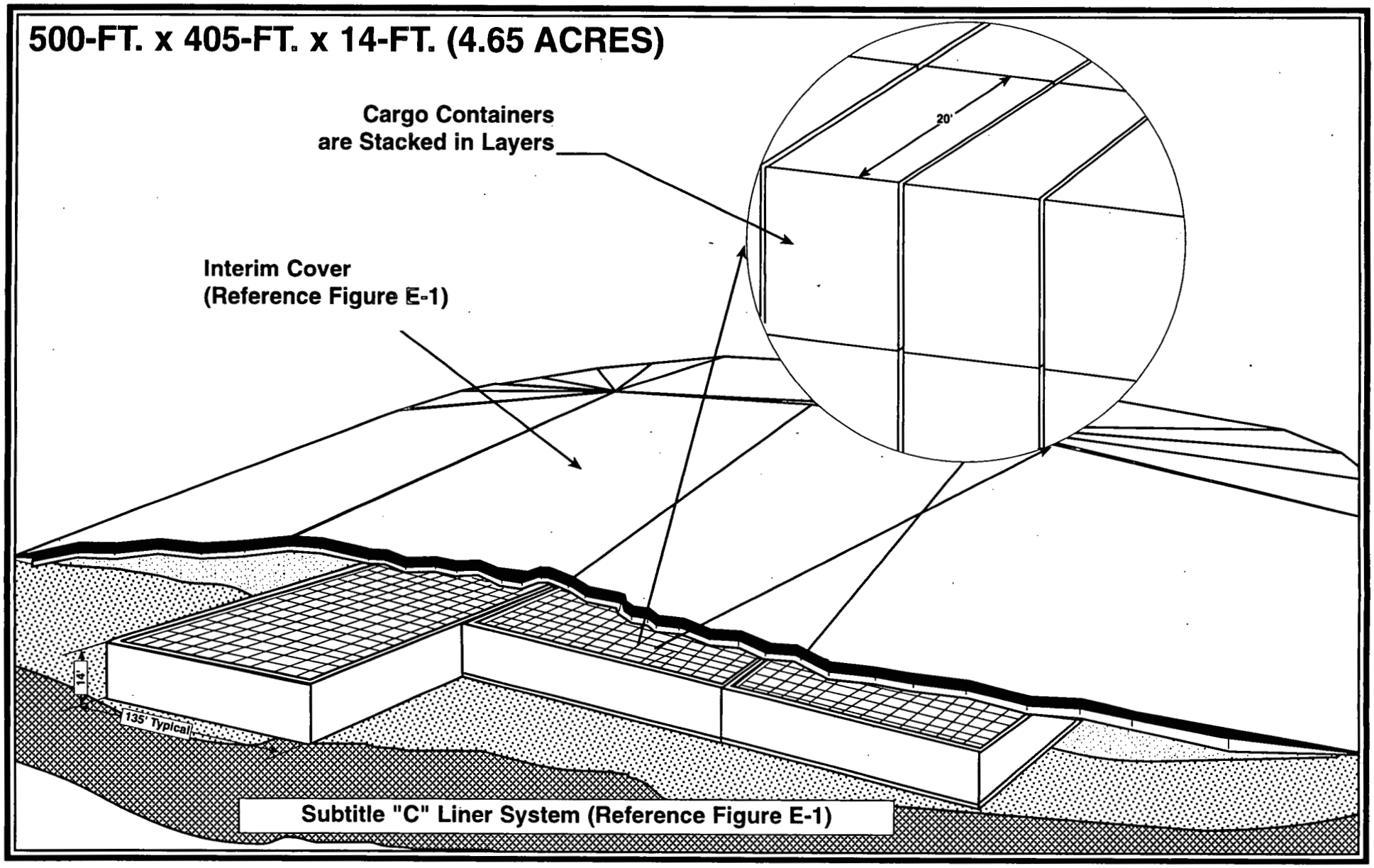


Figure E-3B

CONCRETE-LINED CELL IN CARGO CONTAINERS

TABLE E-3

Concrete Lined Cell with Cargo Containers

Task Description	Estimated Cost
Containers	$74,930,000
Packaging	$1,700,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$1,600,000
Permitting	$300,000
Pre-Construction	$150,000
Site Preparation	$1,970,000
Construction	$18,600,000
Operations	$4,900,000
Interim Cap Installation	$5,300,000
Interim Closure Care and Monitoring	$10,400,000
Off-Site Disposal	N/A
Contingency	$37,700,000
Total Life Cycle Costs	*$165,650,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

HARDENED CONCRETE VAULT

This alternative design would place cargo containers, filled with remediation waste, within an above grade concrete structure (see Figure E-4). The structure would be designed as a self supporting, free standing, above grade, weatherproof structure. This structure would be constructed over a double liner and leachate collection system. The structure would consist of three modules (Vaults). Each module would contain a double row of cargo containers with an access aisle between the rows. The cargo containers would be stacked in the vault by forklifts from the access aisle. At the close of waste placement operations, each cell would be capped with a concrete roof, then the structures comprising the facility would be covered with an interim cover. This design enhances the monitoring capability during placement operations and retrievability after closure due to the open aisles and identified waste in individual containers. The concept for the design was modified from the "E"-Area Vaults from the DOE Savannah River Complex.

During the period of post closure monitoring (or later) access could be made into the vaults (by excavating through the interim cover) to inspect or retrieve the waste containers via the aisles which were left open , but isolated from the environment when the vaults were closed.

- The following features were used to develop the cost estimate (see Table E-4) and may change during detailed design.

  — Facility size would be approximately 560 feet long, 450 feet wide, and 14 feet high and consist of three modules

  — One module could be constructed each year, for three years, (subject to the rate of remediation waste generation)

  — Each module would consist of an 18 inch thick reinforced concrete slab floor, 12 inch thick reinforced concrete walls, and a 12 inch thick reinforced concrete roof

  — A 30 foot wide aisle or central corridor is planned in each module. These corridors would remain open during the life of the facility to allow routine monitoring and inspection

  — Waste would be placed into 20 cy cargo containers (5,000 containers, Total capacity 100,000 cy per Vault, up to 400,000 cy for four Vaults)

  — A double liner system and LCRS would be constructed similar to the CLC (see Figure E-1). This complies with requirements of 6 CCR 1007-3 Part 264 Subpart N.

- The waste cell facility long term footprint would be approximately six acres

- The entire footprint during construction and placement operations would be approximately 12 acres (Cell area + Lay down areas + Operations areas = 12 acres)

- Groundwater Monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring

- Any leachate collected would be treated at another facility, and those costs were not included in the estimate

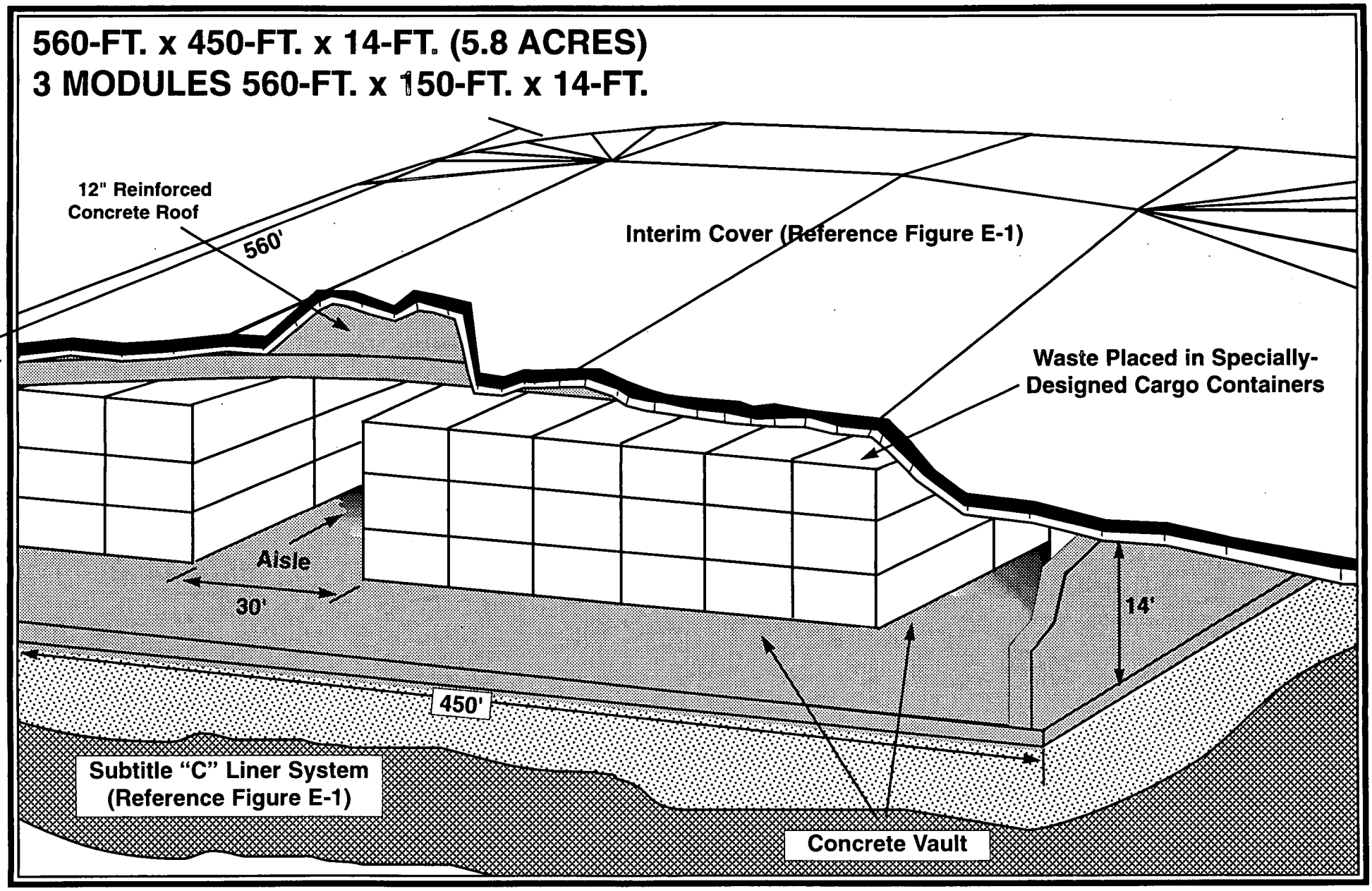


Figure E-4

HARDENED CONCRETE VAULT

TABLE E-4

Hardened Concrete Vault

Task Description	Estimated Cost
Containers	$74,930,000
Packaging	$1,700,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,200,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$6,100,000
Construction	$26,000,000
Operations	$4,900,000
Interim Cap Installation	$5,300,000
Interim Closure Care and Monitoring	$10,400,000
Off-Site Disposal	N/A
Contingency	$41,300,000
Total Life Cycle Costs	*$181,630,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total d

Silo Design

This alternative design consists of a series of 5,000 cy capacity open top concrete silos placed over a double liner and leachate collection system (see Figure E-5). When all of the silos are filled with remediation waste an interim cover is placed over the entire facility. Remediation waste would be placed in each silo in bulk (without containers) and compacted. When each silo is filled a structural concrete roof is constructed over the silo. Individual waste streams would be mapped and recorded to allow retrieval (by excavation) when desired. Individual silos would be constructed as needed to keep pace with remediation waste generation. This design alternative is based on a similar design described in EG&G- INEL *Interim Report: Waste Management Facilities Costs, Information for Mixed Low-Level Waste,* dated March 1994.

- The following features were used to develop the cost estimate (see Table E-5) and may change during the detailed design. This design complies with requirements of 6 CCR 1007-3, Part 264, Subpart N.

  — This waste cell design includes an interim cover (see Figure E-1)

  — The side slope of the finished cover would be approximately 12%

  — Leachate collection layer consisting of one foot of coarse sand

  — Primary liner would be composed of an 80 mil HDPE geomembrane

  — Leak detection system includes a geocomposite (e.g., A geonet with a geotextile on each side)

  — Secondary liner would include three feet of compacted clay, overlain by a 80 mil HDPE geomembrane

  — Facility size of 500 feet wide by 500 feet long by approximately 75 feet high

  — The waste cell facility long term footprint would be approximately six acres

— Self supporting open top reinforced concrete shell silos approximately 50 feet wide by 40 feet long by 70 feet high. Each silo to be constructed with 12 inch thick reinforced concrete walls and an 18 inch thick reinforced concrete slab floor. When filled with waste, a 12 inch thick structural concrete top would be constructed over each silo.

- Space between silos would be backfilled with clean sand or fill
- The entire footprint during construction and placement operations would be approximately 12 acres (Cell area + Lay down areas + Operations areas = 12 acres)
- Groundwater Monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring
- Any leachate collected would be treated at another facility, and those costs were not included in the estimate

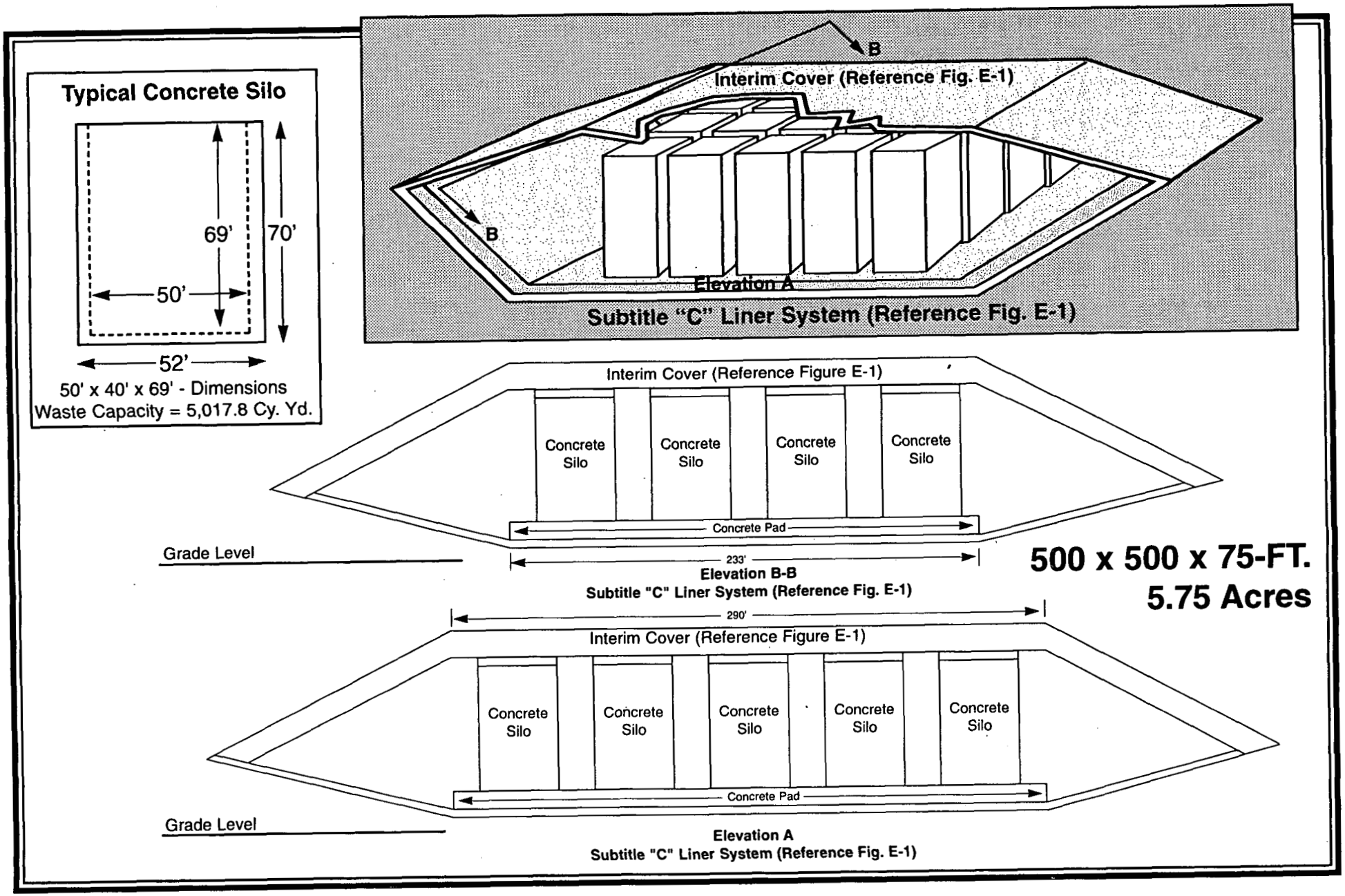


Figure E-5

SILO DESIGN

TABLE E-5

Silo Design

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,000,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$6,100,000
Construction	$30,400,000
Operations	$14,300,000
Interim Cap Installation	$5,300,000
Interim Closure Care and Monitoring	$13,900,000
Off-Site Disposal	N/A
Contingency	$24,400,000
Total Life Cycle Costs	*$107,300,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

SLAB on GRADE

This alternative design consists of 5,000, twenty cubic yard capacity, cargo containers filled with remediation waste placed outdoors on an above grade concrete slab (see Figure E-6). No liner or leachate collection system is incorporated into this design. A concrete berm around the perimeter of the slab and a sump to contain stormwater are integrated into the design. No roof or building enclosure would be placed over the cargo containers. The facility would have a design life of 30 years, at which time it was assumed that the waste would be transported to an off site facility for disposal. This concept is currently in use for storage of RCRA waste at RFETS.

- The following features were used to develop the cost estimate (see Table E-6) and could change during detailed design.
  - The waste would be placed in bulk into the 20 cy cargo containers
  - No double liner system of LCRS
  - Facility design life of 30 years
  - Requires 5,000 each 20 cy cargo containers, whose design life was assumed to be 30 years in outdoor storage
  - The footprint of the facility would be approximately 535 feet by 600 feet
  - The containers would be stacked three high and placed in double rows with a 5 foot aisle between the double rows
  - The slab with a perimeter stormwater curb would be constructed of reinforced concrete at the existing grade
  - The slab would be sloped to a central sump for storm water collection. For estimating purposes it was assumed that the storm water could be discharged without treatment.
  - Any costs associated with maintenance or replacement of the facility at the end of the design life were not included in this estimate
  - The site footprint during long term storage would be approximately 7 acres

— The entire footprint during construction and placement operations would be approximately 12 acres (Cell area + Lay down areas + Operations areas = 12 acres)

— Groundwater monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the life cycle (30 years).

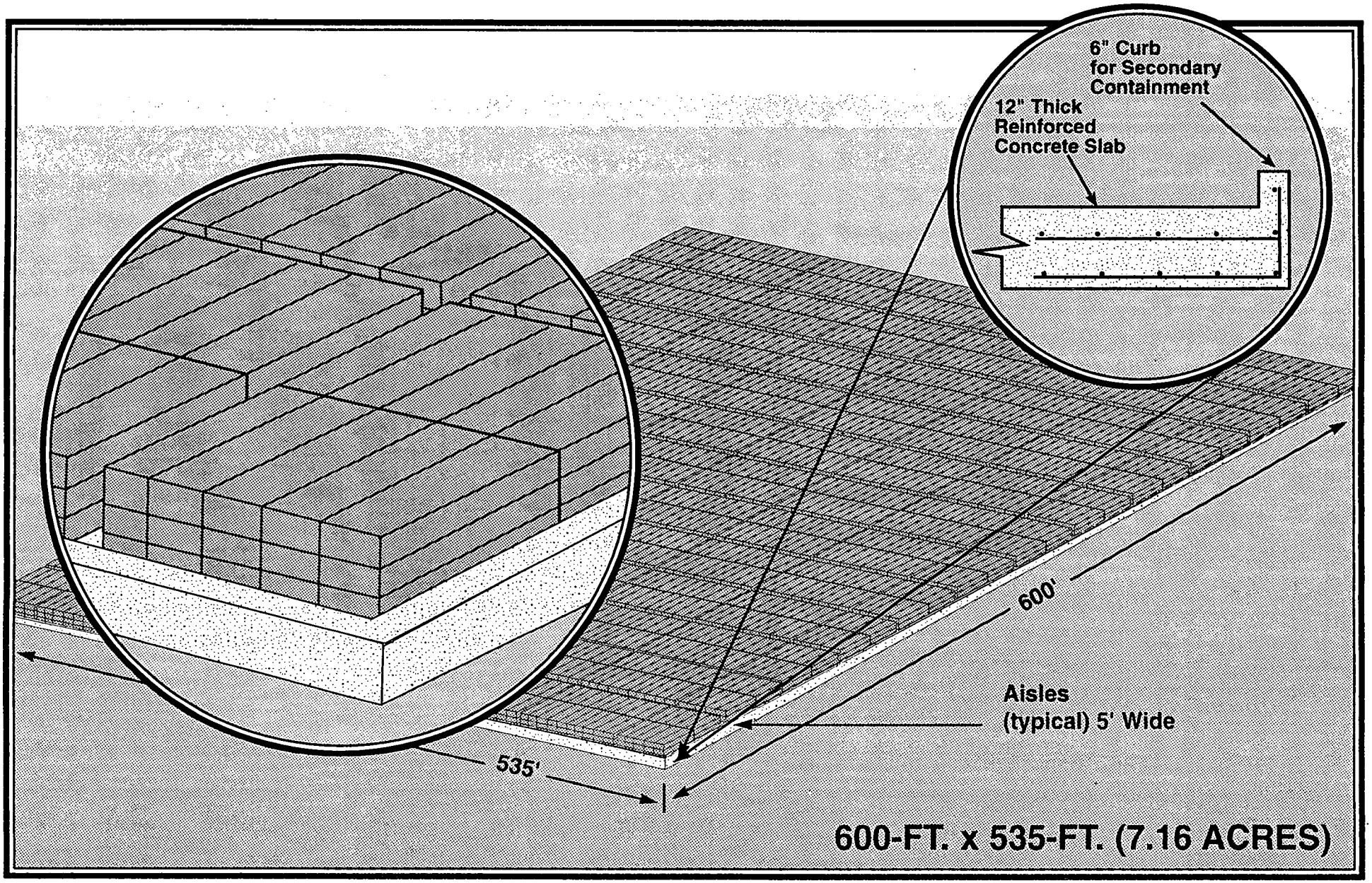


Figure E-6

SLAB ON GRADE

TABLE E-6

Slab on Grade

Task Description	Estimated Cost
Containers	$74,900,000
Packaging	$1,700,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$300,000
Permitting	$300,000
Pre-Construction	$200,000
Site Preparation	$6,100,000
Construction	$3,800,000
Operations	$5,500,000
Interim Cap Installation	N/A
Interim Closure Care and Monitoring	$8,500,000
Off-Site Disposal	N/A
Contingency	$32,200,000
Total Life Cycle Costs	*$141,600,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

METAL BUILDINGS

This alternative design consists of 5,000, twenty cy capacity, cargo containers filled with remediation waste placed inside engineered metal buildings (see Figure E-7). This design alternative is very similar to the Slab-on-Grade design with the exception that in this design option, the cargo containers are sheltered from the weather, and that no storm water would be collected. The buildings would be constructed on a concrete slab. No liner or leachate collection system is incorporated into this design. The facility would have a design life of 30 years, at which time it was assumed that the waste would be transported to an off site facility for disposal. This concept is currently in use for storage of RCRA waste at RFETS.

- The following features were used to develop the cost estimate (see Table E-7) and could change during detailed design.
  - Four metal buildings, each 570 feet long by 130 feet wide by 20 feet high
  - One building would be constructed per year
  - Each building would be placed on a 12 inch thick concrete slab
  - 5,000 each 20 cy capacity cargo containers
  - The containers would be stacked three high in the buildings
  - Each building would retain one centralized corridor and access aisle for routine monitoring and inspection for the design life of the facility
  - 30 year design life of the facility
  - Large forklifts to move the cargo containers
  - Transportation of the waste to an off site disposal facility at the end of the design life
  - No double liner system or LCRS
  - Cost of maintaining or replacing this Remediation Waste Storage facility after the design life were not considered in this cost estimate

— Groundwater monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the life cycle (30 years).

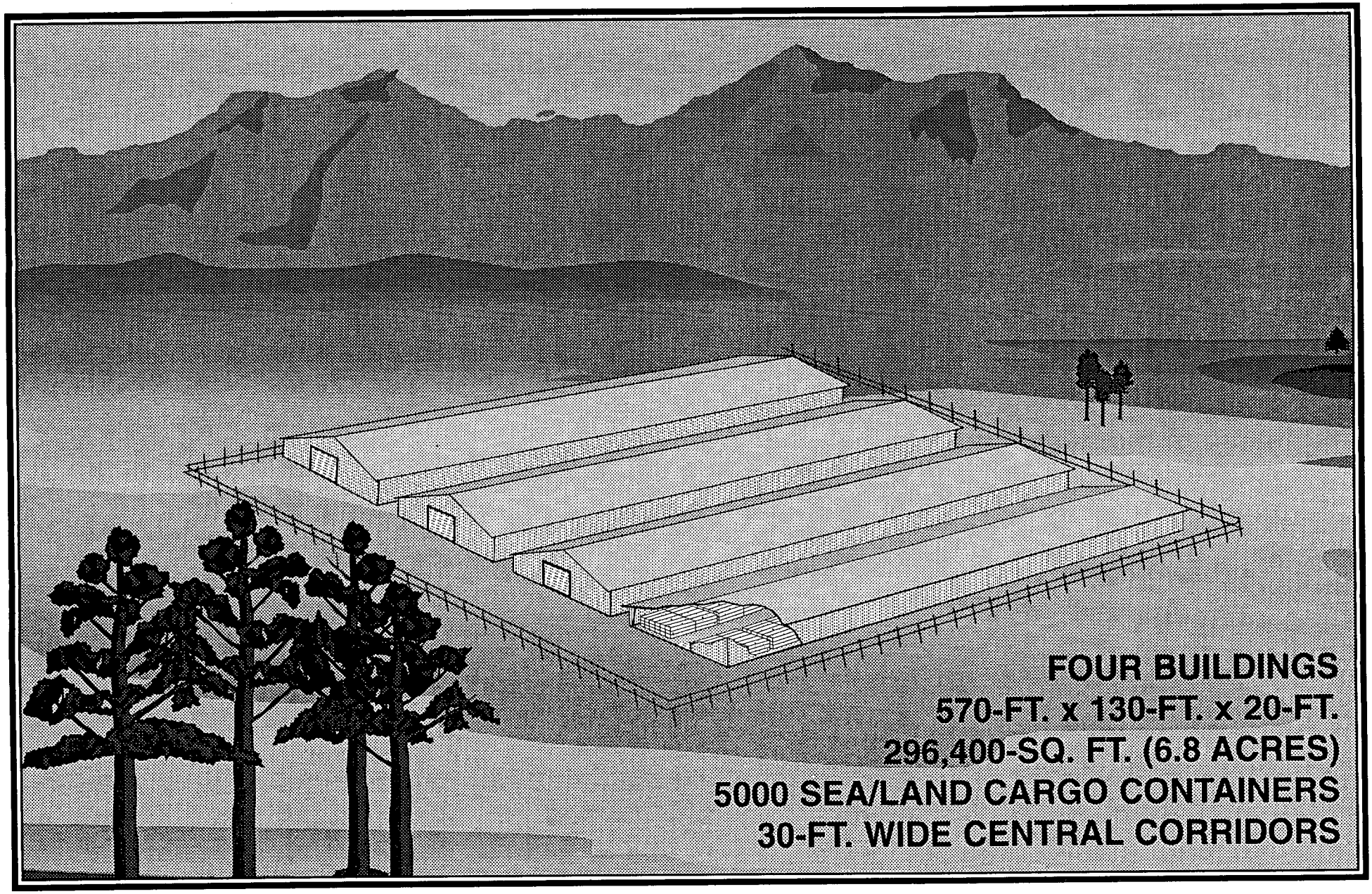


Figure E-7

METAL BUILDINGS

TABLE E-7

Metal Buildings

Task Description	Estimated Cost
Containers	$74,900,000
Packaging	$2,400,000
Characterization	$5,800,000
Transportation	$1,700,000
Design	$2,300,000
Permitting	$300,000
Pre-Construction	$1,300,000
Site Preparation	$2,800,000
Construction	$17,900,000
Operations	$4,900,000
Interim Cap Installation	N/A
Interim Closure Care and Monitoring	$10,400,000
Off-Site Disposal	N/A
Contingency	$36,700,000
Total Life Cycle Costs	*$161,400,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

ENTOMBMENT

Essentially, in this alternative design concept, remediation waste is placed into 55 gallon steel drums. Eight steel drums are then placed into a large concrete canister (or concrete box) which is then filled with grout. The canisters are stored in a weatherproof hardened concrete vault. This design option is intended for long term retrievable storage (see Figure E-8). While meeting the definition of Monitorable Retrievable Storage , the actual waste, while highly retrievable would be less monitorable than several of the alternate designs. This design alternative is based on a similar design described in an EG&G-INEL *Interim Report: Waste Management Facilities Cost Information for Low Level Waste*, dated March 1994.

This design combines several concepts of some of the previous design alternatives, it is most similar to the hardened concrete vault design. The most significant difference is that each waste canister is entombed in concrete. The remediation waste is placed into 55 gallon steel drums. Eight drums are placed into a single larger canister (concrete box), which is then sealed by filling it with (cement) grout. The canisters are then placed into the storage facility which consists of a series of adjacent hardened concrete cells (vaults). The facility would be constructed over a double liner and leachate collection system. The facility itself would consist of rows of concrete cells having an access aisle between the rows. The canisters are placed into the open topped concrete cells, and stacked three high. When a cell is filled with canisters the void spaces in the cell (between the canisters and cell walls), are backfilled with sand and then a concrete cover is constructed on the top of the cell thereby closing the cell. When the cells have been covered with concrete, an interim cover is constructed over the entire facility.

- The following features were used to develop the cost estimate (see Table E-8) and could change during detailed design. This design option complies with 6 CCR 1007-3 Part 264 Subpart N Requirements.

  — This waste cell design includes an interim cover (see Figure E-1)

  — A leachate collection layer consisting of one foot of coarse sand

  — The primary liner would be composed of an 80 mil HDPE geomembrane

  — The leak detection system includes a geocomposite (e.g., A geonet with a geotextile on each side)

  — Secondary liner would include three feet of compacted clay, overlain by a 80 mil HDPE geomembrane

- Each cell floor would be reinforced concrete
- The canisters would be stacked three high in the cells with each canister holding 8 drums
- Each cell would have one adjacent aisle for routine monitoring and inspection
- 1,000 year design life of the facility
- Groundwater Monitoring wells (3 each) will be installed both up gradient and down gradient and will be operated from start of construction through the end of post closure monitoring
- Any leachate collected would be treated at another facility, and those costs were not included in the estimate

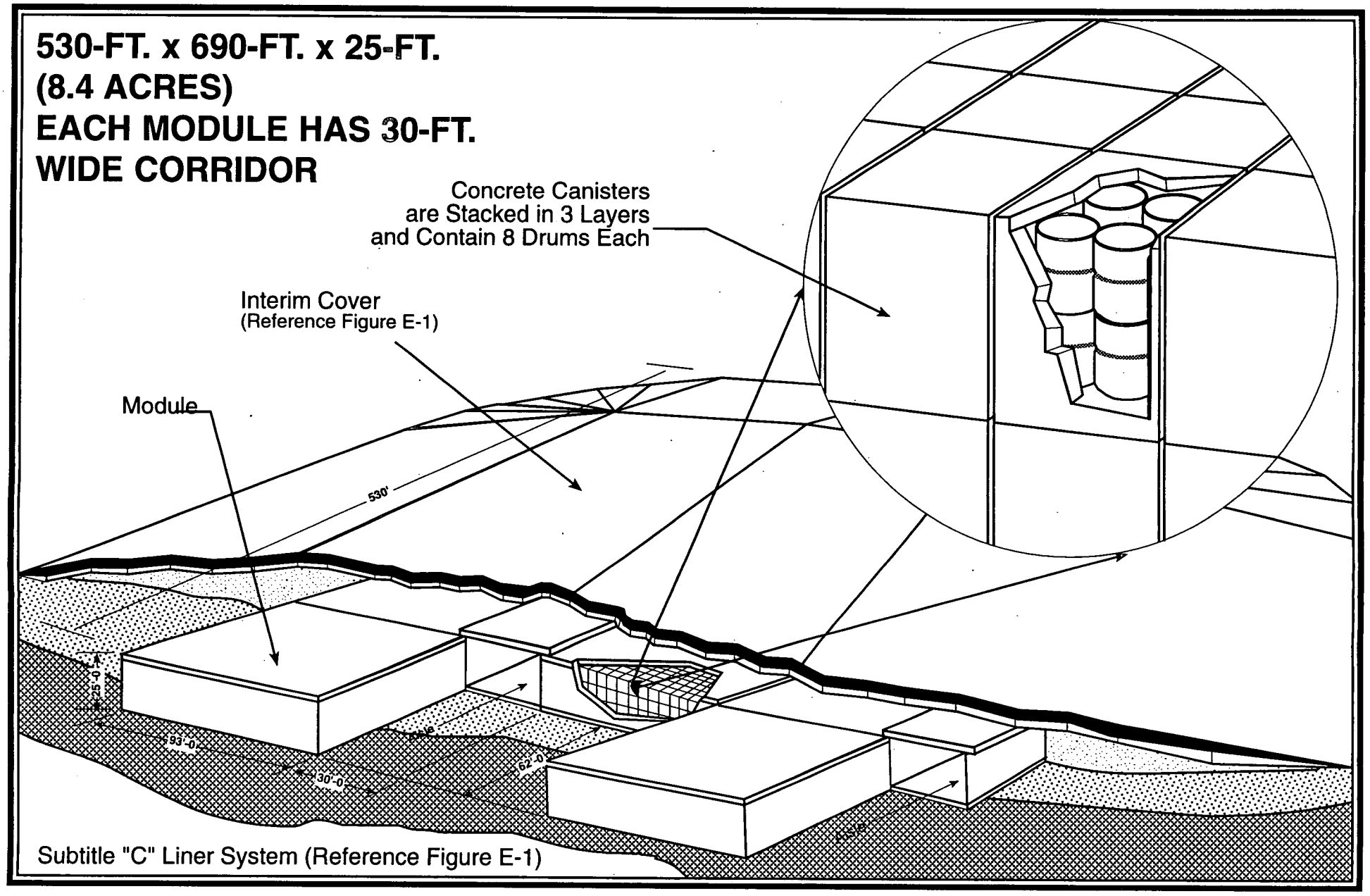


Figure E-8

ENTOMBMENT

TABLE E-8

Entombment

Task Description	Estimated Cost
Total Cost	$525,000,000
Total Life Cycle Costs	*$525,000,000*

Note: Based on Idaho National Engineering Laboratory report, "Waste Management Facilities Cost Information for Mixed Low Level Waste", dated March 1994.
Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

PYRAMID DESIGN

This alternative design concept is to construct a pyramid around compacted remediation waste in bulk (see Figure E-9). The base/floor of the pyramid would have a rectangular footprint and constructed to be a structurally sound base of slab-on-grade reinforced concrete and quarried stone. The structure/facility would be built in a series of compacted lifts of remediation waste with a "ring" of quarried stone blocks forming the perimeter. The length of the perimeter would decrease as the height increased. It is believed that the quarried stone blocks would not exclude all stormwater over time. Sealant would be used between the quarried stone blocks to prevent stormwater from infiltrating the compacted waste. This design alternative was described and estimated as a result of input from the Citizens Advisory Board.

It was perceived that the ease of monitoring a selected remediation waste would be among the lowest of the options considered. In addition, the structural integrity of the facility would be provided by the compacted waste itself. The quarried stone blocks, due to their large size, would be extremely expensive to procure, transport, and install. Due to the limited mass of stone relative to the mass of compacted waste, the quarried stone blocks themselves would contribute little to the overall integrity of the facility. A sealant placed between the blocks would be expected to fail when differential settling of the waste occurred, allowing stormwater to enter the waste. Because the engineering properties of the remediation waste (if any) have yet to be defined, it is not clear if the compacted waste would support the quarried stone blocks. Imposing strict physical structural requirements upon the waste to be placed into the pyramid in order to achieve the necessary structural integrity for the intended purpose could exclude significant quantities of remediation waste from this facility or that the waste be treated to a defined strength requirement at additional cost.

For these reasons the pyramid design was discarded after initial cost estimates (see Table E-9) were prepared.

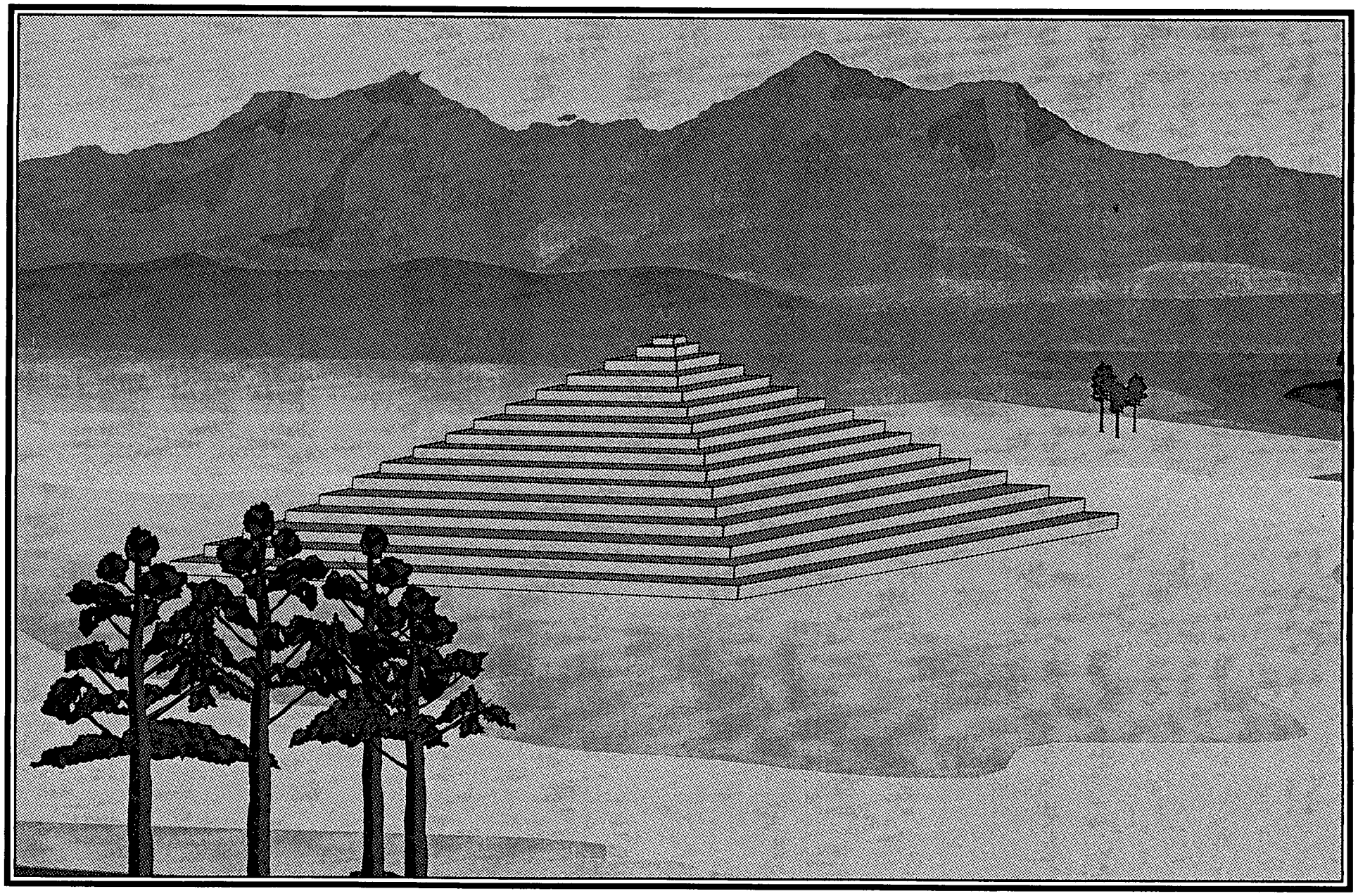


Figure E-9

PYRAMID

TABLE E-9

Pyramid Design

Task Description	Estimated Cost
Containers	$0
Packaging	$2,100,000
Characterization	$5,800,000
Transportation	$2,300,000
Design	$2,200,000
Permitting	$300,000
Pre-Construction	$400,000
Site Preparation	$14,500,000
Construction	$57,900,000
Operations	$9,000,000
Interim Cap Installation	N/A
Interim Closure Care and Monitoring	$13,900,000
Off-Site Disposal	N/A
Contingency	$31,900,000
Total Life Cycle Costs	*$140,300,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

Waste Pile

This alternative design concept was patterned after the Waste Pile constructed in 1988 at the Rocky Mountain Arsenal. The design was developed and implemented to isolate Basin F hazardous soils and sludges from the environment pending selection of a treatment method and a disposal site. In this concept wastes-in-bulk are compacted into a rectangular pile, covered with a geomembrane , (bottom, sides, and top) and dirt which is vegetated with native grasses (see Figure E-10). No special embankments, pits, buildings, or berms are employed. As the pile is constructed of compacted waste, the waste is covered (daily) with a plastic membrane to prevent the spread of contamination. When complete the pile is sealed within a geomembrane. The geomembrane would be covered with fill dirt and vegetated with native grasses. This alternative would provide 30 year monitored retrievable storage of remediation waste pending agreement by the public, the regulators, and the DOE as to disposition. See Table E-10 for a conceptual cost estimate.

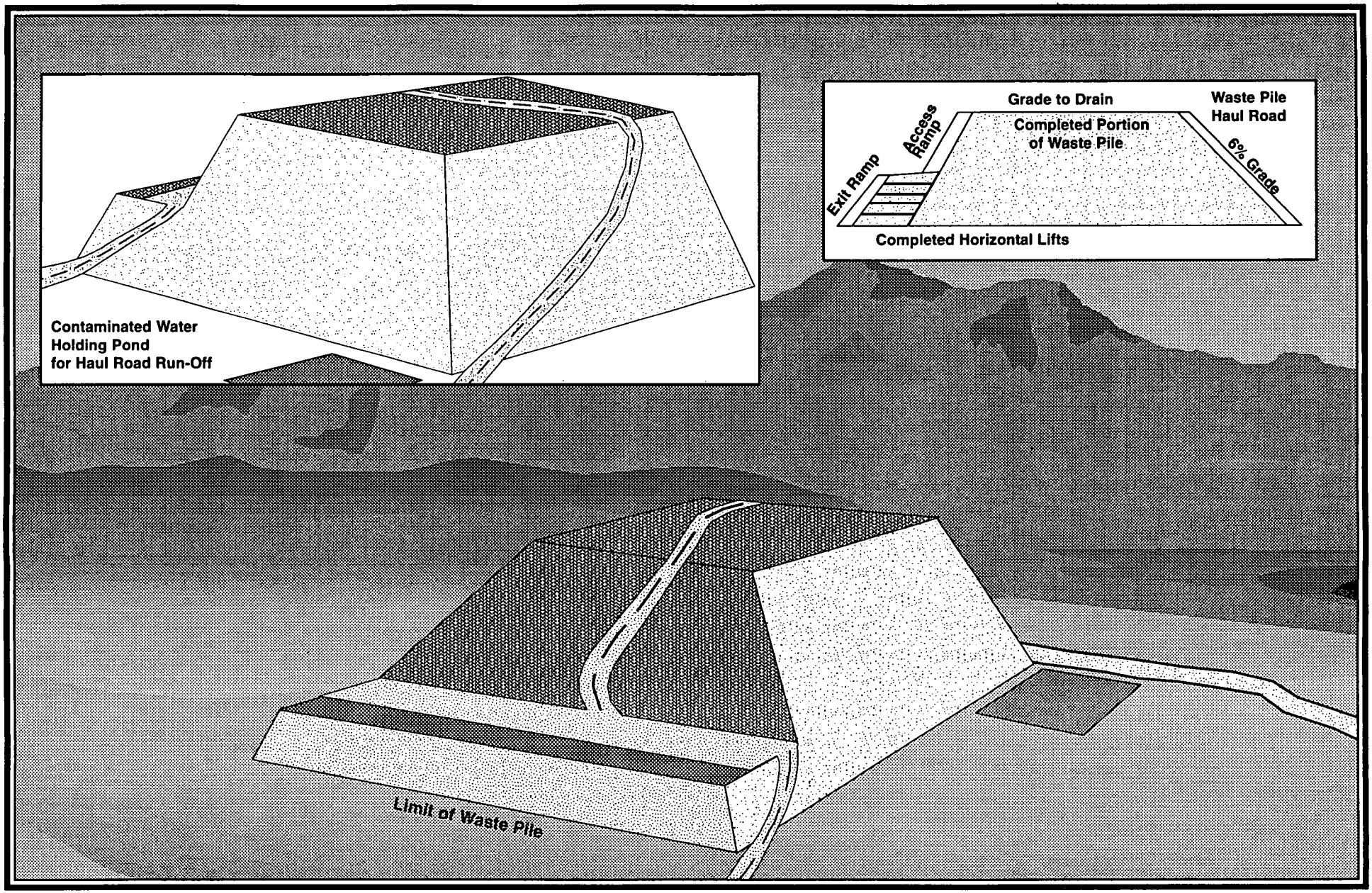


Figure E-10
WASTE PILE

TABLE E-10

WASTE PILE

Task Description	Estimated Cost
Actual Costs (Escalated 1988 to 1996)	$36,669,000
Off-Site Disposal	N/A
Total Life Cycle Costs	*$36,669,000*

Note: Costs escalated to expected year incurred. Total life cycle costs do not include offsite disposal costs. These costs would include retrieval, transportation and disposal costs and would add over $150 million dollars to the total cost.

NO ACTION

The "No Action" alternative is included in this listing of design options to fulfill the requirements of NEPA. NEPA requires that the "No Action" option continues to be considered through the end of the decision making process.

The Proposed Action is an onsite facility

The proposed action is to permit and construct an onsite storage facility to contain remediation waste(s) generated as part of the cleanup and closure activities at RFETS. This facility would be designed and permitted as a CAMU, a storage facility to isolate the wastes from the environment in a retrievable fashion. This facility would be designed to meet RCRA Subtitle "C" Landfill facility requirements. Permitted storage under a CAMU permit would allow remediation waste which does not meet Land Disposal Requirements (LDR's) to be stored. This storage would allow an indefinite period of time for the general public, the DOE and the CDPHE to determine and agree upon the ultimate fate (disposal) of the wastes via a Record of Decision (ROD). One of the disposal options which could be considered during this time period could be the permitting of the Remediation Waste Storage Facility as a permanent CAMU storage facility.

The No Action alternative is to ship remediation waste off site as soon as it is produced

The "NO ACTION" option is to package and ship all remediation waste generated as part of the cleanup and closure activities to an off site disposal facility, as a permitted onsite hazardous, LLW, or LLMW disposal facility does not exist. This option requires that all waste meet Department of Transportation regulations for Interstate shipment of hazardous, radioactive, and mixed waste before it leaves the Site. This option also requires that all remediation wastes generated meet LDR's prior to disposal. See Table E-11 for the conceptual cost estimate summary.

TABLE E-11

NO ACTION

(Offsite disposal concurrent with generation)

Task Description	Estimated Cost
Containers	$4,600,000
Packaging	$2,900,000
Treatment/Characterization	$78,400,000
Transportation	$7,600,000
Design	N/A
Permitting	N/A
Pre-Construction	N/A
Site Preparation	N/A
Construction	N/A
Operations	N/A
Closure (Cap Installation)	N/A
Interim Closure Care and Monitoring	N/A
Off-Site Disposal (years 1997,8,9)	$73,300,000
*Contingency **	$49,100,000
Total Life Cycle Costs	*$215,900,000*

Note: (1) costs escalated to year incurred. These costs do include offsite disposal and are therefore higher than the other alternatives. This alternative is the least expensive when disposal costs are incorporated into all of the estimates.

Appendix F

Backup for Facility Design Screen

TABLE OF CONTENTS

F.1 ABOVEGRADE STORAGE CELL F-1

F.2 CONCRETE LINED CELL WITH BULK PLACEMENT F-4

F.3 CONCRETE LINED CELL IN CARGO CONTAINERS F-7

F.4 HARDENED CONCRETE VAULT F-10

F.5 SILO DESIGN F-12

F.6 SLAB ON GRADE F-14

F.7 METAL BUILDINGS F-17

F.8 ENTOMBMENT F-20

F.9 PYRAMID DESIGN F-24

F.10 WASTE PILE F-27

F.11 NO ACTION F-29

Appendix F - Backup for Facility Design Screen

This appendix provides details of the facility design screen for each of the major criteria. This appendix backs up information provided in Table 6-1. Specific criteria have been referenced in parentheses (e.g., [C #.#]). Additional information on specific criteria can be found in Section 5 and Appendix D.

F.1 ABOVEGRADE STORAGE CELL

Description:

This facility is similar in construction to a typical waste management cell except that fill would be used to build up the sides of the cell so it could be placed abovegrade. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

Many of the features of the abovegrade storage cell support a CAMU designation. The facility would have a double liner, a leachate collection system, and an impermeable cap to ensure that releases do not occur (C 1.4). The facility could well support the timing of remedial activities since it is a simple and proficient design and remediation waste can be placed in the facility without as much additional processing (C 1.5). Because waste could be placed in bulk, remediation waste could go from treatment or excavation directly into the cell. This could both expedite accelerated actions as well as reduce the cost by eliminating the need for a remediation waste staging area. Construction and of the facility could be expedient because the design is simple and the technology is readily available and well known.

Public Protection (Geotechnical and Hydrological Criteria)

The abovegrade storage cell has many of the advantages of other designs including double liners and a shallow slope around the edge of the structure to protect against erosion (C 2.1, 2.3). The double liner system and abovegrade design would isolate the facility from the substrate and ground water (C 2.3, 2.10, 2.12). The impermeable cap could have an impact on surface water drainage and groundwater infiltration since water will be diverted to the edges of the cap (C 2.11).

Site Special Issues:

The abovegrade storage cell would require a larger footprint than many other designs because of the

additional space required to construct the embankment around the facility. To ensure slope stability, the embankment would be at a five to one slope. This would impact the ability to collocate other waste facilities next to this facility (C 3.9) and could impact some additional utilities (C 3.2). Other than space considerations, it would support the Site Vision well because the storage cell cap could be tied into the cap planned for the Industrial Area of the Site (C 3.1).

Cost Criteria:

The Cost of Construction (C 4.1) was calculated as follows:

Design	$2,200,000
Pre-Construction	$400,000
Construction	$41,700,000
Total Cost of Construction	$44,300,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$8,800,000

The Cost of Interim Closure (C 4.3) was calculated as follows:

Interim Cover	$5,300,000
Interim Care And Monitoring	$13,900,000
Total Cost of Interim Closure	$19,200,000

The above costs were combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$118,800,000

The cost of construction would be high because of the cost of fill material that would be used to build up the embankments and because of all of the earthwork that would be required to place that fill (C 4.1). The low total life cycle cost (C 4.4) would be the result of onsite management in bulk form and potentially low interim closure costs (C 4.3). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

In terms of the regulatory support criteria, this facility would not have a lot of future applicability or utility outside of its use to manage bulk waste (C 5.4). For any use, only low level waste would be

put in this type of facility (C 5.5). Also, this design is more the current standard than it is state of the art (C 5.3) although the liner and the cap have the potential to be a state of the art design.

Other Stakeholder Concerns:

This would be one of the simpler facilities to design and construct (C 6.10). The needed materials, services and technologies would be readily available (C 6.12, 6.13). In terms of schedule requirements, this facility could be both expediently constructed and expediently operated (C 6.11) because:

- The design is simple
- The materials are easy to obtain
- The waste can be placed directly into the facility in bulk
- The technology is well known

F.2 CONCRETE LINED CELL WITH BULK PLACEMENT

Description:

Bulk waste would be placed in modular concrete cells. A double liner and a leachate collection system would be under the facility. Upon filling the cells an impermeable cap would placed above them. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The concrete walls and floors provide an additional barrier of protection to prevent leakage (C 1.4). This design supports the timing of remedial activities in a number of ways (C 1.5). Waste would be placed in bulk, so remediation waste could go from treatment or excavation directly into the cell. This could both expedite accelerated action as well as reduce the cost by eliminating the need for a remediation waste staging area. Construction of the facility would be expedient because the design is simple and the technology is readily available and well known. The modular design allows use after filling of the cells while other are under construction so the facility could start accepting waste prior to the completion of construction.

Public Protection (Geotechnical and Hydrological Criteria) :

The combination of abovegrade design and a double liner barrier will provide reasonable assurances that groundwater and subsurface soils are protected (C 2.1, 2.5, 2.10). Structurally, the concrete walls could provide additional structural stability (C 2.3). Drainage and infiltration could be impacted by the impermeable cover (C 2.11). Geomorphic effects will be minimized by maintaining a gentle slope and by forcing the design to accommodate surface features and the existing drainage patterns (C 2.2, 2.11).

Site Special Issues:

This option has a smaller footprint than some designs although it is slightly larger than the hardened concrete vault. This design well supports Site Vision objectives (C 3.1) since the facility could be part of a continuous cap planned for the Industrial Area and the smaller size of the facility means less total space for managing waste. The modular design should facilitate the placement of similar structures near this facility since walls of the unit could be shared with new modules allowing additional units to be placed right beside existing ones (C 3.9). The use of modules in this design will also enhance the ability of the facility to accept a variety of remediation waste types including Decontamination and Decommissioning waste (C 3.6).

Cost Criteria:

The Cost of Construction (C 4.1) was calculated as follows:

Design	$1,600,000
Pre-Construction	$150,000
Construction	$18,600,000
Total Cost of Construction	$20,350,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$1,970,000

The Cost of Interim Closure (C 4.3) was calculated as follows:

Interim Cover	$5,300,000
Interim Care And Monitoring	$13,000,000
Total Cost of Interim Closure	$18,300,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$77,320,000

Low construction, site preparation, and closure costs (C 4.1, 4.2, 4.3) plus cost savings resulting from bulk storage of the waste would give the lowest total life cycle costs (C 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This facility design would offer a greater degree of applicability and utility than many of the other designs and is permitable (C 5.3, 5.4). It is a state of the art design (C 5.3) used in Europe for similar applications. Only low-level waste is currently planned for this type of facility design (C 5.5).

Other Stakeholder Concerns:

The modular concrete lined cell allows for a variety of materials to be placed into the facility while still maintaining the ability to retrieve the waste (C 6.6). This facility would offer long-term effectiveness and permanence since it has additional barriers between the waste and the environment (C 6.7, 6.9). The demonstrated performance is better known since this design adds the additional protection of concrete to a storage cell type cap and liner system (C 6.9). Because of the concrete work, this design is expect to be more work intensive in terms of construction but less intensive in

terms of operation since it will be a bulk facility (C 6.10). Because the waste could be placed in bulk, it could go directly into the facility after treatment or excavation. Materials, services, and the technology would be readily available (C 6.12, 6.13).

F.3 CONCRETE LINED CELL IN CARGO CONTAINERS

Description:

Waste would be put into cargo containers and then placed in modular concrete cells. A double liner and a leachate collection system would be under the facility. Upon filling the cells an impermeable cap would placed above them. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The concrete walls and floors provide an additional barrier of protection to prevent leakage (C 1.4). Construction and of the facility could be expedient because the design is simple and the technology is readily available and well known (C 1.5). The modular design allows use after filling of the cells while other are under construction so the facility could start accepting waste prior to the completion of construction.

Public Protection (Geotechnical and Hydrological Criteria):

The cargo containers themselves could provide some structural support ad well as providing an additional barrier to prevent leaking (C 2.3). Further protection of groundwater and the subsurface strata is provided by the concrete base (C 2.5, 2.11, 2.12). Drainage and erosion could be controlled by maintaining a shallow slope and by adjusting the design to account for existing drainage; however the impermeable cover would still have some impact (C 2.10).

Site Special Issues:

This option has a smaller footprint than some designs although it is slightly larger than the hardened concrete vault. This design well supports Site Vision objectives (C 3.1) since the facility could be part of a continuous cap planned for the Industrial Area and the smaller size of the facility would mean less total space for managing waste. The modular design would facilitate the placement of similar structures near the facility since walls of the unit could be shared with new modules allowing additional units to be placed right beside existing ones (C 3.9). The use of modules in this design will also enhance the ability of the facility to accept a variety of remediation waste types including Decontamination and Decommissioning waste (C 3.6).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	$1,600,000
Pre-Construction	$150,000
Construction	$18,600,000
Total Cost of Construction	$20,350,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$1,970,000

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	$5,300,000
Interim Care And Monitoring	$10,400,000
Total Cost of Interim Closure	$15,700,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$165,650,000

Low construction costs (C 4.1) would offset the cost for containers to yield a relative low total life-cycle cost (C 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This facility design would offer a greater degree of applicability and utility than many of the other designs and is permitable (C 5.3, 5.4). It is a state of the art design (C 5.3) used in Europe for similar applications. Only low-level waste is currently planned for this type of facility design (C 5.5).

Other Stakeholder Concerns:

The use of containers better supports retrievability since the waste will be segregated, accessible and easier to inspect and remove (C 6.1, 6.2). As with the concrete lined call with bulk management, it compares favorably to the other designs in terms of useful life, effectiveness, demonstrated performance, and the availability of the technology, services and materials (C 6.7, 6.9, 6.12, 6.13). It will take additional time to construct than some of the other abovegrade designs due to all of the

concrete work (C 6.10, 6.11). Operations will be slightly more intensive than the concrete lined bulk facility due to the use of containers (C 6.10, 6.11).

F.4 HARDENED CONCRETE VAULT

Description:

Remediation waste inside cargo containers would be stored in a modular, abovegrade, self-supporting concrete structure placed over a double liner and leachate collection system. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

This design has additional features that enhance its protectiveness including additional barriers provided by concrete walls and floors and the containers (C 1.1). The waste would be very accessible since aisle ways would be present and containers could be removed and visually inspected for leaks. The modular design would allow use of one module prior to completion of the facility. This would allow use of the facility to be available sooner (C 1.5).

Public Protection (Geotechnical and Hydrological Criteria):

Concrete walls and floor could provide some additional structural support. Impermeable cap could impact drainage and infiltration patterns (C 2.11).

Site Special Issues:

The footprint for the hardened concrete vault would not be as large as many of the other designs considered. It would be easier to place additional facilities next to this facility because of its smaller foot print and concrete walls (C 3.9). One drawback would be that it could take a little longer to design and build and the filling of the facility is more work intensive and would take resources always from other Site closure activities (C 3.1). It would take longer to fill each vault which could also cause scheduling problems.

Cost Criteria:

The Cost of Construction (C 4.1) was calculated as follows:

Design	$2,200,000
Pre-Construction	$400,000
Construction	$26,000,000
Total Cost of Construction	$28,600,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$6,100,000

The Cost of Interim Closure (C 4.3) was calculated as follows:

Interim Cover	$5,300,000
Interim Care And Monitoring	$10,400,000
Total Cost of Interim Closure	$15,700,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$181,630,000

In spite of high site preparation costs (C 4.2), moderately high closure costs (C 4.3) and the cost for containers, the life-cycle cost would compare favorable with the other designs considered (C 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This design could have utilized for other applications including management of other waste types because there would be access aisles and it would be designed to hold cargo containers which could be used for other materials as well (C 5.4), although this design is only being considered for low-level waste (C 5.5). It is a state of the art design C 5.3).

Other Stakeholder Concerns:

This facility offers a high degree of monitorability and retrievability (C 6.1, 6.2) because there would be aisles for access, the waste would be in containers, and the modular design would enhance the ability to segregate and track the waste. In terms of construction and operation, this design would be more intensive (C 6.10) since additional effort would be required to construct the concrete vaults walls. During operations additional effort would be needed in containerizing the waste. The materials, services, or the technology needed to construct and operate this facility would be readily available (C 6.12, 6.13).

F.5 SILO DESIGN

Description:

Concrete silos would be placed over a double composite liner system and leachate collection system. Remediation waste would be placed in the silos in bulk Upon completion of filling operations, the entire facility would be covered with an interim cap. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The concrete silos, double liner and leachate collection system enhance the protectiveness of this design (C 1.1). Bulk placement in the silos would be easy to place but inspection would be limited.

Public Protection (Geotechnical and Hydrological Criteria):

Interim cap could impact drainage and infiltration patterns (C 2.11)

Site Special Issues:

The interim cap and small footprint would tie in well into the planned cap for the Industrial Area Cap as part of the Site Vision (C 3.1).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	$2,000,000
Pre-Construction	$400,000
Construction	$30,400,000
Total Cost of Construction	$32,800,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$6,100,000

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	$5,300,000
Interim Care And Monitoring	$13,900,000
Total Cost of Interim Closure	$19,200,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$107,300,000

Middle of the range construction costs (C 4.1) and low closure costs (C 4.3) combined cost savings from with bulk storage yielded a low life-cycle cost of the facility design alternatives (C 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This design meets some of the state principles. It is a state of the art design (C 5.3) and it is design to be permitted under RCRA; however its future use would be limited since the design is geared towards the bulk management of low-level soils (C 5.4, 5.5).

Other Stakeholder Concerns:

This design is not in wide use and so the performance and useful life is not as established (C 6.7, 6.9, 6.12). The intensive nature of this design would be very demanding in terms of design and construction and would probably take longer to get into operation (F10, F11). The main activities that would affect the schedule would be the additional time setting up forms and filling the silos and additional time preparing the detailed design (C 6.11).

F.6 SLAB ON GRADE

Description:

Waste would be put in cargo containers and placed on an abovegrade slab. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The Slab on Grade would be quick and easy to install due to its simple design, known technology, and the materials would be easily available. Since the time to complete the design work would be less also due to simplicity and the construction would mostly consist of site preparation and pouring the slab, it is anticipated that this design could be implemented in a relatively short period of time (C 1.5). The use of containers would allow for visual inspection in order to detect leaks prior to contaminants escaping to the environment (C 1.1, 1.2). Waste containers would be exposed to the elements unless a covering such as tent was placed over the slab. Contaminants that did escape from the containers could be collected in the concrete berm. Any waste material not captured by the concrete berm could escape into the environment, but since the waste is containers the possibility would be remote.

Public Protection (Geotechnical and Hydrological Criteria):

The ability to meet CAMU criteria is dependent on maintenance of the slab (C 2.5, C 2.10). A slab on grade design would be a temporary facility and the remediation waste would have to be shipped at a later date to some other facility to provide reasonable assurance that it could protect the public for a thousand years (C 2.1). A slab on grade could be engineered to provide adequate drainage (C 2.11), and a permeability of less than 10^{-7} centimeter/second (C 2.5). Slab design would also have to account for settling, expansion and contraction to avoid cracks and structural damage.

Site Special Issues:

The Slab on Grade would have minimal impact on utilities since there is little excavation involved and some overhead utilities could still run over the facility (C 3.2). As with Metal Buildings, this facility could readily support short-term Site Vision goals since it could be designed and constructed in less time, but it is temporary and could remain as an unclosed facility long after other plant facilities have been shut down (C 3.1). The collocation of other waste facilities is a problem only because the slab will have such a large footprint that it could limit the space available for other facilities (C 3.9).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	$300,000
Pre-Construction	$200,000
Construction	$3,800,000
Total Cost of Construction	$4,300,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$6,100,000

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	N/A
Interim Care And Monitoring	$8,500,000
Total Cost of Interim Closure	$8,500,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$141,600,000

Site preparation costs (C 4.2) and construction costs (C 4.1) would be very low because little earth work would be involved and construction would consist mainly of pouring the pad. However, these costs would be insignificant in comparison to the costs for offsite disposal and container costs which would give a very high total life-cycle cost (C 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

Like the Metal Buildings design, this RWSF would be designed meet RCRA requirements for permitted storage including the ability to visually inspect the waste (C5.3). The lack of cover and continual exposure of the waste containers to the elements could be an issue in permitting this facility (5.3, 5.4). It would have a good degree of future applicability and utility since it is basically just a concrete pad (C 5.4). Future applications could include other storage uses, a lay down yard, a staging pad for other cleanup operations, or a tent could be constructed over it. This facility design is far from being state of the art (C 5.3) since it really offers nothing new or innovative in the way of waste management.

Other Stakeholder Concerns:

The containers would be exposed to the elements and there would a slight possibility that the run off could get into surface water systems (C 6.2, 6.7). Due to the simplicity of this design it should be easy to design and construct in less time than the other designs (C 6.10, 6.11, 6.12, 6.13). Monitoring and retrieval would be well supported by this facility since all sides of the facility are potentially accessible and the containers can be easily moved and inspected. It would have a very short useful life relative to the other designs (C 6.7, 6.9). The materials, services and technology for this facility would easy to obtain because it a well known technology utilizing common construction materials (C 6.12, 6.13).

F.7 METAL BUILDINGS

Description:

Waste would be put in cargo containers and placed in four engineered metal buildings constructed on a concrete slab. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

The use of cargo containers would allow visual leak detection; however, the cost for these containers is high (C 1.1). Like the slab on grade, contaminants that did escape from the containers could be collected in the concrete berm. The building roof would protect containers from precipitation and further minimize any possibility of leaching (C 1.1). The simple, proven design and less intensive construction would allow this facility to be available sooner which could quicken near term remedial activities and might avoid temporary storage of this waste at another facility or staging area (C 1.1).

Public Protection (Geotechnical and Hydrological Criteria):

The design life of this facility would be less than other alternatives considered (C 2.1). An advantage would be that most leaks could be contained prior to escaping to the environment. The metal building design would be engineered to provide adequate drainage (C 2.11). Because this design actually consists of different buildings precipitation could be allowed to infiltrate to the water table without compromising the waste with in the buildings.

Site Special Issues:

The Metal Building design would have a large footprint compared to the other designs because additional space would be needed for aisle ways and to provide spacing between the buildings (C 3.1). The facility could be used before completely constructed since only one building would need to be ready for remediation waste to be placed inside. This would better support the Site Vision objectives of accelerated site clean up; however, its large footprint would not incorporate the Site Vision objective of reducing the foot print of contaminated area (C 3.1). One advantage to the Metal Buildings design is that there would be a little more flexibility in configuring the buildings so that utilities and other features could be worked around (C 3.2). The collocation of other waste facilities would be a problem only because the Metal Buildings would have such a large footprint that it could limit the space available for other facilities (C 3.9).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	$2,300,000
Pre-Construction	$1,300,000
Construction	$17,900,000
Total Cost of Construction	$21,500,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$2,800,000

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	N/A
Interim Care And Monitoring	$10,400,000
Total Cost of Interim Closure	$10,400,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$161,400,000

Low construction costs (C 4.1) would be offset by the cost of containers to yield one of the higher total life-cycle costs (C 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million). Since the waste is in containers, packaging costs would be lower once offsite shipment commenced.

Regulatory Support:

This facility design would be designed meet RCRA requirements for permitted storage including the ability to visual inspect the waste (C 5.3). The lack of cover and continual exposure of the waste containers to the elements could be an issue in permitting this facility (5.3, 5.4). It would have a good degree of future applicability and utility since it would be basically just a concrete pad (C 5.4). Future applications could include other storage uses or as a building for other closure activities. Like the Slab on Grade, this facility design is not state of the art (C 5.3) since it really offers nothing new or innovative in the way of waste management.

Other Stakeholder Concerns:

Monitoring and retrieval could be performed from the aisle ways in each buildings and the waste containers could be pulled out for even closer inspection. This is a well known technology (C 6.12) and its performance is well demonstrated (C 6.9); however, in comparison to other designs it would have a poor useful life since it is designed as a temporary facility. Even with maintenance, its effectiveness would eventually degrade as the buildings degrade (F7, F9). This facility would be easy to construct in a timely manner and the services and materials would very easy to acquire (C 6.10, 6.11, 6.13).

F.8 ENTOMBMENT

Description:

Remediation waste would be placed in 55 gallon drum containers and then placed in a concrete canister that are then sealed with grout. The canisters are then placed in a hardened concrete vault. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

This would have additional features that would add to the overall but protectiveness but would come at a high cost. These protective features would include an impermeable cap, a double liner, an impermeable cap, and hardened concrete walls. Inside the facility, the waste would be further contained by placement in 55 gallon drums which in turn would be entombed in concrete canisters (C 1.1). Entombment in canisters would be incorporating a treatment technology (similar to solidification) that enhances long-term effectiveness (C 1.6). Due to work intensive nature of this design compared to most facilities, additional time could be needed to design and construct this facility (C 1.5). Once in operation, this design would probably require more effort to get the waste from the field and into the facility and could require an additional staging area to seal the waste in concrete canisters.

Public Protection (Geotechnical and Hydrological Criteria)

Numerous barriers protect groundwater and surface water from any form of contaminant migration (C 2.5, 2.11, 2.12). Impermeable cap could have some impact on drainage patterns and infiltration (C 2.11).

Site Special Issues:

Entombment would require a very large footprint because the concrete box containment takes up more space than either bulk management or cargo containers. Like other designs with concrete walls, it would be easier to place additional facilities in the vicinity of an entombment facility (C 3.9). Additional staging areas would be required to grout and then place the waste containers. This could have an impact on Site activities including Site closure activities (C 3.1). Additional problems could result when the waste is to be disposed of. Because the waste would be grouted into the containers, other facilities might not be willing to accept this waste. It could require expensive and time consuming reprocessing which would also have an impact to Site closure activities (C 3.1).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	N/A
Pre-Construction	N/A
Construction	N/A
Total Cost of Construction	N/A

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	N/A

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	N/A
Interim Care And Monitoring	N/A
Total Cost of Interim Closure	N/A

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$525,000,000

* The cost for entombment was not calculated using a bottoms-up method and therefore a breakdown of costs is not available.

Entombment would be more expensive or as expensive as any of designs considered in terms of construction costs (C4.1), site preparation (C 4.2), closure (C 4.3), and total life-cycle cost (C 4.4). Factors that contribute to this high cost could include:

- Placement in concrete boxes would be labor and material intensive
- The facility itself would be very large which would increase construction costs
- The larger footprint would require more site preparation work

As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This facility design could be considered state of the art (C 5.3) due its more advanced containment system. Although the materials would be sealed in place, the concrete boxes would be retrievable for inspection (C 5.3, 5.4).

Other Stakeholder Concerns:

Retrieval of the concrete boxes themselves would be simple as long as the facility was in operation. After the placement of the cap retrieval would be more difficult. Retrieval of individual drums would be further compounded by the fact that the drums would be set in grout and would have to be chiseled out. This unit would have a long useful life and would be very effective (C 6.7, C 6.9) since it would be constructed from time tested materials and would offer multiple levels of containment. Ultimately problems could occur if the entombed waste were shipped offsite since other facilities might not accept the waste in the concrete boxes. Removing the waste from the concrete boxes would be very expensive since the waste would have to be chipped out of the grout. This facility would be much more labor, material and time intensive for both construction and operation (C 6.10, 6.11). Additional time and effort would be needed to:

- Design the facility
- Develop the technology
- Build packaging facilities
- Perform additional site preparation

The operation phase would also be more intensive due to the additional efforts required to prepare the waste in concrete canisters (C 6.10, 6.11). There could also be some problems encountered with the availability of the needed technology since this type of facility is not as common (C 6.12). No problems are expected in getting the needed raw materials and services (C 6.13). There could be some limitations in accepting some waste due to the size limitations of the 55 gallon drums (C 6.8).

F.9 PYRAMID DESIGN

Description:

Bulk remediation waste would be placed inside of a giant hollow pyramid constructed of quarried stone blocks. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

This design could require more maintenance to maintain its protectiveness since settling or shifting of the outside block could cause areas of exposure requiring repair (C 1.1). A more lengthy design and construction period could be required for development of this technology and because availability of materials could be limited (C 1.5).

Public Protection (Geotechnical and Hydrological Criteria)

The Pyramid design should provide good drainage based on its geometry but could alter area drainage and infiltration patterns (C 2.11). The pyramid design would have to account for weight of the facility as well as impacts to slope stability (C 2.3).

Site Special Issues:

This alternative could need additional design and construction time which would impact cleanup efforts under the Site Vision (C 3.1). This additional time would be utilized for technology development since this is a new application. Additional time would also be spent obtaining a supplier of stone blocks, having the blocks cut, and for geotechnical work. As an innovative design, some additional time could also be required to verify the soundness of the technology. Ultimately, this could potentially impact building deactivation, decontamination, and decommissioning activities (C 3.5, 3.6). The prolonged design and construction of the facility could cause additional remediation waste to be placed in RCRA storage units consuming space needed for other waste (C 3.7). There could be some problems with locating future waste facilities near the pyramid since changes in geometry of the facility are limited and the footprint is larger than other designs (C 3.9).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	$2,200,000
Pre-Construction	$400,000
Construction	$57,900,000
Total Cost of Construction	$60,500,000

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	$14,500,000

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	N/A
Interim Care And Monitoring	$13,900,000
Total Cost of Interim Closure	$13,900,000

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$140,300,000

Although this design would be one of the more expensive designs to prepare the site for and construct (C 4.1, 4.2), it would be one of the least expensive to close (C 4.3) and the total life cycle cost would place this design in the lower part of the range of those considered (C 4.4). Because the design is untested, additional costs could be incurred due technology development and additional design. These costs were not incorporated into the estimate. As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

Although it is an innovative design, it is not currently state of the art (C 5.3) since the technology has never been developed for this application. Nor would the facility offer "the greatest degree of future applicability and utility" since it would be designed specifically for one use, the containment of contaminated soils.

Other Stakeholder Concerns:

Due to its innovative nature, a lot of unknowns are associated with this design. Although there is

demonstrated performance with pyramids by ancient man for observatories, temples, or tombs, in general, there is no demonstrated performance for this particular design nor with the application of this design to waste management (C 6.9). If the blocks were to remain intact, the life of the structure itself could be similar to ancient pyramids. It is not known whether differential settling would open up the seams between the blocks allowing precipitation into the interior. Depending on their size and type of stone used, the blocks for the pyramid could be difficult to acquire (C 6.11, 6.12, 6.13).

F.10 WASTE PILE

Description:

Bulk waste would be compacted into a rectangular pile, sealed in a geomembrane and covered with dirt. The facility would be underlain with a liner and leachate collection system. A more detailed description of this design is given in Appendix E.

CAMU Criteria:

Because the necessary design and site preparation of this facility would be minimal, use of the facility could be available sooner which could expedite some near-term early actions (C 1.5).

Public Protection (Geotechnical and Hydrological Criteria)

The design life of this facility is to approximately 30 years. At the end of its useful life, the facility would have to modified, a new facility would have to be constructed or the waste would have to be sent to another facility (C 2.1).

Site Special Issues:

The impermeable cap could be tied into the cap planned for the Industrial Area as part of Site closures activities under the Site Vision (C 3.1).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	N/A
Pre-Construction	N/A
Construction	N/A
Total Cost of Construction	N/A

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	N/A

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	N/A
Interim Care And Monitoring	N/A

Total Cost of Interim Closure	N/A

The above costs are combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$36,670,000

* A breakdown of specific costs are not available. Life-cycle costs are based on actuals from a similar facility.

The construction costs and site preparations costs would be very low (C 4.1, 4.2), resulting in a a low life-cycle cost (C 4.4). As with the other onsite alternatives, life cycle cost does not include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs would increase the total life-cycle cost significantly (by more than $150 million).

Regulatory Support:

This design is geared specifically towards soil and other remediation recovered during Site clean up and therefore this facility would not have many other uses (C 5.4).

Other Stakeholder Concerns:

The useful life of this facility would be limited since the intent is to provide safe, cost-effective storage until the waste can be moved to a more permanent facility (C 6.6, 6.9). The simplicity of this facility would allow for a reduced design and construction period (C 6.11). Because waste would be placed in an easily accessed pile, operations would also be facilitated by this design. Once the waste pile is covered over, retrieval and monitoring of individual waste streams would be hampered by access problems and a lack of separation. On the other hand, retrieval of all of the waste at once could be relatively simple since the cover could be breached and the waste could be removed with a front end loader.

F.11 NO ACTION

Description:

The no action alternative is to shipped the waste to an offsite facility as it is generated. A more detailed description of this design is given in Appendix E and Appendix B.

CAMU Criteria:

CAMU criteria are not applicable to this action since an offsite facility would not be used as a CAMU.

Public Protection (Geotechnical and Hydrological Criteria)

Public protection would be dependent on the facility. Protection to the groundwater would likely be equivalent or better than RCRA Title C Landfill requirements. Offsite facilities could have less permeable geologic strata to meet minimum permeability of 10^{-7} centimeters/second, whereas onsite facility would likely meet the same minimum permeability with engineered barriers (C 2.5).

Site Special Issues:

This option would only require a staging area for packaging and transporting the waste. Since no space would be needed for a storage facility, this option would well address the Site Vision objective of reducing the footprint of contaminated areas (C 3.1). Delays in shipping could cause valuable RCRA storage space to be utilized (C 3.7).

Cost Criteria:

The Cost of Construction (C 4.1) is calculated as follows:

Design	N/A
Pre-Construction	N/A
Construction	N/A
Total Cost of Construction	N/A

The Cost of Site Preparation (C 4.2) is:

Cost of Site Preparation	N/A

The Cost of Interim Closure (C 4.3) is calculated as follows:

Interim Cover	N/A
Interim Care And Monitoring	N/A
Total Cost of Interim Closure	N/A

The above costs were combined with the costs for containers, packaging, characterization, transportation, permitting, operations, and contingency to yield the Total Life-Cycle Cost (C 4.4):

Total Life-Cycle Cost	$215,900,000

Because a major facility would not have to be constructed, most of the cost would be tied up in offsite disposal (C 4.4). Unlike the onsite alternatives considered, life cycle cost do include the eventual cost of offsite disposal which would include retrieval, packaging, transportation and disposal costs. The inclusion of these costs make this option if feasible, the least expensive of the options considered.

Regulatory Support:

These criteria are not applicable to this option, because these criteria only apply to onsite facilities.

Other Stakeholder Concerns:

Because this option would utilize an existing facility, issues associated with construction and the availability of the technology, materials, and services do not exist (C 6.10, 6.12 6.13). Some offsite facilities might not be able to accept all of the waste types that would be generated due permit or license restrictions, differing waste acceptance criteria, or restrictions based on regulation (C 6.8). In terms of schedule requirements, there would be no delays due to construction of the facility, although additional handling, packaging, and transportation facilities at the Site could be needed (C 6.11). During the operation phase, there would be delays in putting waste in the facility due to characterization, documentation, packaging, and acceptance requirements. Remediation waste would be put in temporary storage at the Site while these requirements were being addressed.

Appendix G
Backup Information for Risk Evaluation

FORWARD:

This document was developed in the early spring of 1996. The intent was to define a typical waste stream based on actual analytical data in the site characterization database (Rocky Flats Environmental Data System). Since significant data gaps exist in the characterization of the Industrial Area, data from the solar ponds characterization was used to estimate a representative waste stream. No inferences should be made regarding actual waste streams which will be activity specific and subject to regulatory agency approval. The use of waste streams such as pondcrete and solar ponds vadose zone soils were for the sole purpose of estimating typical waste streams at RFETS.

Appendix G is a report titled "Estimation Of Contaminant Concentrations From Probable Leachate Compositions At Seep Pathways In The Vicinity Of The Waste Management Facility, Rocky Flats Environmental Technology Site, Colorado."

Appendix A of this report , consisting of two reports as supporting documentation starts on page G-20.

TABLE OF CONTENTS

NOTE: G-2

ESTIMATION OF CONTAMINANT CONCENTRATIONS FROM PROBABLE LEACHATE COMPOSITIONS AT SEEP PATHWAYS IN THE VICINITY OF THE WASTE MANAGEMENT FACILITY, ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, COLORADO G-5

1.0 INTRODUCTION G-6

2.0 METHODOLOGY G-6

3.0 ESTIMATION OF LEACHATE CONCENTRATIONS G-7

4.0 ESTIMATION OF LEACHATE FLUX G-7

5.0 ESTIMATION OF MASS/ACTIVITY OF LEACHATE CONSTITUENTS G-9

6.0 ESTIMATION OF GROUNDWATER VOLUME BELOW WMF G-9

7.0 ESTIMATION OF GROUNDWATER CONCENTRATIONS BENEATH WMF FROM LEACHATE G-10

8.0 CONCLUSIONS AND RECOMMENDATIONS G-10

- 8.1 Scenario 1 (Cap and Liner) G-10
- 8.2 Scenario 2 (Liner) G-10
- 8.3 Scenario 3 (Flux equals Recharge) G-10
- 8.4 Recommendations G-11

9.0 REFERENCES G-11

TABLES G-12

- Table 1: Estimated Leachate Concentrations G-12
- Table 2: Estimated Mass/Activity of Leachate Constituents Exiting WMF G-14
- Table 3: Estimated Groundwater Concentrations Beneath WMF From Leachate G-16
- Table 4: DRAFT RFCA Surface Water Action Levels for Stream Segment 5 (Walnut Creek) G-18

APPENDIX A - SUPPORTING DOCUMENTATION FOR LEACHATE CONCENTRATIONS G-20

- CALCULATION OF PROBABLE MAXIMUM LEACHATE CONCENTRATIONS G-21
  - COMPOUNDS CONSIDERED IN ANALYSIS G-21
  - TABLE 1: Compounds Used in Analysis G-21
  - DETERMINATION OF LEACHATE CONCENTRATIONS G-22

TABLE 2: Computed Leachate Concentrations G-23
REFERENCES G-23
ANALYSIS OF INORGANIC CONSTITUENTS AND PROBABLE LEACHATE COMPOSITION FROM WASTE STORED IN THE NEW WASTE CELL AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN, COLORADO G-24
1.0 INTRODUCTION G-25
Table 1: Sampling Locations with Data Available for Subsurface Soils G-26
Table 2: Sampling Locations with Data Available for Groundwater Samples G-27
2.0 DATA ANALYSIS G-28
2.1 Subsurface Soil G-28
2.2 OU4 Vadose-Zone Water G-29
Table 3a: Summary of Data for Subsurface Soils: Waste Boreholes G-30
Table 3b: Summary of Data for Subsurface Soils: Background Boreholes G-31
Table 4: Comparison of Concentrations of Inorganic Constituents in Waste-Cell Subsurface Soils vs. Background Subsurface Soils G-32
Table 5: Pore-Water Data for pH and Specific Conductivity G-33
Table 6: Summary of Pore-Water Data for OU 4 Lysimeters G-34
2.3 OU4 Pondcrete G-35
Table 7a: Kd Values (L/kg) for Selected Analytes G-36
Table 7b: Kd Values (L/kg) Used at Other DOE Facilities for Selected Radionuclides G-36
2.4 OU4 Sludges G-37
Figure 1: Optimum pH Values for Precipitation of Various Metal Hydroxides. G-38
Table 8: Average Leachate (TCLP) compositions for Treated Pondcrete and Sudges G-39
2.5 Groundwater G-40
3.0 GEOCHEMICAL MODELING G-40
Table 9: Summary of Groundwater Data for Areas with Contaminated Subsurface Soils G-41
Table 10: Summary of Data and Estimated Leachate Composition for Waste-Cell Wastes G-42
3.1 Modeling of Groundwater Chemistry G-43
3.2 Modeling of Estimated Leachate Solution G-43
Figure 2: Generalized Eh-pH diagram showing conditions of natural environments.. G-44
4.0 SUMMARY AND CONCLUSIONS G-45
Figure 3a: Distribution of dissolved uranium species in a carbonate-free system at 25°C G-46
Figure 3b: Distrib. of dissolved uranium species in a syst. containing carbonate, at 25°C G-46
5.0 REFERENCES G-48
APPENDIX A: Speciation in Estimated Leachate Solution G-49
APPENDIX B: HELP MODEL OUTPUT G-58

ESTIMATION OF CONTAMINANT CONCENTRATIONS FROM PROBABLE LEACHATE COMPOSITIONS AT SEEP PATHWAYS IN THE VICINITY OF THE WASTE MANAGEMENT FACILITY, ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, COLORADO

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1.0 INTRODUCTION

A Waste Management Facility (WMF) has been proposed to be constructed at the Rocky Flats Environmental Technology Site (RFETS). A conceptual level, semi-quantitative assessment of the maximum level of contamination that could migrate from the Waste Management Facility (WMF) to surface water was performed. This effort serves as part of the analysis of the facility design in terms of CAMU protectiveness requirements and Part 2 Siting criteria. This report presents an estimate of the concentrations that could result from groundwater exiting from seeps and/or entering surface water from the WMF, given the current design.

Based on preliminary design drawings from RMRS/Engineering, the WMF will consist of a concrete slab, 500 by 360 feet in plan (approximately 4.13 acres). The slab will be constructed as three modules (500 feet long by 120 feet wide), which will be separated from each other by vertical concrete walls (18 feet high). A 14 foot high perimeter wall will enclose the entire slab. Various waste materials will be placed in the bins, including bulk wastes (contaminated soils), pondcrete (low strength concrete in approximately one meter cubes), and structural steel.

In concept, the bottom of the slab will be poured at existing grade. However, the slab will be underlain by a composite liner system consisting of one foot of drainage gravel, a geotextile, an 80 mil textured HDPE geomembrane, a geotextile, a geonet leak detection layer, a geotextile, an 80 mil textured HDPE geomembrane, and three feet of compacted clay.

After the various bins are filled with waste, a composite cover system will be constructed. The cover will include (from the top) two feet of vegetated soil with armament, a geotextile, one foot of graded gravel, three feet of riprap (biotic barrier), a geotextile, one foot of sand, a geotextile, an 80 mil HDPE geomembrane, a geosynthetic clay membrane, and two feet of compacted clay. Three leachate flux scenarios are addressed in this document. Scenario 1 uses a leachate flux resulting from a capped and lined WMF, representing a post-closure time period. Scenario 2 uses a leachate flux from an uncapped, but lined WMF prior to closure. The leachate flux for these scenarios are estimated using a computer model. Scenario 3 is a worst case scenario, using a leachate flux equal to an assumed RFETS recharge rate of 1 inch per year.

2.0 METHODOLOGY

A simple dilution calculation is used to obtain potential concentrations of groundwater exiting at seeps or entering surface water. In order to estimate the contamination concentrations of groundwater at locations where it intercepts surface water, (at seeps or the drainages) the following methodology was used:

1. Estimate leachate concentrations;
2. Estimate flux of leachate though the base of the WMF;
3. Estimate mass of leachate constituents in leachate exiting WMF;
4. Estimate concentrations of leachate constituents after mixing in groundwater below WMF.

In order to complete this analysis, the following assumptions were made:

- instantaneous mixing of leachate in groundwater below WMF
- annual flux out of WMF base is at equilibrium conditions (it does not change with time)
- groundwater concentrations beneath WMF do not include existing contamination
- retardation is ignored
- no thorough flow of groundwater beneath the WMF
- contamination from the WMF leachate does not "build up" over time

- concentrations are estimated for a time period after the WMF has been capped.

3.0 ESTIMATION OF LEACHATE CONCENTRATIONS

In order to estimate the concentrations of contaminants at seep locations near the WMF, it is necessary to estimate the probable leachate composition. To accomplish this, the commonly used soil/water partitioning equation (EPA, 1994) was used to estimate maximum concentrations for organic constituents and the leachate composition from Siders (1996) was used for metals and radionuclides.

The soil/water partitioning equation is a more simplified approach than numerical transport modeling. Based on the unknowns regarding the analysis parameters (amount of waste in place, contaminant concentrations in the waste, etc.) a more simplified approach is more appropriate. The soil/water partitioning equation describes the partitioning of a contaminant between solid, liquid, and gaseous phases under equilibrium conditions. The soil/water partitioning equation is:

$$C_w = C_s/[K_d + (\theta_w + \theta_a H')/\rho_b]$$

where:

C_w is the soil water concentration (mg/l)

C_s is the waste soil contaminant concentration (mg/kg)

K_d is the distribution coefficient (ml/kg)

θ_w is the water filled porosity of the waste soils (assumed to be 1.0)

θ_a is the air-filled porosity of the waste soils (assumed to be 0.0)

H' is the Henry's Law constant

ρ_b is the representative bulk density of the waste soils (assumed to be 1.5 g/cm^3)

Leachate concentrations for volatile and semi-volatile organic compounds (VOC/SVOCs) contaminants were estimated by Roberts (1996) with greater than 15% detection frequency. These VOC/SVOC leachate concentrations were used in this analysis for the initial leachate concentrations and composition for VOC/SVOCs. Roberts calculated K_d values for the VOC/SVOCs using site-specific data. Roberts (1996) estimation of VOC/SVOC leachate composition and concentrations are presented in Table 1.

A similar approach (using the soil/water partitioning equation) was initially planned for estimating the leachate composition and concentrations for metals and radionuclides. Examination of K_d values for metals and radionuclides (used in the soil/water partitioning equation) revealed virtually no site specific values and that literature values ranged over several orders of magnitude. This variability makes it much more difficult to derive K_ds for metals than VOC/SVOCs. EPA (1994) indicates that the K_ds for metals (and metallic radionuclides) are affected by several factors, including numerous geochemical processes and parameters, variability in the field, and differences in experimental methods. These factors result in variabilities of up to seven orders of magnitude.

Because no meaningful literature or site-specific values for metal K_ds could be obtained, the leachate composition derived by Siders (1996) was used. Siders calculated a probable leachate compositions for metals, radionuclides, and inorganic parameters based on estimated volumes of waste to be stored in the WMF and available data for leachates, pore water, and groundwater from wastes and waste areas. Siders (1996) estimated metals and radionuclides leachate composition and concentrations are also presented in Table 1.

Roberts (1996) and Siders (1996) are contained in Appendix A as supporting documentation.

4.0 ESTIMATION OF LEACHATE FLUX

In order to estimate the amount of contaminants that could potentially reach surface water from the WMF, it was necessary to estimate the flux of fluid through the base of the WMF. This was accomplished using the results of two Hydrologic Evaluation of Landfill Performance (HELP) models and an assumed value of leachate flux. The HELP numerical code was developed for the EPA by the

U.S. Army Corps of Engineers. HELP is used to obtain rapid and economical estimation of water flux in and out of landfills. Both site-specific and literature values were used in the preparation of this model, which was used to evaluate the effectiveness of the proposed WMF cap/liner system design. The model was run for 100 years.
The HELP model for the WMF consisted of 17 layers over a 10 acre site, representing the engineered liner and cap system. The layers are:

Layer 1 - angular pea gravel

Layer 2 - vegetative layer with gravel

Layer 3 - general backfill

Layer 4 - sand/gravel

Layer 5 - bioexclusion layer (cobbles)

Layer 6 - sand/gravel

Layer 7 - geomembrane and geosynthetic clay liner

Layer 8 - clay liner

Layer 9 - general backfill

Layer 10 - compacted waste

Layer 11 - drainage network

Layer 12 - concrete slab with drainage pipes

Layer 13 - gravel

Layer 14 - leachate collection membrane

Layer 15 - geocomposite

Layer 16 - leak detection membrane

Layer 17 - barrier soil liner (clay).

To evaluate a range of possibilities regarding leachate fluxes, three scenarios were examined. Two scenarios using HELP were examined. Scenario 1 includes both cap and liner systems (simulating post-closure), while Scenario 2 includes only the liner system with no cap(simulating pre-closure).

Another scenario (Scenario 3) was also considered in which the leachate flux through the base of the WMF is equal to an assumed recharge rate at RFETS (1 inch/year). Scenario 3 would represent a worst-case scenario because in order for this scenario to take place, the cap/liner system would either have experienced complete failure or would have never been installed. It should be noted that the assumed recharge rate is probably greater than the actual value at Rocky Flats.
From the HELP model scenarios, the average annual leakage through the base of layer 17 (the bottom clay liner) is 0.084 ft^3 (2.38 liters) for Scenario 1 (cap and liner) and 0.205 ft^3 (5.81 liters) for Scenario 2 (liner). These fluxes are probably greater than what would actually result from the WMF, due to the differences in the areas for the HELP models (10 acres) and the proposed design (4.13 acres). This is a conservative result because it would introduce more leachate into the groundwater. This results are only valid for the various inputs used in the model, including industry standard parameters, literature values, and the proposed design of the WMF. Any changes in the model parameter values could change the results of the model. Of course, the model is only a predictor of ideal conditions. Actual design and construction of the WMF will affect performance. It is assumed that the amount of leachate exiting the WMF is continuous and at equilibrium (it will not change with time). The HELP model output is contained in Appendix B.

USING THE ASSUMED VALUE OF SITE RECHARGE (1 INCH/YEAR) AND THE SAME AREA USED IN THE HELP MODEL (10 ACRES) RESULTS IN 36,300 FT^3 (1.03 MILLION LITERS) OF LEACHATE EXITING THE WMF ANNUALLY. AGAIN, THIS SCENARIO REPRESENTS A WORST-CASE SCENARIO WHICH COULD ONLY RESULT FROM EITHER NO CAP/LINER INSTALLATION OR COMPLETE FAILURE OF THE CAP/LINER SYSTEM.

5.0 ESTIMATION OF MASS/ACTIVITY OF LEACHATE CONSTITUENTS

Using the flux exiting the WMF estimated in section 4.0, the mass (or activities for the radionuclides) of the leachate constituents were calculated. This was accomplished by multiplying the amount of the annual flux for each scenario (2.38, 5.81, and 1.03 million liters for scenarios 1, 2, and 3, respectively) by the concentration of the constituents comprising the leachate. The results of this calculation are presented in Table 2. These results represents the mass/activities of contaminants available for mixing in groundwater below the WMF.

6.0 ESTIMATION OF GROUNDWATER VOLUME BELOW WMF

To calculate the resulting concentrations of the mass/activity of leachate constituents, it is necessary to estimate the volume of groundwater beneath the WMF. To obtain this volume, the average saturated thickness was estimated, based on water levels wells screened in the upper hydrostratigraphic unit (UHSU). These data are available in EG&G (1995a). Since the UHSU is comprised of both alluvial materials and weathered bedrock, the estimated saturated thickness included the thickness of the weathered bedrock. The thickness of the weathered bedrock was obtained from EG&G (1995b). Using a saturated thickness of approximately 35 feet, a porosity of 0.3, and an assumed area of 10 acres, there is approximately 130 million liters of groundwater beneath the WMF available for mixing.

7.0 ESTIMATION OF GROUNDWATER CONCENTRATIONS BENEATH WMF FROM LEACHATE

Using the volume of groundwater beneath the WMF (estimated in section 6.0) and the mass/activity of the leachate constituents (estimated in section 5.0), the concentration of the groundwater from leachate constituents is calculated for each scenario. This is accomplished by dividing the volume of groundwater by the mass/activity of the constituents. This assumes instantaneous mixing of the

leachate and the groundwater beneath the WMF and instantaneous appearance at surface water points and seeps. This is a conservative assumption, since no retardation and decay of the contaminants is considered. Concentrations of the leachate constituents which already exist (either naturally or through anthropogenic agencies) in the groundwater are not considered.
This estimation, however, does not consider the addition of contaminants over time. Table 3 presents the potential concentrations of groundwater beneath the WMF from leachate for each scenario. These concentrations represent a potential value for groundwater exiting at seeps and entering surface water for the given scenarios.

8.0 CONCLUSIONS AND RECOMMENDATIONS

These estimates represent potential concentrations for groundwater contamination from leachate. Assuming that this concentration reaches the surface water and seeps, it also represents a potential concentration that could appear at these locations. Resulting groundwater concentrations for the three scenarios were compared to draft RFCA (RFCA, 1996) action levels for surface water as a mean of evaluating the impact of the WMF. Table 4 lists the applicable RFCA surface water action levels for stream segment 5 (the section of Walnut Creek near the WMF).
Any modifications to the existing HELP model and/or changes in the design of the WMF could result in changes to the concentrations obtained in this analysis. Actual construction of the WMF could also result in differences between the predicted concentrations and observed concentrations in the future.

8.1 Scenario 1 (Cap and Liner)

The predicted concentrations, when compared with applicable surface water action levels listed in the draft RFCA, are much less than those levels requiring action. Because the estimated concentrations are very low, it appears that the design of the cap/liner system (as used in the HELP model) is sufficient to protect surface water and seeps from contamination.
It should be noted that changing the saturated thickness from 35 feet to 5 feet (thickness of the alluvial part of the UHSU) will lessen the resulting volume by less than an order of magnitude. Thus, reduction in the saturated thickness will only increase the resulting concentrations by an order of magnitude. These values would still be well below the actions levels specified by RFCA.

8.2 Scenario 2 (Liner)

Comparison of the resulting concentrations for Scenario 2 with RFCA surface water action levels reveals that for most leachate constituents, the concentrations are less than the action levels. Because the estimated concentrations are very low, it appears that during the active life of the facility, while waste is being loaded into the WMF modules, the liner system is sufficient to protect surface water and seeps from contamination.
Changing the saturated thickness from 35 feet to 5 feet (the thickness of the alluvial part of the UHSU) will lessen the resulting volume by less than an order of magnitude, thus increasing the groundwater concentrations by an order of magnitude. This action would not increase groundwater concentration above RFCA action levels for surface water.

8.3 Scenario 3 (Flux equals Recharge)

Comparison of the resulting concentrations for Scenario 3 with RFCA surface water action levels reveals that for most leachate constituents, the concentrations are less than the action levels. Only for certain VOC/SVOCs (carbon tetrachloride, 1,1 dichloroethane, 1,2 dichloroethene, methylene chloride, tetrachloroethylene, and trichloroethene) are groundwater concentrations greater than RFCA action levels for surface water. It should be noted that this scenario is the worst-case scenario. This scenario is not likely to take place because a liner would restrict leachate percolation into the UHSU. This scenario would either represent a complete failure of the cap/liner system or no cap/liner.
It should be noted that changing the saturated thickness from 35 feet to 5 feet (thickness of the alluvial part of the UHSU) will lessen the resulting volume by less than an order of magnitude, thus increasing the groundwater concentrations by an order of magnitude. This modification would lead to

a greater number of leachate constituents exceeding the draft RFCA surface water action levels. In addition to the VOC/SVOCs mentioned previously, bis (2-ethylhexyl) phthalate exceeds the draft RFCA surface water action levels, as do some metals (manganese, mercury, and silver) and radionuclides (gross alpha, gross beta, U-233/234, and U-238).

8.4 Recommendations

It is recommended that a transport model, using the fluxes obtained from the HELP model and the leachate concentrations from Roberts (1996) and Siders (1996). A numerical model could incorporate retardation and decay, as well as account for mass transfer from the groundwater system to the surface water and seeps. It may be possible to utilize the ASAP groundwater flow model, once it is calibrated. The ASAP modeling effort is anticipated to be calibrated by the end of August 1996. It is also recommended that a three-dimensional scientific visualization be constructed of the area where the WMF is to be constructed. RMRS Environmental Restoration has the capability to perform this task, which would show the relationships of geology and hydrogeology with the WMF. A three-dimensional model would be invaluable for integrating data and interpretations and would be useful for both technical and non-technical personnel.

9.0 REFERENCES

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TABLES

Table 1: Estimated Leachate Concentrations

Constituent	Leachate Concentrations	Units
Volatile Organic Compounds		
Acetone	150000	µg/L
Carbon Tetrachloride	2100	µg/L
Chloroform	3000	µg/L
1,1 Dichloroethane	3100	µg/L
1,1 Dichloroethene	2800	µg/L
1,2 Dichloroethene	16000	µg/L
Diethyl Phthalate	12000	µg/L
Di-n-Butyl Phthalate	3600	µg/L
Bis (2-Ethylhexyl) Phthalate	140	µg/L
Methylene Chloride	19000	µg/L
Tetrachloroethylene	2000	µg/L
1,1,1-Trichloroethane	2500	µg/L
Trichloroethene	2500	µg/L
Metals		
Aluminum	547	µg/L
Antimony	22	µg/L
Arsenic	48	µg/L
Barium	133	µg/L
Beryllium	1.8	µg/L
Cadmium	8.5	µg/L
Calcium	111230	µg/L
Cesium	146	µg/L
Chromium	173	µg/L
Cobalt	37	µg/L
Copper	59	µg/L
Iron	970	µg/L
Lead	27	µg/L
Lithium	528	µg/L
Magnesium	17910	µg/L
Manganese	550	µg/L
Mercury	0.46	µg/L
Molybdenum	302	µg/L
Nickel	90	µg/L
Potassium	165300	µg/L
Selenium	5.5	µg/L

Table 1 (cont.)
Estimated Leachate Concentrations

Constituent	Leachate Concentrations	Units
Silver	10	µg/L
Sodium	783800	µg/L
Strontium	1640	µg/L
Thallium	8	µg/L
Tin	84	µg/L
Vanadium	17	µg/L
Zinc	60	µg/L
Radionuclides		
Americium-241	0.11	pCi/L
Cesium-134	ID	pCi/L
Cesium-137	0.33	pCi/L
Gross Alpha	375	pCi/L
Gross Beta	230	pCi/L
Plutonium-239/240	0.12	pCi/L
Radium 226	1.4	pCi/L
Radium-228	3.2	pCi/L
Tritium (total)	1310	pCi/L
Uranium-233/234	147	pCi/L
Uranium-235	6.1	pCi/L
Uranium-238	142	pCi/L

Notes:

ID = Insufficient Data
µg/L = micrograms per liter
pCi/L = picocuries per liter

Table 2: Estimated Mass/Activity of Leachate Constituents Exiting WMF

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Volatile Organic Compounds				
Acetone	357000	871500	1.54E+11	µg
Carbon Tetrachloride	4998	12201	2.16E+09	µg
Chloroform	7140	17430	3.09E+09	µg
1,1 Dichloroethane	7378	18011	3.19E+09	µg
1,1 Dichloroethene	6664	16268	2.88E+09	µg
1,2 Dichloroethene	38080	92960	1.65E+10	µg
Diethyl Phthalate	28560	69720	1.24E+10	µg
Di-n-Butyl Phthalate	8568	20916	3.70E+09	µg
Bis (2-Ethylhexyl) Phthalate	333.2	813.4	1.44E+08	µg
Methylene Chloride	45220	110390	1.96E+10	µg
Tetrachloroethylene	4760	11620	2.06E+09	µg
1,1,1-Trichloroethane	5950	14525	2.57E+09	µg
Trichloroethene	5950	14525	2.57E+09	µg
Metals				
Aluminum	1301.86	3178.07	5.60E+08	µg
Antimony	52.36	127.82	2.26E+07	µg
Arsenic	114.24	278.88	4.94E+07	µg
Barium	316.54	772.73	1.37E+08	µg
Beryllium	4.284	10.458	1.85E+06	µg
Cadmium	20.23	49.39	8.75E+06	µg
Calcium	264727.4	646246.3	1.15E+11	µg
Cesium	347.48	848.26	1.50E+08	µg
Chromium	411.74	1005.13	1.78E+08	µg
Cobalt	88.06	214.97	3.81E+07	µg
Copper	140.42	342.79	6.05E+07	µg
Iron	2308.6	5635.7	19.95E+08	µg
Lead	64.26	156.87	2.78E+07	µg
Lithium	1256.64	3067.68	5.45E+08	µg
Magnesium	42625.8	104057.1	1.84E+10	µg
Manganese	1309	3195.5	5.65E+08	µg
Mercury	1.0948	2.6726	4.73E+05	µg
Molybdenum	718.76	1754.62	3.11E+08	µg
Nickel	214.2	522.9	9.25E+07	µg
Potassium	393414	960393	1.70E+11	µg
Selenium	13.09	31.955	5.56E+06	µg

Table 2 (cont.)
Estimated Mass/Activity of Leachate Constituents Exiting WMF

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Silver	23.8	58.1	1.03E+07	µg
Sodium	1865444	4553878	8.05E+11	µg
Strontium	3903.2	9528.4	1.69E+09	µg
Thallium	19.04	46.48	8.20E+06	µg
Tin	199.92	488.04	8.65E+07	µg
Vanadium	40.46	98.77	1.75E+07	µg
Zinc	142.8	348.6	6.15E+07	µg
Radionuclides				
Americium-241	0.2618	.6391	1.13E+05	pCi
Cesium-134	ID	ID	ID	pCi
Cesium-137	0.7854	1.9173	3.40E+05	pCi
Gross Alpha	892.5	2178.75	3.86E+08	pCi
Gross Beta	547.4	1336.3	2.37E+08	pCi
Plutonium-239/240	0.2856	.6972	1.24E+05	pCi
Radium 226	3.332	8.134	1.44E+06	pCi
Radium-228	7.616	18.592	3.29E+06	pCi
Tritium (total)	3117.8	7611.1	1.35E+09	pCi
Uranium-233/234	349.86	854.07	1.51E+08	pCi
Uranium-235	14.518	35.441	6.25E+06	pCi
Uranium-238	337.96	825.02	1.46E+08	pCi

Notes:

ID = Insufficient Data
Mass/Activity calculated from leachate concentrations in Table 1.
µg = micrograms (mass)
pCi = picocuries (activity)
Scenario 1 leachate flux = 2.38 liters.
Scenario 2 leachate flux = 5.81 liters.
Scenario 3 leachate flux = 1.03 million liters.

Table 3: Estimated Groundwater Concentrations Beneath WMF From Leachate

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Volatile Organic Compounds				
Acetone	2.76E-03	6.73E-03	1190	µg/L
Carbon Tetrachloride	3.86E-05	9.42E-05	16.65	µg/L
Chloroform	5.51E-05	1.35E-04	23.8	µg/L
1,1 Dichloroethane	5.70E-05	1.39E-04	24.6	µg/L
1,1 Dichloroethene	5.14E-05	1.26E-04	22.2	µg/L
1,2 Dichloroethene	2.94E-04	7.18E-04	127	µg/L
Diethyl Phthalate	2.20E-04	5.38E-04	95	µg/L
Di-n-Butyl Phthalate	6.61E-05	1.61E-04	28.55	µg/L
Bis (2-Ethylhexyl) Phthalate	2.57E-06	6.28E-06	1.11	µg/L
Methylene Chloride	3.49E-04	8.52E-04	151	µg/L
Tetrachloroethylene	3.67E-05	8.97E-05	15.85	µg/L
1,1,1-Trichloroethane	4.59E-05	1.12E-04	19.85	µg/L
Trichloroethene	4.59E-05	1.12E-04	11	µg/L
Metals				
Aluminum	1.01E-05	2.45E-05	4.34	µg/L
Antimony	4.04E-07	9.87E-07	0.175	µg/L
Arsenic	8.82E-07	2.15E-06	0.381	µg/L
Barium	2.44E-06	5.97E-06	1.06	µg/L
Beryllium	3.31E-08	8.07E-08	0.0143	µg/L
Cadmium	1.56E-07	3.81E-07	0.0675	µg/L
Calcium	2.04E-03	4.99E-03	885	µg/L
Cesium	2.68E-06	6.55E-06	1.16	µg/L
Chromium	3.18E-06	7.76E-06	1.375	µg/L
Cobalt	6.80E-07	1.66E-06	0.294	µg/L
Copper	1.08E-06	2.65E-06	0.469	µg/L
Iron	1.78E-05	4.35E-05	7.7	µg/L
Lead	4.96E-07	1.21E-06	0.215	µg/L
Lithium	9.70E-06	2.37E-05	4.19	µg/L
Magnesium	3.29E-04	8.03E-04	142	µg/L
Manganese	1.01E-05	2.47E-05	4.37	µg/L
Mercury	8.45E-09	2.06E-08	0.0037	µg/L
Molybdenum	5.55E-06	1.35E-05	2.395	µg/L
Nickel	1.65E-06	4.04E-06	0.72	µg/L
Potassium	3.04E-03	7.41E-03	1310	µg/L
Selenium	1.01E-07	2.47E-07	0.0437	µg/L
Silver	1.84E-07	4.49E-07	0.0795	µg/L

Table 3 (cont.)
Estimated Groundwater Concentrations Beneath WMF From Leachate

Constituent	Scenario 1	Scenario 2	Scenario 3	Units
Sodium	1.44E-02	3.52E-02	6200	µg/L
Strontium	3.01E-05	7.36E-05	13	µg/L
Thallium	1.47E-07	3.59E-07	0.0635	µg/L
Tin	1.54E-06	3.77E-06	0.665	µg/L
Vanadium	3.12E-07	7.63E-07	0.135	µg/L
Zinc	1.10E-06	2.69E-06	0.476	µg/L
Radionuclides				
Americium-241	2.02E-09	4.93E-09	0.0009	pCi/L
Cesium-134	ID	ID	ID	pCi/L
Cesium-137	6.06E-09	1.48E-08	.0026	pCi/L
Gross Alpha	6.89E-06	1.68E-05	2.98	pCi/L
Gross Beta	4.23E-06	1.03E-05	1.83	pCi/L
Plutonium-239/240	2.20E-09	5.38E-09	0.001	pCi/L
Radium 226	2.57E-08	6.28E-08	0.011 1	pCi/L
Radium-228	5.88E-08	1.44E-07	0.0254	pCi/L
Tritium (total)	2.41E-05	5.88E-05	10.4	pCi/L
Uranium-233/234	2.70E-06	6.59E-06	1.17	pCi/L
Uranium-235	1.12E-07	2.74E-07	0.0484	pCi/L
Uranium-238	2.61E-06	6.37E-06	1.13	pCi/L

Notes:

ID = Insufficient Data

Concentrations calculated from mass/activities in Table 3 and estimated groundwater volume of 130 million liters.

µg/L = micrograms per liter

pCi/L = picocuries per liter

Table 4: DRAFT RFCA Surface Water Action Levels for Stream Segment 5 (Walnut Creek)

Constituent	Concentration	Units
Volatile Organic Compounds		
Acetone	365000	µg/L
Carbon Tetrachloride	5	µg/L
Chloroform	100	µg/L
1,1 Dichloroethane	1010	µg/L
1,1 Dichloroethene	7	µg/L
1,2 Dichloroethene	70	µg/L
Diethyl Phthalate	29200	µg/L
Di-n-Butyl Phthalate	3650	µg/L
Bis (2-Ethylhexyl) Phthalate	6	µg/L
Methylene Chloride	5	µg/L
Tetrachloroethylene	5	µg/L
1,1,1-Trichloroethane	200	µg/L
Trichloroethene	5	µg/L
Metals		
Aluminum	8700	µg/L
Antimony	1400	µg/L
Arsenic	50	µg/L
Barium	1000	µg/L
Beryllium	4	µg/L
Cadmium	1.5	µg/L
Calcium	NAL	µg/L
Cesium	NAL	µg/L
Chromium	50	µg/L
Cobalt	NAL	µg/L
Copper	16	µg/L
Iron	300	µg/L
Lead	6500	µg/L
Lithium	NAL	µg/L
Magnesium	NAL	µg/L
Manganese	50	µg/L
Mercury	0.01	µg/L
Molybdenum	1000	µg/L
Nickel	123	µg/L
Potassium	NAL	µg/L
Selenium	10	µg/L
Silver	0.6	µg/L
Sodium	NAL	µg/L

Table 4 (cont.)
DRAFT RFCA Surface Water Action Levels for Stream Segment 5
(Walnut Creek)

Constituent	Concentrations	Units
Strontium	NAL	µg/L
Thallium	NAL	µg/L
Tin	NAL	µg/L
Vanadium	NAL	µg/L
Zinc	141	µg/L
Radionuclides		
Americium-241	0.15	pCi/L
Cesium-134	NAL	pCi/L
Cesium-137	NAL	pCi/L
Gross Alpha	10	pCi/L
Gross Beta	11	pCi/L
Plutonium-239/240	0.15	pCi/L
Radium 226	5	pCi/L
Radium-228	5	pCi/L
Tritium (total)	500	pCi/L
Uranium-233/234	10	pCi/L
Uranium-235	10	pCi/L
Uranium-238	10	pCi/L

Notes:

µg/L = micrograms per liter
pCi/L = picocuries per liter
NAL = No listed Action Level

APPENDIX A - SUPPORTING DOCUMENTATION FOR LEACHATE CONCENTRATIONS

CALCULATION OF PROBABLE MAXIMUM LEACHATE CONCENTRATIONS

To assist in the design of the leachate treatment system for the Waste Management Facility, the following analysis was performed to determine the probable maximum leachate concentrations for the major organic contaminants found at the Rocky Flats Environmental Technology Site (RFETS). For this analysis, the commonly used soil/water partitioning equation was used to determine the contaminant concentrations in interstitial water in waste soils within the Waste Cell.

Although a more in-depth approach to estimating the leachate concentrations was considered (1D vertical transport modeling), the goals of the analysis (determination of maximum expected concentrations), and the ambiguity of the analysis parameters (amount of waste in place, contaminant concentrations in waste, etc.) indicated a simplified approach would be more appropriate. Because of the simplifying assumptions that would be adopted for 1D vertical transport modeling, the results from transport modeling should be very similar to those presented here.

COMPOUNDS CONSIDERED IN ANALYSIS

To determine which volatile organic compounds (VOC) and semivolatile organic compounds (SVOC) to use in this analysis, the detection frequency for all VOC/SVOC compounds of concern at RFETS was computed. Only those compounds tested for in at least 100 samples, and with a detection frequency of at least 5% were included in the leachate concentration calculations. The compounds and their detection frequency are listed in Table 1.

TABLE 1: Compounds Used in Analysis

COMPOUNDS WITH A DETECTION FREQUENCY OF AT LEAST 5%					
COMPOUND	CAS ID	Non-detects	Detects	Total	% Detects
ACETONE	67-64-1	2713	463	3176	15
CARBON TETRACHLORIDE	56-23-5	4576	1060	5636	19
CHLOROFORM	67-66-3	4477	1177	5654	21
1,1 DICHLOROETHANE	75-34-3	5345	341	5686	6
1,1-DICHLOROETHENE	75-35-4	5215	463	5678	8
1,2-DICHLOROETHENE	540-59-0	2875	338	3213	11
DIETHYL PHTHALATE	84-66-2	552	63	615	10
DI-n-BUTYL PHTHALATE	84-74-2	569	45	614	7
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	470	143	613	23
METHYLENE CHLORIDE	75-09-2	4607	1038	5645	18
TETRACHLOROETHENE	127-18-4	4054	1620	5674	29
1,1,1-TRICHLOROETHANE	71-55-6	5150	516	5666	9
TRICHLOROETHENE	79-01-6	4025	1653	5678	29

DETERMINATION OF LEACHATE CONCENTRATIONS

For this analysis the VOC/SVOC contaminated soils in the waste cell were considered to be directly exposed to rain and snow fall. Leachate concentrations were calculated assuming the soils at the base of the waste soil pile were saturated. This assumption is conservative and will provide maximum leachate concentrations. Drainage from unsaturated soils would result in somewhat lower concentrations.

The saturated-soil, contaminant water concentrations were calculated using the soil-groundwater partitioning equation, as presented in EPA (1994). This equation describes the partitioning of a contaminant between solid, liquid, and gaseous phases assuming equilibrium conditions. It is assumed that the concentrations of the interstitial water in the soil waste is representative of the maximum concentrations of any leachate that would be collected from the waste cell facility. Dilution from other waters collecting in the waste cell are not considered in these calculations. The soil/water partitioning equation is defined as:

$$C_w = C_s / \ [Kd + (\theta_w + \theta_a H') / \rho_b]$$

where:

C_w is the soil water concentration
C_s is the contaminant concentration in the waste soils
Kd is the soil-water partitioning coefficient
θ_w is the water-filled porosity of the waste soils
θ_a is the air-filled porosity of the waste soils
H' is the Henry's Law constant
ρ_b is the representative bulk density of the waste soils

The contaminant concentrations in the waste soils were assumed to be equal to the values defined by the Universal Treatment Standards (UTS) (Table 2). These values were selected because soils placed in the waste cell will be required to meet the UTS criteria. In many cases, the concentrations of contaminants in the soils placed in the cell will be significantly lower than those defined by the UTS. This is because of the efficiency of the soil treatment technology and/or low initial soil concentrations.

Because waste soils will be coming from various locations within RFETS, values representative of sitewide conditions at RFETS were used for several of the parameters during the calculations. The partitioning coefficients (Kd), which are chemical specific, were computed using the appropriate chemical specific parameters, and representative RFETS sitewide values for environmental parameters. The water filled porosity (θ_w) and soil bulk density (ρ_b) were assumed as 0.40 and 1.5 gm/cm^3 respectively. Since the soils were considered saturated, the Henry's Law constant and air filled porosity values were not used in the calculations.

Table 2 presents the computed maximum soil water (leachate) concentrations. In addition, the partitioning coefficients (Kd) and UTS soil concentration data used in the calculations are also listed. For comparison purposes the maximum soil concentration observed to date for each compound at RFETS is also listed. Contaminant concentrations greater than those historically observed may be encountered during full scale excavation of contaminant source areas.

TABLE 2: Computed Leachate Concentrations

COMPOUND	Kd	UTS Soil Concen.	Maximum RFETS Soil Concen.	Water Concen.
	(ml/g)	(mg/kg)	(mg/kg)	(mg/L)
ACETONE	0.80	160	5100	150
CARBON TETRACHLORIDE	2.5	6	25000	2.1
CHLOROFORM	1.8	6	63	3.0
1,1 DICHLOROETHANE	1.7	6	0.049	3.1
1,1 DICHLOROETHENE	1.9	6	2	2.8
1,2 DICHLOROETHENE	1.6	30	1.2	16
DIETHYL PHTHALATE	2.1	28	3.1	12
DI-n-BUTYL PHTHALATE	7.5	28	43	3.6
BIS(2-ETHYLHEXYL) PHTHALATE	198	28	190	0.14
METHYLENE CHLORIDE	1.3	30	2400	19
TETRACHLOROETHYLENE	2.7	6	13000	2.0
1,1,1-TRICHLOROETHANE	2.2	6	240	2.5
TRICHLOROETHENE	2.2	6	16	2.5

REFERENCES

EPA, 1994, Soil Screening Guidance (Draft), EPA/540/R-94/101.

ANALYSIS OF INORGANIC CONSTITUENTS AND PROBABLE LEACHATE COMPOSITION FROM WASTE STORED IN THE NEW WASTE CELL AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE, GOLDEN, COLORADO

March 29, 1996

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1.0 INTRODUCTION

The composition and volume of wastes to be placed in the proposed Waste Cell at Rocky Flats Environmental Technology Site (RFETS) were evaluated as part of the preparatory analysis for design and construction of the Cell. This report presents an assessment of the inorganic constituents in the waste, as well as estimations of the probable composition of leachate that may emanate from wastes stored in the Cell.

Wastes to be disposed of in the Cell include a variety of materials from a number of Operable Units (OUs) at RFETS. The estimated proportions, by volume, of waste to be placed in the cell are as follows:

OU4 vadose-zone soils	24.1%	
OU4 pondcrete	14.5%	
OU2 903 Pad and Lip	14.5%	
OU4 asphalt liners	14.2%	
OU4 subgrade & subsoils	14.2%	
OU4 sludge	7.2%	
OU9 tanks 14 & 16	4.0%	
OU2 mound area	1.8%	
OU2 trenches T-5 to T-11	1.2%	
OU2 trench T-1		1.2%
OU4 debris	0.8%	
OU9 tanks 9 & 10	0.6%	
OU2 trench T-3		0.3%
OU2 trench T-4		0.3%
OU10 tank 40	0.2%	
IDM wastes	0.2%	
OU1 IHSS 119.1	0.1%	
Misc. hot spots	0.1%	

Chemical analyses of solid materials and groundwater from these areas, in addition to analytical data for leachates derived from Operable Unit 4 (OU4) pondcrete and sludges, were compiled and evaluated for this assessment. Data used in this analysis were retrieved from the Rocky Flats Environmental Database System (RFEDS) and from treatability reports for OU4 pondcrete and sludges. Only data for inorganic constituents are evaluated here; data for organic compounds were evaluated as a separate task.

Analytical data for subsurface soils (i.e., borehole data) and groundwater were obtained from RFEDS. These data were compiled as SAS7 data sets, prepared following standard data-cleanup protocols, and statistically summarized. Locations for which borehole and groundwater data were available are listed in Tables 1 and 2, respectively.

Table 1.
Sampling Locations with Data Available for Subsurface Soils

Metals		Radionuclides		"'Water-Quality"	
02695	13091	02695	13091	02695	13091
02795	21793	02795	21793	02795	21793
02895	40293	02895	40293	02895	40293
02995	40393	02995	40393	02995	40393
04795	40593	04795	40593	*	40593
04895	40793	04895	40793	*	40793
04995	40993	04995	40993	*	40993
05095	41293	05095	41293	*	41293
06591	41593	06591	41593	06591	41593
06691	41793	06691	41793	06691	41793
06791	42193	06791	42193	06791	42193
06891	42493	06891	42493	06891	42493
06991	42593	06991	42593	06991	42593
07091	43193	07091	43193	07091	43193
07191	43393	07191	43393	07191	43393
07291	43693	07291	43693	07291	43693
07391	43793	07391	43793	07391	43793
07891	44093	07891	44093	07891	44093
07991	44393	07991	44393	07991	44393
08091	B217589	08091	B217589	08091	B217589
08191	BH2287	08191	BH2287	08191	BH2287
08291	BH2387	08291	BH2387	08291	BH2387
08391	BH2487	08391	BH2487	08391	BH2487
08491	BH3587	08491	BH3587	08491	BH3587
08591	BH3687	08591	BH3687	08591	BH3687
08691	BH3787	08691	BH3787	08691	BH3787
08791	BH3987	08791	BH3987	08791	BH3987
08891	BH4087	08891	BH4087	08891	BH4087
08991	BH4287	08991	BH4287	08991	BH4287
09091	BH4387	09091	BH4387	09091	BH4387
09191	BH4687	09191	BH4687	09191	BH4687
09391	BH4887	09391	BH4887	09391	BH4887
09591	BH4987	09591	BH4987	09591	BH4987
09891	BH5087	09891	BH5087	09891	BH5087
09991	BH5187	09991	BH5187	09991	BH5187
10191	BH5287	10191	BH5287	10191	BH5287
10291	BH5387	10291	BH5387	10291	BH5387
10491	BH5487	10491	BH5487	10491	BH5487
10591	BH5587	10591	BH5587	10591	BH5587

Asterisk (*) indicates that data were not available for this location.

Table 2.
Sampling Locations with Data Available for Groundwater Samples

Metals		Radionuclides		Water-Quality
Dissolved	Total	Dissolved	Total	Unfiltered *
*	*	*	*	02695
*	*	*	02795	02795
*	02895	*	*	02895
*	*	*	02995	02995
*	*	*	*	04795
*	*	*	*	04895
*	*	*	*	04995
06591	06591	06591	06591	06591
06691	06691	06691	06691	06691
06791	06791	06791	06791	06791
06891	06891	06891	06891	06891
06991	06991	06991	06991	06991
*	*	*	*	*
07191	07191	07191	07191	07191
07291	*	07291	07291	07291
07391	07391	07391	07391	07391
07891	07891	07891	07891	07891
07991	07991	07991	07991	07991
*	*	08091	08091	08091
*	*	*	*	08391
*	*	*	*	08591
08891	08891	08891	08891	08891
09091	09091	09091	09091	09091
13091	13091	13091	13091	13091
B217589	*	B217589	B217589	B217589

Asterisk (*) indicates that data were not available for this location.

* Samples collected for analysis of anions and water-quality paramters are not filtered; however, anions are assumed to exist in the dissolved state.

Data for OU4 vadose-zone waters were obtained from tables in the *OU4 Proposed IM/IRA EA Decision Document*, dated February 10, 1995 (EG&G, 1995a). Data for OU4 pondcrete and sludges were available in *Treatability Study Report and Process Formulation Report for Pondcrete* (EG&G, 1995b) and *Treatability Study Report and Process Formulation Report for Pond Sludge and Clarifier* (EG&G, 1995c). Unfortunately, the data presented in these treatability studies do not include major-ion compositions of the leachates; only data for selected radionuclides and trace metals, nitrate, and pH are given. Without major-ion data, standard geochemical modeling cannot be performed for the pondcrete and sludge leachates.

2.0 DATA ANALYSIS

Standard data-treatment protocols for RFEDS data call for the exclusion of QC data from the real-sample data, removal of rejected data (validation code = "R"), and the standardization of units and analyte names. Computation of summary statistics used a simple replacement value of one-half the result for nondetects. One-half the result was used instead of one-half the detection limit, in order to minimize the problems associated with high-value detection limits (i.e., the contract-required reporting limits [CRDL]) reported in the detection-limit field for some records.

Because distributional testing was not performed, these summary statistics should be considered only a general approximations of the true mean. In addition, the user should be cognizant of the detection rate for each analyte; as the detection rate decreases, the calculated mean value is generally less representative of the true population mean (i.e., the mean becomes more strongly influenced by the nondetect replacement values). Subsurface-soil data for background and waste populations were compared using analysis of variance (ANOVA) testing (Wilcoxon Rank Sum). Electronic data were not available to conduct ANOVA testing for pondcrete and sludge samples. Results of the ANOVA testing, as well as a discussion of their meaning, are given in the following sections.

2.1 Subsurface Soil

Data for subsurface soils were available for borehole locations in the 903 Pad and Lip Area, OU2 Mound Area, OU2 Trench T-1, OU2 Trench T-3, OU2 Trench T-4, OU2 Trenches T-5 through T-11, OU9 Tanks 9 & 10, OU10 Tank 40, and OU4 (see Table 1). The largest volume of subsurface soils to be placed in the Cell are the vadose-zone soils of OU4. These subsurface soils comprise an estimated 24.1%, by volume, of all wastes destined for the Cell.

Overall detection rates were calculated for each analyte in the subsurface-soil medium. Quality parameters, such as pH, were also evaluated for these soils. In general, the subsurface soils exhibit a neutral to alkaline condition; pH ranges from 6.23 to 11.0, with a mean value of 8.1. Most metals and radionuclides are less leachable under neutral to alkaline conditions than under a lower pH (i.e., more acidic), so a mean pH of 8.1 is favorable for decreasing the mobility of most constituents of concern. However, the mobility of anionic species, such as nitrate, is not greatly dependent on pH. To put the inorganic composition of the waste soils in context, data for soils destined for the Cell were compared with data for background subsurface soils. Background data were obtained on diskette from the *Background Geochemical Characterization Report* (DOE, 1993); only data for the upper hydrostratigraphic unit (UHSU) were used. Summary statistics and detection rates for inorganic analytes in both groups (i.e., waste and background) are shown in Tables 3a and 3b. However, the numbers shown here for the waste soils do not include the data for OU4 pondcrete and sludges, which are estimated to comprise 21.7 percent (by volume) of all waste destined for the Cell. Pondcrete and sludges are addressed separately in Sections 2.4 and 2.5 of this report.

The comparison of waste soils and background soils provides a sort of "reality check" for the general nature of the waste. As shown in the right-hand column of Table 4, the results of nonparametric

ANOVA (Wilcoxon Rank Sum) indicate whether or not the two groups (i.e., waste soils and background soils) show statistically significant differences in composition. Taken at the 95-percent confidence level, a p-value of <0.05 indicates a significant difference. Of course, the results of any statistical analysis must be subjected to the scrutiny of professional judgment. A good point in case is the insignificant p-value obtained for tritium. Clearly, some of the waste soils contain substantially higher levels of tritium than do the background soils; however, the huge variance in tritium activities seen for waste soils produces huge uncertainties (i.e., the assumption of equal variances is violated), and, consequently poor power of discernment for the statistical tests. In such cases, an alternative statistical test, such as the quantile test, would have more power than the Wilcoxon test to detect differences between the two populations.

Concentrations of nitrate/nitrite in waste materials are obviously higher than those in background soils, but a significant p-value is not seen, due to the statistical violations discussed in the previous paragraph. The large variances seen for nitrate/nitrite concentrations and tritium activities invalidate the negative ANOVA results for these analytes. The mean and standard deviation for these two analytes, clearly indicate that some of the waste soils contain levels of nitrate/nitrite and tritium that are well above those seen for background soils. Overall, based on results of the ANOVA testing, the waste soils contain significantly higher levels of arsenic, calcium, americium-241, cesium-137, gross alpha, plutonium-239+240, tritium, uranium-233+234, uranium-235, and uranium-238.

2.2 OU4 Vadose-Zone Water

Pore water from the vadose zone in OU4 was collected in a series of lysimeters installed as part of the Phase-1 vadose-zone monitoring in OU4. Data for OU4 pore waters were obtained from tables in the *OU4 Proposed IM/IRA EA Decision Document*, dated February 10, 1995 (EG&G, 1995a), and are compiled here as Tables 5 and 6.

As discussed in the OU4 Decision Document, analyses of pore-water samples and soil materials from the same location were used to derive an estimated, chemical-specific partition coefficient, K_d, for selected trace metals, radionuclides, and nitrate. These K_d values, along with values obtained from the literature were presented in the Treatability Reports for pondcrete and sludges (EG&G, 1995b and 1995c).

Table 3a.
Summary of Data for Subsurface Soils: Waste Boreholes

Analyte	N	% Detects	Min	Max	Mean	Std. Dev.	Units
Aluminum	354	100.0	931	39100	9940	4907	MG/KG
Antimony	333	4.8	1.6	22.4	5.2	2.5	MG/KG
Arsenic	354	92.7	0.3	30.8	5.8	4.9	MG/KG
Barium	354	86.2	16.8	4150	120	332	MG/KG
Beryllium	353	45.9	0.055	22.9	0.71	1.23	MG/KG
Cadmium	320	39.4	0.145	547	5.5	41.3	MG/KG
Calcium	354	99.7	500	232000	22900	41010	MG/KG
Cesium	247	69.2	225	116.5	19.0	27.6	MG/KG
Chromium	354	99.2	1.0	304	14.6	24.4	MG/KG
Cobalt	354	66.4	0.6	78.1	6.6	6.0	MG/KG
Copper	354	91.2	1.8	132	12.3	9.8	MG/KG
Iron	354	100.0	1010	50800	12710	7225	MG/KG
Lead	354	100.0	1.2	278	13.4	28.4	MG/KG
Lithium	243	84.0	0.115	50.8	7.5	6.8	MG/KG
Magnesium	354	94.9	231	6300	2276	979	MG/KG
Manganese	354	100.0	1.3	3140	247	391	MG/KG
Mercury	354	26.8	0.023	6.00	0.088	0.328	MG/KG
Molybdenum	239	21.3	0.415	19.0	2.0	2.5	MG/KG
Nickel	354	84.5	2.15	173	14.7	15.4	MG/KG
Potassium	354	78.5	100	12600	1325	1074	MG/KG
Selenium	354	4.5	0.08	3.4	0.34	0.34	MG/KG
Silicon	216	98.2	1.35	14000	920	1535	MG/KG
Silver	351	10.5	0.16	96.5	1.4	6.3	MG/KG
Sodium	354	57.1	0.8	5990	419	791	MG/KG
Strontium	354	85.0	6.9	220	45.4	39.5	MG/KG
Thallium	353	16.4	0.095	1.00	0.46	0.37	MG/KG
Tin	242	28.1	1.55	91.1	18.0	12.3	MG/KG
Vanadium	354	97.7	5.0	82.2	26.7	12.8	MG/KG
Zinc	354	99.7	2.0	437	41.8	42.6	MG/KG
Ammonia	148	32.4	0.155	8.6	0.56	1.15	MG/KG
Chromium IV	12	16.7	0.265	0.86	0.40	0.22	MG/KG
Cyanide	275	12.7	0.07	43	0.98	2.94	MG/KG
Nitrate/Nitrite	208	80.3	0.0	6100	119	529	MG/KG
Oil & Grease	55	23.6	0.85	508	15.3	76.2	MG/KG
Petroleum Hydrocarbon	35	97.1	2.93	394	134	114	MG/KG
Sulfide	304	9.9	1.0	200	42.6	49.9	MG/KG
TOC	154	98.7	31.2	19200	982	2083	MG/KG
pH	276	100.0	6.23	11.0	8.1	0.5	PH
Americium-241	319	81.5	-0.06	25.0	0.277	1.696	PCi/G
Cesium-134	44	100	0.005	0.15	0.078	0.036	PCi/G
Cesium-137	318	90.9	-0.8	4.7	0.11	0.39	PCi/G
Gross alpha	305	100.0	-7.9	380	26	32.4	PCi/G
Gross beta	346	100.0	2.54	56.7	22.9	7.4	PCi/G
Plutonium-238	13	100	-0.002	0.205	0.036	0.062	PCi/G
Plutonium-239+240	333	88.0	-0.11	94	1.13	7.09	PCi/G
Radium-226	152	94.7	0.23	1.9	0.67	0.26	PCi/G
Radium-228	155	100.0	0.50	3.00	1.460	0.51	PCi/G
Strontium-89+90	315	75.2	-0.50	1.10	1.76	0.24	PCi/G
Strontium-90	6	100.0	-0.21	1.08	0.39	0.55	PCi/G
Tritium	336	74.4	-570	62000	1537	5764	PCi/G
Uranium-233+234	342	100.0	0.045	192	1.75	10.51	PCi/G
Uranium-235	237	90.7	-0.005	11.5	0.118	0.749	PCi/G
Uranium-238	352	100.0	0.23	113	1.44	6.21	PCi/G

Summary statistics calculated for RFEDS data compiled for this assessment, assuming a normal distribution.

Table 3b.
Summary of Data for Subsurface Soils: Background Boreholes

Analyte	N	% Detects	Min	Max	Mean	Std. Dev.	Units
Aluminum	98	99.0	279	102000	12710	11330	MG/KG
Antimony	66	15.2	0.95	23.5	4.5	3.7	MG/KG
Arsenic	99	70.7	0.27	41.8	3.6	4.4	MG/KG
Barium	99	88.9	12.9	777	96.1	96.6	MG/KG
Beryllium	99	81.8	0.45	23.5	4.7	4.8	MG/KG
Cadmium	81	7.4	0.08	1.5	0.6	0.3	MG/KG
Calcium	99	99.0	580	157000	7053	16180	MG/KG
Cesium	95	1.1	81.8	1415	130.0	135	MG/KG
Chromium	99	84.8	2.1	176	18.8	24.7	MG/KG
Cobalt	99	22.2	1.9	51.4	6.4	7.1	MG/KG
Copper	99	95.0	2.2	123	12.6	12.8	MG/KG
Iron	99	100.0	1300	132000	14530	13260	MG/KG
Lead	99	99.0	2	39.8	10.8	7.1	MG/KG
Lithium	99	61.6	1.4	83.2	10	8.5	MG/KG
Magnesium	99	96.0	356	32500	2853	3246	MG/KG
Manganese	99	100.0	37	3330	218	342	MG/KG
Mercury	86	25.6	0.025	2.95	0.19	0.34	MG/KG
Molybdenum	99	50.5	1	67.6	10.9	8.6	MG/KG
Nickel	96	85.4	4.3	193	19.8	20.6	MG/KG
Potassium	98	52.0	186	18700	1404	2064	MG/KG
Selenium	82	2.4	0.11	6.8	0.9	1.2	MG/KG
Silver	83	39.8	0.3	40.9	5.6	9.5	MG/KG
Silicon	*	*	*	*	*	*	
Sodium	99	17.2	63	3680	304	422	MG/KG
Strontium	99	36.4	10.2	242	52	48.3	MG/KG
Thallium	75	4.0	0.1	2.45	0.5	0.5	MG/KG
Tin	92	27.2	10.1	441	62.5	112	MG/KG
Vanadium	99	98.0	4.2	283	31.5	28.5	MG/KG
Zinc	98	92.9	0.5	486	36.3	51.4	MG/KG
Ammonia	*	*	*	*	*	*	MG/KG
Chromium IV	*	*	*	*	*	*	MG/KG
Cyanide	*	*	*	*	*	*	MG/KG
Nitrate/Nitrite	98	39.8	0.5	7.1	1.3	1.1	MG/KG
Oil & Grease	*	*	*	*	*	*	MG/KG
Petroleum Hydrocarbon	*	*	*	*	*	*	MG/KG
Sulfide	89	16.8	1.0	43000	485	4558	MG/KG
TOC	*	*	*	*	*	*	MG/KG
pH	97	100.0	6.1	9.1	8.0	0.7	PH
Americium-241	28	"100"	-0.015	0.01	-0.002	0.007	PCi/G
Cesium-134	*	*	*	*	*	*	PCi/G
Cesium-137	99	"100"	0	0.2	0.012	0.041	PCi/G
Gross alpha	99	"100"	5	48	24.9	9.3	PCi/G
Gross beta	99	"100"	6	44	24.7	6.1	PCi/G
Plutonium-238	*	*	*	*	*	*	PCi/G
Plutonium-239+240	99	"100"	-0.01	0.03	0.004	0.007	PCi/G
Radium-226	83	"100"	0.5	1.3	0.75	0.23	PCi/G
Radium-228	83	"100"	0.50	2.20	1.40	0.32	PCi/G
Strontium-89+90	99	"100"	-0.60	1.20	0.03	0.36	PCi/G
Strontium-90	*	*	*	*	*	*	PCi/G
Tritium	99	"100"	-150	440	142	127	PCi/G
Uranium-233+234	99	"100"	0.2	8.9	0.78	0.93	PCi/G
Uranium-235	99	"100"	0	0.2	0.02	0.05	PCi/G
Uranium-238	99	"100"	0.2	3.2	0.73	0.38	PCi/G

Summary statistics calculated for RFEDS data compiled for this assessment, assuming a normal distribution.
Asterisk (*) indicates that data are not available. The "100" indicates that no records were qualified as nondetects.

Table 4.
Comparison of Concentrations of Inorganic Constituents in Waste-Cell Subsurface Soils vs. Background Subsurface Soils

ANALYTE	DETECTIONS		HIGHER	MEAN CONCENTRATIONS		MEAN + 2 SD		UNITS	Wilcoxon
	Waste Cell	UHSU Bkgd	% DETECT	Waste Cell	UHSU Bkgd	Waste Cell	UHSU Bkgd		p-values
Aluminum	100.0	99.0	Cell	9940	12710	19754	35380	MG/KG	0.0155 @
Antimony	4.8	15.2	Back	*	*	*	*	MG/KG	*
Arsenic	92.7	70.7	Cell	5.8	3.6	15.6	12.4	MG/KG	0.0001 @
Barium	86.2	88.9	Back	120	96.1	784	290	MG/KG	0.4236
Beryllium	45.9	81.8	Back	0.7	4.7	3.2	14.3	MG/KG	0.0001 @
Cadium	39.4	7.4	Cell	5.5	*	88.1	*	MG/KG	*
Calcium	99.7	99.0	Cell	22900	7052	104910	39410	MG/KG	0.0001 @
Cesium	69.2	1.1	Cell	19.0	*	74.2	*	MG/KG	*
Chromium	99.2	84.8	Cell	14.6	18.8	63.6	68.2	MG/KG	0.0040 @
Cobalt	66.4	22.2	Cell	6.6	6.4	18.6	20.6	MG/KG	0.1184
Copper	91.2	95.0	Back	12.2	12.6	32.0	38.2	MG/KG	0.9263
Iron	100.0	100.0	*	12710	14530	27160	41046	MG/KG	0.0651
Lead	100.0	99.0	Cell	13.4	10.8	70.2	25.0	MG/KG	0.3489
Lithium	84.0	61.6	Cell	7.5	10.0	21.1	27.0	MG/KG	0.0010 @
Magnesium	94.9	96.0	Back	2276	2853	4234	9345	MG/KG	0.1410
Manganese	100.0	100.0	*	247	218	1028	902	MG/KG	0.6382
Mercury	26.8	25.6	Cell	0.09	0.19	0.75	0.87	MG/KG	0.0001 @
Molybdenum	21.3	50.5	Back	2.0	10.9	7.0	28.1	MG/KG	0.0001 @
Nickel	84.5	85.4	Back	14.7	19.8	45.5	61.0	MG/KG	0.0001 @
Potassium	78.5	52.0	Cell	1325	1404	3473	5532	MG/KG	0.8680
Selenium	4.5	2.4	Cell	*	*	*	*	MG/KG	*
Silicon	98.2	39.8	Cell	920	ND	3990	ND	MG/KG	NA
Silver	10.5	17.2	Back	*	*	*	*	MG/KG	*
Sodium	57.1	36.4	Cell	419	304	2000	1148	MG/KG	0.5814
Strontium	85.0	36.4	Cell	45.4	52.0	124	149	MG/KG	0.5690
Thallium	16.4	4.0	Cell	*	*	*	*	MG/KG	*
Tin	28.1	27.7	Cell	18.0	62.5	42.6	286	MG/KG	0.9318
Vanadium	97.7	98.0	Back	26.7	31.5	52.3	88.5	MG/KG	0.0533
Zinc	99.7	92.9	Cell	41.8	36.3	127	139	MG/KG	0.0713
Americium-241	81.5	"100"	NA	0.277	0.00	3.67	0.01	PCi/G	0.0001 @
Cesium-134	100	"100"	NA	0.078	ND	0.15	ND	PCi/G	NA
Cesium-137	90.9	"100"	NA	0.11	0.01	0.89	0.09	PCi/G	0.0001 @
Gross alpha	100	"100"	NA	26.0	24.9	90.8	43.5	PCi/G	0.0481 @
Gross beta	100	"100"	NA	22.9	24.7	37.7	36.8	PCi/G	0.0046 @
Plutonium-238	100	"100"	NA	0.036	ND	0.16	ND	PCi/G	NA
Plutonium-239+240	88.0	"100"	NA	1.13	0.00	15.3	0.02	PCi/G	0.0001 @
Radium-226	94.7	"100"	NA	0.67	0.74	1.19	1.21	PCi/G	0.0037 @
Radium-228	100	"100"	NA	1.46	1.40	2.47	2.04	PCi/G	0.6431
Strontium-89+90	75.2	"100"	NA	0.18	0.03	0.66	0.75	PCi/G	0.0001 @
Tritium	74.4	"100"	NA	1537	142	13065	396	PCi/L	0.1770
Uranium-233+234	100	"100"	NA	1.75	0.78	22.8	2.6	PCi/G	0.0005 @
Uranium-235	90.7	"100"	NA	0.12	0.02	1.62	0.11	PCi/G	0.0001 @
Uranium-238	100	"100"	NA	1.44	0.73	13.9	1.5	PCi/G	0.0001 @
Ammonia	32.4	ND	NA	0.56	ND	2.9	ND	MG/KG	NA
Chromium-VI	16.7	ND	NA	0.4	ND	0.83	ND	MG/KG	NA
Cyanide	12.7	ND	NA	0.98	ND	6.86	ND	MG/KG	NA
Nitrate/Nitrite	80.3	39.8	Cell	119	1.2	1177	3.4	MG/KG	0.4491
Oil and Grease	23.6	ND	NA	15.3	ND	168	ND	MG/KG	NA
Petro. Hydrocarb	97.1	ND	NA	134	ND	362	ND	MG/KG	NA
Sulfide	9.9	16.8	Back	*	*	*	*	MG/KG	*
TOC	98.7	ND	NA	982	ND	5148	ND	MG/KG	NA
pH	100	100	*	8.1	8.0	9.2	9.4	MG/KG	0.5194

NA = Not Applicable; ND = No Data; * = < 20% Detects, Mean Not Calculated; "100" means 100% detection is assumed (per DOE Order 5400.1).

Nonparametric ANOVA testing was performed using the Wilcoxon Rank Sum test; please see text for discussion and qualification of these results.

An @ indicates that the Wilcoxon test is significant (P-value < 0.05).

Table 5.
Pore-Water Data for pH and Specific Conductivity

Lysimeter Location	pH		Specific Conductivity (uS)	
	Range	Mean	Range	Mean
40293	10.8-12.6	11.7	2.06-5.01	3.54
40393	10.8-12.9	11.6	1.62-2.58	1.94
40593	7.9-9.1	8.5	1.78-1.88	1.83
40793	9.8-10.9	10.2	0.52-1.18	0.81
40993	6.8-10.3	9.0	8.14-19.9	16.18
40993	6.9-10.9	9.5	NA	19.99
41293	9.0-11.0	10.1	1.11-2.68	2.24
41593	6.2-9.0	6.8	1.24-19.9	15.04
41793	7.8-12.2	9.8	1.06-7.61	2.27
42493	NA	7.6	NA	2.04
42493	7.0-7.8	7.3	1.43-2.64	2.22
42893	7.0-7.8	7.3	0.77-2.47	1.93
43193	7.4-7.9	7.7	2.76-4.55	3.25
43193	6.5-7.3	7.0	8.55-11.22	9.72
43693	7.0-7.8	7.4	4.36-19.9	18.19
43793	7.1-9.7	8.2	1.15-2.90	2.11
43793	8.1-11.4	10.8	2.18-3.84	3.02
44093	6.9-9.6	8.0	0.51-1.29	0.90
44093	8.0-8.5	8.2	2.57-3.20	2.91
44393	7.3-9.8	8.5	0.50-1.35	1.03
44393	9.9-11.5	10.4	0.86-2.50	1.09

Summary data from OU4 IM/IRA EA Decision Document, Draft February 10, 1995.

NA = Not applicable.

Table 6.
Summary of Pore-Water Data for OU4 Lysimeters

Analyte	N	% Detects	Min	Max	Mean	Units
Aluminum	67	37.3	25	10700	984	UG/L
Antimony	66	56.1	0	ND	ND	UG/L
Arsenic	66	90.1	0	120	8.4	UG/L
Barium	67	86.6	0	1470	122	UG/L
Beryllium	66	56.1	0	ND	ND	UG/L
Cadmium	68	14.7	3	54	14	UG/L
Calcium	66	95.4	0	3490000	110200	UG/L
Cesium	27	11.1	39	75	59	UG/L
Chromium	66	60.1	0	10200	255	UG/L
Cobalt	67	58.2	0	2100	60.2	UG/L
Copper	68	14.7	6	900	107	UG/L
Iron	69	63.8	28	37400	1800	UG/L
Lead	70	47.1	1	1110	48.2	UG/L
Lithium	27	66.7	24	6170	984	UG/L
Magnesium	65	87.7	0	236000	20120	UG/L
Manganese	69	73.9	1	13100	925	UG/L
Mercury	70	0.0	ND	ND	ND	UG/L
Molybdenum	26	53.8	26	3660	547	UG/L
Nickel	66	68.2	0	6460	160	UG/L
Potassium	67	91.0	0	11400000	308700	UG/L
Selenium	66	74.2	0	19	1.4	UG/L
Silicon	26	96.2	11300	288000	71320	UG/L
Silver	69	24.6	4	21	10.3	UG/L
Sodium	66	98.5	0	24000000	905400	UG/L
Strontium	26	96.2	190	20100	2613	UG/L
Thallium	67	56.7	0	89	2.3	UG/L
Tin	27	0.0	ND	ND	ND	UG/L
Vanadium	66	71.2	0	730	24.8	UG/L
Zinc	69	75.4	6	1270	104	UG/L
Nitrate/Nitrite	77	97.4	4	17600000	1064020	UG/L
Sulfide	13	46.2	1	43000	17900	UG/L
Cyanide	18	11.1	0	1000	500	UG/L
Americium-241	1	0.0	ND	ND	ND	PCi/L
Gross alpha	15	66.7	4	6300	706	PCi/L
Gross beta	15	100.0	4	5400	433	PCi/L
Plutonium-239+240	1	100.0	0	0.013	0.013	PCi/L
Radium-226	9	100.0	0	6	1.804	PCi/L
Radium-228	2	100.0	3	5	4.150	PCi/L
Strontium-89+90	1	100.0	1	1	0.60	PCi/L
Total Radiocesium	1	0.0	ND	ND	ND	PCi/L
Tritium	14	35.7	620	5600	2384	PCi/L
Uranium-233+234	14	100.0	1	3400	274	PCi/L
Uranium-235	14	85.7	0	120	11.48	PCi/L
Uranium-238	15	100.0	0	3700	264.5	PCi/L

Summary data from OU4 IM/IRA EA Decision Document, Draft February 10, 1995. ND = not defined.

The formula used to calculate K_d values from lysimeter data was as follows:

$$K_d = \frac{\text{Concentration in solid phase (i.e., subsurface soil)}}{\text{Concentration in the liquid phase (i.e., pore water)}}$$

These derived K_d values were then refined through model calibration (EG&G, 1995b). In addition, the K_d values from literature sources were also reviewed for comparison to these calculated K_d values (see Tables 7a and 7b).

In addition to using K_d values to determine what concentration in soils will lead to exceedances of groundwater standards, the geochemical modeling of vadose-zone water (i.e., pore water) would be helpful in providing a picture of rock/water interaction under varying Eh-pH conditions. Unfortunately, analyses of major anions (e.g., bicarbonate, chloride, sulfate, etc.) are not reported in the Decision Document, so geochemical modeling cannot be performed separately for vadose-zone waters.

2.3 OU4 Pondcrete

Treatability studies, conducted in support of pondcrete disposal at RFETS, evaluated the leachability of pondcrete. Pondcrete samples were subjected to the toxicity characteristic leaching procedure (TCLP), and the subsequent leachate analyzed for organic and inorganic constituents. These treatability studies evaluated both treated and untreated pondcrete, and both the "triwall" pondcrete and the "metals" pondcrete, which are so-called based on the type of storage container (EG&G, 1995b). Treatment of pondcrete involved the addition of lime, concrete, and fly ash to stabilize the pondcrete material.

Waste acceptance criteria (WAC) were used to determine whether or not leachate derived from treated and untreated pondcrete would meet disposal standards. The liquid-phase WAC is defined as "...the chemical-specific leachate concentration generated from the waste material in an engineered disposal facility which will ensure an acceptable groundwater concentration at the point of compliance (POC) within a required protective time frame" (EG&G, 1995b). The WAC for selected metals and radionuclides for the 1-inch-per-year infiltration rate (assumed as typical for RFETS) were given in tables in the Pondcrete Treatability Report (EG&G, 1995b), and are as follows:

Radionuclides	Waste Criteria	Metals & Nitrate	Waste Criteria
Americium-241	74.5 pCi/L	Arsenic	142 g/L
Cesium-134	12,800 pCi/L	Beryllium	14.2 g/L
Cesium-137	737 pCi/L	Cadmium	51.8 g/L
Plutonium-239+240	4.43 pCi/L	Chromium	881 g/L
Radium-226	415 pCi/L	Sodium	14,900 g/L
Uranium-233+234	254 pCi/L	Nitrate	166,000 g/L
Uranium-235	10.2 pCi/L		
Uranium-238	177 pCi/L		

Table 7a.
Kd Values (L/kg) for Selected Analytes

Analyte	Calibr'd Kd Vadose Zone	Calibr'd Kd Sat'd Zone	Literature Kd Value	Literature Kd Value	Kd Calculated from Lysimeter	RFETS Vadose	RFETS Sat'd Zone
Americium-241	100	10	8.2 - 300000	700	NA	100	10
Arsenic	2	0.5	*	200	NA	*	*
Beryllium	5	1	250	650	NA	*	*
Cadmium	5	1	2.7 - 625	6.5	597	*	*
Cesium-134	1	0.1	40 - 3968	1000	NA	*	*
Cesium-137	1	0.1	40 - 3968	1000	NA	1	0.1
Chromium	35	1.5	1.7 - 1729	850	NA	*	*
Nitrate	0.01	0.01	*	*	0.127	*	*
Plutonium-239+240	100	20	27 - 36000	4500	NA	100	20
Radium-226	690	106	57 - 21000	450	690	690	106
Sodium	10	1.5	*	100	NA	*	*
Uranium-233+234	17	2	.03 - 2200	450	19.8	17	2
Uranium-235	17	2	.03 - 2200	450	NA	17	2
Uranium-238	17	2	.03 - 2200	450	14.5	17	2

Tables from "Treatability Study Report and Process Formulation Report for Pondcrete," June 1995.
Asterisk (*) indicates data not available in the specific reference. NA = not applicable or not available.

Table 7b.
Kd Values (L/kg) Used at Other DOE Facilities for Selected Radionuclides

Analyte	Oak Ridge	Savannah River	Hanford	INEL Sat'd Zone	INEL Vadose	Fernald Sat'd Zone	Fernald Vadose
Americium-241	40	150	100	NA	NA	10	100
Cesium-137	3000	100	1	20	20	1370	1810
Plutonium-239+240	40	100	100	200	2000	100	1700
Radium-226	3000	500	10	5	50	106	696
Uranium-233+234	40	50	0	100	1000	1.78	3.1
Uranium-235	40	50	0	100	1000	1.78	3.1
Uranium-238	40	50	0	100	1000	1.78	3.1

Tables from "Treatability Study Report and Process Formulation Report for Pondcrete," June 1995.
Asterisk (*) indicates data not available in the specific reference. NA = not applicable or not available.

Results of the leachate analyses showed a strong dependence between pH and constituent concentrations in the leachate. In general, a moderately alkaline condition (pH = 9 to 11) significantly reduced the concentrations of dissolved trace metals and radionuclides in the leachate (see Figure 1). Nitrate and sodium concentrations were unaffected by variations in pH.

Based on the results of the treatability study, it was determined that pondcrete subjected to "...the treatment process will meet all applicable waste-acceptance criteria..." given stated assumptions (EG&G, 1995b). Only sodium in the treated pondcrete was seen to exceed the waste acceptance criteria (WAC). In contrast, untreated pondcrete leached excessive amounts (i.e., > WAC) of plutonium-239+240, americium-241, uranium-238, beryllium, and cadmium, under a 1-inch-per-year infiltration rate, which is the current best estimate for the infiltration rate at RFETS. Assuming that pondcrete materials are treated prior to placement in the Cell, the possible composition of leachate derived from the stored pondcrete should meet WAC for the scenario of 1-inch-per-year infiltration rate. The mean leachate compositions for pondcrete samples are summarized in Table 8.

The mean concentrations/activities of leachate analytes for **"triwall" pondcrete** are for those samples treated with lime, fly ash, and cement. The mean values for leachate analytes for **"metals" pondcrete** are for those samples treated with lime, fly ash, and cement. For additional details, the reader should refer to the Pondcrete Treatability Report (EG&G, 1995b).

2.4 OU4 Sludges

Sludge samples from the Solar Evaporation Ponds and from the Building 788 clarifier were subjected to TCLP testing, and the subsequent leachate analyzed for organic and inorganic constituents. The leachate was analyzed for selected hazardous constituents, which included arsenic, barium, cadmium, chromium, lead, nickel, sodium, nitrate, and selected radionuclides. These treatability studies evaluated both treated and untreated sludges. Treatment of the sludges involved the addition of lime, concrete, and fly ash to stabilize the sludge materials. Leachability of constituents of concern was determined for both the treated and untreated materials.

As with the pondcrete, results of the leachate analyses for sludges showed a strong dependence between pH and constituent concentrations in the leachate. In general, a moderately alkaline condition (pH = 9 to 11) significantly reduced the concentrations of trace metals and radionuclides in the leachate (see Figure 1).

Based on the results of the treatability study, it was determined that treated sludges will meet all WAC, given the stated assumptions (EG&G, 1995c). Only sodium in the treated sludges was seen to exceed the WAC. In contrast, untreated sludge materials leached excessive amounts (i.e., > WAC) of plutonium-239+240, uranium isotopes, arsenic, beryllium, cadmium, nitrate, and sodium under a scenario of a 1-inch-per-year infiltration rate. Values of WAC are shown in Section 2.3 above. The mean leachate compositions for various sludge materials are listed below and summarized in Table 8.

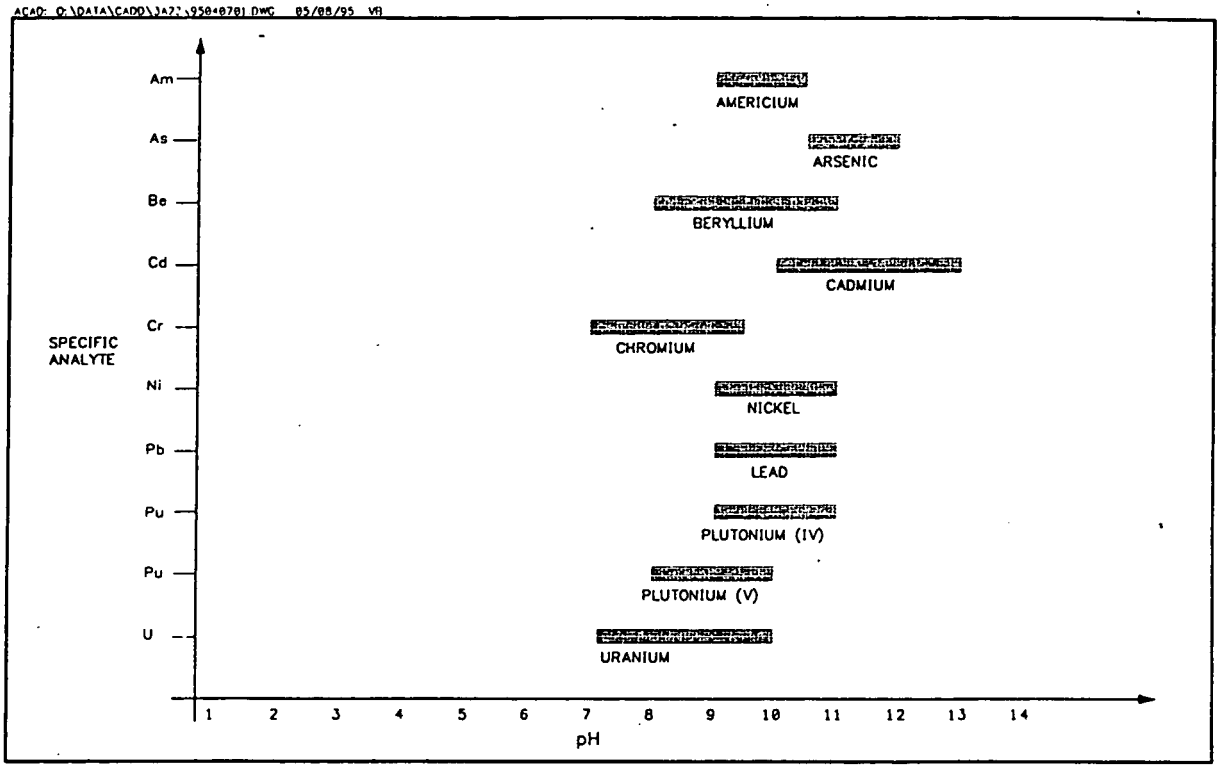

Figure 1. Optimum pH Values for Precipitation of Various Metal Hydroxides. (Figure from *Pondcrete Treatability Study Report and Process Formulation Report*, Revision 0, June 1995).

Table 8.
Average Leachate (TCLP) Compositions for Treated Pondcrete and Sludges

Analyte	Phase II "Triwall" Pondcrete	Phase I "Metals" Pondcrete	Phase II Pond 207A/B Sludges	Phase II Pond 207C Sludges	Phase II Clarifier Sludges	Phase II Pond 207C & Clarifier Sludges	Units
Americium-241	<0.35	<0.15	<0.24	1	<0.33	<0.3	PCi/L
Cesium-134	<5.5	•	<5.3	<5.5	<5	<5.7	PCi/L
Cesium-137	<5.7	•	<5.8	<6.5	<5.3	<6	PCi/L
Plutonium-238	<0.11	<0.05	<0.095	<0.05	<0.095	<0.1	PCi/L
Plutonium239+240	<0.07	0.034	<0.05	<0.05	<0.054	<0.1	PCi/L
Radium-226	1.4	0.75	0.28	0.52	0.63	0.54	PCi/L
Uranium-233+234	0.044	<0.4	0.06	0.15	0.05	0.08	PCi/L
Uranium-235	<0.038	<0.36	0.08	<0.064	<0.05	<0.07	PCi/L
Uranium-238	0.042	<0.45	0.06	0.16	<0.06	0.08	PCi/L
Arsenic	<100	<100	<100	550	<100	140	UG/L
Beryllium	<0.5	<0.5	<0.5	<3.0	<0.55	<0.8	UG/L
Cadmium	<5.0	<5.0	<5.0	<5.0	5	<5	UG/L
Chromium	198	150	125	150	160	170	UG/L
Lead	<50	<50	<50	<50	<50	<50	UG/L
Nickel	<20	<20	<20	27	<20	<20	UG/L
Sodium	413000	555000	208000	3070000	383000	2397000	UG/L
Nitrate/Nitrite	110700	125000	12900	1320000	84300	1417000	UG/L
pH	11.4	11.1	11.3	11.8	11.1	11.8	PH
Reference	Table 3-11 EG&G, 1995b	Table 3-19 EG&G, 1995b	Table 3-14 EG&G, 1995c	Table 3-27 EG&G, 1995c	Table 3-37 EG&G, 1995c	Table 3-39 EG&G, 1995c	

NOTE: If reported detection rate was > 50%, then a replacement value of one-half the detection limit was used for calculation of summary statistics.

Assuming that the sludges are treated prior to placement in the Cell, the possible composition of leachate derived from the stored sludges should meet WAC for the scenario of a 1-inch-per-year infiltration rate. The mean concentrations/activities reported for leachate analytes for **Ponds 207 A and B sludges, Pond 207 C sludges,** and **clarifier sludges** are for those samples treated with lime, fly ash, and cement (Phase II). For additional details, the reader should refer to the Pondcrete Treatability Report (EG&G, 1995c).

2.5 Groundwater

An evaluation of the groundwater chemistry in areas of contaminated subsurface soils destined for the Cell may also provide insights as to the likely composition of waste leachates. Locations for which both subsurface-soil and groundwater data were available are listed in Table 2. Summary statistics were calculated for these groundwater data (Table 9), and a series of modeling runs were conducted using mean concentrations and varying Eh conditions. Discussion of geochemical modeling and the results of modeling are given below in Section 3.0.

3.0 GEOCHEMICAL MODELING

Geochemical modeling takes into account solution chemistry, temperature, pH, and Eh to determine speciation and solubilities of various components. These four variables are the main factors influencing the solubility and behavior of inorganic constituents. Geochemical modeling is based on thermodynamic data and does not take into account various kinetic factors that may influence water/rock interactions; professional judgment should always be applied when evaluating model output.

Model input includes concentration data, pH, Eh, temperature, and specification of either the Debye-Huckel or Davies equation for determining individual ion-activity coefficients. By using actual concentration data, but varying selected parameters such as Eh, the general effects of such changes on constituent behavior can be assessed. This allows the user to evaluate and define optimum conditions for a given situation.

Using WATEQF (Plummer *et al.*, 1976), a limited modeling analysis was performed for groundwater related to the wastes destined for the proposed waste cell (see Table 9), in addition to modeling of an estimated leachate solution (see Table 10). Groundwater models were run for three Eh conditions (-0.2, 0.0, and 0.5 volts), whereas the estimated leachate solution was run for only two Eh conditions (0.0 and 0.5 volts).

Model output includes a listing of the distribution of aqueous species for each constituent, as well as the calculated saturation indices (SI) for a variety of phases. The SI is defined as the log of the ratio of the ion-activity product (IAP) to the solubility product (K_{sp}) for a given phase. The SI value for each phase indicates the likelihood that the phase will precipitate from, or dissolve into, the groundwater. If the SI value is approximately zero (i.e., +/- 0.5), then the phase is in equilibrium with the solution; if the SI value is less than zero (i.e., < 0.5), then the phase is likely to dissolve; if the SI value is greater than zero (i.e., > 0.5), then the phase is likely to precipitate. Modeling results are discussed below.

Table 9.

Summary of Groundwater Data for Areas with Contaminated Subsurface Soils

Analyte (dissolved)	N	% Detects	Min	Max	Mean	Std. Dev.	Units
Aluminum	97	12.4	5.5	269	22.1	34.9	UG/L
Antimony	103	3.9	5.5	51.5	13.1	7.1	UG/L
Arsenic	102	14.7	0.35	9	1.5	1.8	UG/L
Barium	105	99.1	43.3	675	195	114	UG/L
Beryllium	104	2.9	0.11	1.5	0.51	0.19	UG/L
Cadmium	104	4.8	0.9	21.7	1.6	2.1	UG/L
Calcium	100	100.0	33500	678000	160450	147770	UG/L
Cesium	84	1.2	6.5	309	70.1	101	UG/L
Chromium	105	1.0	1	4.8	1.8	0.6	UG/L
Cobalt	105	14.3	1	6.9	2.7	1.4	UG/L
Copper	104	22.1	1	17.6	2.2	1.9	UG/L
Iron	97	20.6	2	342	18.6	43.6	UG/L
Lead	103	5.8	0.35	13.8	0.8	1.3	UG/L
Lithium	100	55.0	1	42.4	12.3	9.5	UG/L
Magnesium	100	100.0	4120	105000	20060	23790	UG/L
Manganese	100	69.0	0.5	1850	228	420	UG/L
Mercury	105	1.0	0.05	0.23	0.099	0.017	UG/L
Molybdenum	96	10.4	1.5	34.1	6.7	5.5	UG/L
Nickel	103	17.5	1.5	86.1	9.3	14.6	UG/L
Potassium	100	91.0	242	11100	3098	2312	UG/L
Selenium	105	19.1	0.5	12	1.4	1.4	UG/L
Silicon	32	100.0	3630	9780	6632	1393	UG/L
Silver	105	1.0	1	25.1	1.8	2.4	UG/L
Sodium	100	100.0	4840	497000	46630	92500	UG/L
Strontium	100	100.0	240	3110	749	749	UG/L
Thallium	105	1.9	0.45	18.9	1.5	2.2	UG/L
Tin	100	17.0	3.6	74.6	14.2	12.5	UG/L
Vanadium	105	19.1	1	93	4.7	9.8	UG/L
Zinc	99	28.3	0.6	65.3	6.1	8.9	UG/L
Bicarb as CaCO3	127	100.0	65000	690000	264800	79440	UG/L
Chloride	130	97.7	500	3010000	170040	439190	UG/L
Fluoride	130	99.2	100	1410	505	240	UG/L
Nitrate/Nitrite	128	94.5	10	444000	9400	39400	UG/L
Orthophosphate	91	45.1	1.9	247	23	44	UG/L
Silica	64	100.0	8000	20965	15830	2894	UG/L
Sulfate	132	96.2	10000	250000	40744	36240	UG/L
TDS	127	100.0	210000	3800000	672095	775800	UG/L
TSS	127	96.1	2000	43000000	1553800	5121800	UG/L
pH	10	100.0	6.8	10.5	7.9	1.0	PH
Americium-241	6	83.3	0.006	0.435	0.108	0.169	PCi/L
Cesium-134	6	100.0	-0.63	0.71	-0.2	0.48	PCi/L
Cesium-137	8	87.5	-0.37	0.37	0.07	0.24	PCi/L
Gross alpha	99	88.9	0.32	67.1	10.4	11	PCi/L
Gross beta	95	90.5	-1.4	56.4	9.5	10.3	PCi/L
Plutonium-239+240	8	87.5	-0.001	1.999	0.403	0.01	PCi/L
Radium-226	45	95.6	0	2.82	0.87	0.67	PCi/L
Tritium (total)	110	53.6	-109	1067	154	163	PCi/L
Uranium-233+234	95	100.0	0.32	24.4	5.63	5.49	PCi/L
Uranium-235	95	76.8	-0.085	1.5	0.27	0.34	PCi/L
Uranium-238	95	100.0	0.24	75.7	7.68	12.01	PCi/L

Summary statistics calculated for RFEDS data compiled for this evaluation. ND = no data.
Locations for which data were evaluated are given in Table 2 of this report.

Table 10.

Summary of Data and Estimated Leachate Composition for Waste-Cell Wastes

Analyte	52.5% OU4 Pore Water - 52.5%		25.8% Waste-site GW		14.5% OU4 Pondcrete		7.2% OU4 Sludges		Estimated Leachate Composition	Units
	BKGD	Mean	BKGD	Mean	BKGD	Mean	BKGD	Mean		
Aluminum		984		22.1	X	114	X	114	547	UG/L
Antimony	X	25		13.1	X	25	X	25	22	UG/L
Arsenic		8.4		1.5	X	27		550	48	UG/L
Barium		122		195	X	84	X	84	133	UG/L
Beryllium	X	2.2		0.51	X	2.2	X	2.2	1.8	UG/L
Cadmium		14		1.6	X	2.4		5	8.5	UG/L
Calcium		110200		160450	X	55205	X	55205	111230	UG/L
Cesium		59		70.1	X	446	X	446	146	UG/L
Chromium		255		1.8		180		170	173	UG/L
Cobalt		60.2		2.7	X	20.5	X	20.5	37	UG/L
Copper		107		2.2	X	10.8	X	10.8	59	UG/L
Iron		1800		18.6	X	94	X	94	970	UG/L
Lead		48.2		0.8	X	8.6	X	8.6	27	UG/L
Lithium		984		12.3	X	38.7	X	38.7	528	UG/L
Magnesium		20120		20060	X	10026	X	10026	17910	UG/L
Manganese		925		228	X	32.7	X	32.7	550	UG/L
Mercury	X	0.59		0.099	X	0.59	X	0.59	0.46	UG/L
Molybdenum		547		6.7	X	61.2	X	61.2	302	UG/L
Nickel		160		9.3	X	15.5		15.5	90	UG/L
Potassium		308700		3098	X	11270	X	11270	165300	UG/L
Selenium		1.4		1.4	X	20.5	X	20.5	5.5	UG/L
Silicon		71320		6632	X	62.8	X	62.8	39170	UG/L
Silver		10.3		1.8	X	31900	X	31900	62.8	UG/L
Sodium		905400		46630		555000		3000000	783800	UG/L
Strontium		2613		749	X	352	X	352	1640	UG/L
Thallium		2.3		1.5	X	29.6	X	29.6	8	UG/L
Tin	X	108		14.2	X	108	X	108	84	UG/L
Vanadium		24.8		4.7	X	12.4	X	12.4	17	UG/L
Zinc		104		6.1	X	14.3	X	14.3	60	UG/L
Bicarb as CaCO3	X	223810		264800	X	223810	X	223810	234400	UG/L
Chloride	X	12832		170040	X	12832	X	12832	53400	UG/L
Fluoride	X	690		505	X	690	X	690	640	UG/L
Nitrate/Nitrite		1064020		9400		125000		1000000	651200	UG/L
Orthophosphate	X	13		23	X	13	X	13	16	UG/L
Silica	X	14300		15830	X	14300	X	14300	14700	UG/L
Sulfate	X	86230		40744	X	86230	X	86230	74500	UG/L
TDS	X	354151		672095	X	354151	X	354151	736200	UG/L
pH		8.8		7.9		11.2		11.5	9.1	UG/L
Americium-241	X	0.011		0.108	X	0.011		1	0.11	PCi/L
Cesium-134	X		X		X		X		ID	PCi/L
Cesium-137	X	0.42		0.07	X	0.42	X	0.42	0.33	PCi/L
Gross alpha		706		10.4	X	8.4	X	8.4	375	PCi/L
Gross beta		433		9.5	X	4.9	X	4.9	230	PCi/L
Plutonium-239+240		0.013		0.403		0.034	X	0.011	0.12	PCi/L
Radium-226		1.804		0.87		1.4		0.5	1.4	PCi/L
Radium-228		4.15	X	2.12	X	2.12	X	2.12	3.2	PCi/L
Tritium (total)		2384		154	X	102	X	102	1310	PCi/L
Uranium-233+234		274		5.63	X	6.91	X	6.91	147	PCi/L
Uranium-235		11.48		0.27	X	0.195	X	0.195	6.1	PCi/L
Uranium-238		264.5		7.68	X	4.83	X	4.83	142	PCi/L

X indicates that the background value was used for that analyte; ID indicates insufficient data provided in reference source.

3.1 Modeling of Groundwater Chemistry

Using the mean concentrations of constituents, models were run for three redox conditions: Eh = -0.2 volts (reducing), Eh = 0.2 volts (mildly oxidizing), and Eh = 0.5 volts (oxidizing). The dominant aqueous species, as well as phases that may control solubility, were then reviewed for each of the three redox conditions (see Figure 2).

At the low Eh value of -0.2 volts, representative of environments isolated from the atmosphere, the solution is oversaturated with respect to Ag_2Se; native silver; copper sulfide - Cu_2S; chromite - $FeCr_2O_4$; PbSe; ferroselite - $FeSe_2$; illite, smectite, and kaolinite clays; ZnSe; native selenium; FeSe; and uranium species - U_4O_9, uraninite (UO_2), and coffinite ($USiO_4$); in addition to various iron oxides, calcite, and quartz.

Unconfined groundwater in the shallow subsurface probably exhibits Eh values in the range of 0.0 to 0.2 volts. At an Eh of 0.2 volts, the solubility of uranium species increases markedly. The solution is still oversaturated with respect to iron oxides and oxyhydroxides, clays, calcite, native silver and silver selenide, and quartz. Molybdenum, vanadium, selenium, arsenic, and uranium have oxyanion complexes or negatively charged carbonate complexes as the dominant aqueous species.

To represent an environment in contact with the atmosphere (e.g., surface water or leachates from wastes stored aboveground), an Eh = 0.5 volts was used. Again, iron, aluminum, and manganese oxides and oxyhydroxides are predicted to precipitate, along with calcite and quartz, and various clay minerals. Actually, the solution appears to be at or near equilibrium with calcite, quartz, barite, pyrolusite, manganese phosphate, and hydroxyapatite. The groundwater remains undersaturated with respect to uranium-bearing phases, such as uranium carbonates. Anionic complexes for molybdenum, uranium, vanadium, chromium, arsenic, and selenium are the dominant species for these constituents in solution.

3.2 Modeling of Estimated Leachate Solution

An estimated leachate composition was derived by assembling data for vadose-zone water, groundwater, and TCLP leachates from treated pondcrete and sludges. The concentration data were then weighted for the relative proportion of a waste type. As shown in Table 10, the mean concentration multiplied by the relative proportion, which is based on the estimated volume of waste, was used to generate an estimate of leachate. If data for specific analytes were unavailable, then the mean concentration for background groundwater was used for that proportion. The mean pH of 9.1, an oxidizing Eh of 0.5 volts, and a temperature of 12°C were used for one model and a more reducing Eh of 0.0 volts was used for the second model (all other parameters unchanged).

The proportions of each waste type used for the estimated leachate composition were 52.5% OU4 vadose-zone water, 25.8% waste-site groundwater, 14.5% treated-pondcrete leachate, and 7.2% treated-sludge leachate (see Table 10). The estimated values shown here should be considered rough, preliminary estimates of constituent concentrations. As noted below, changes in physicochemical conditions can change the leachate composition.

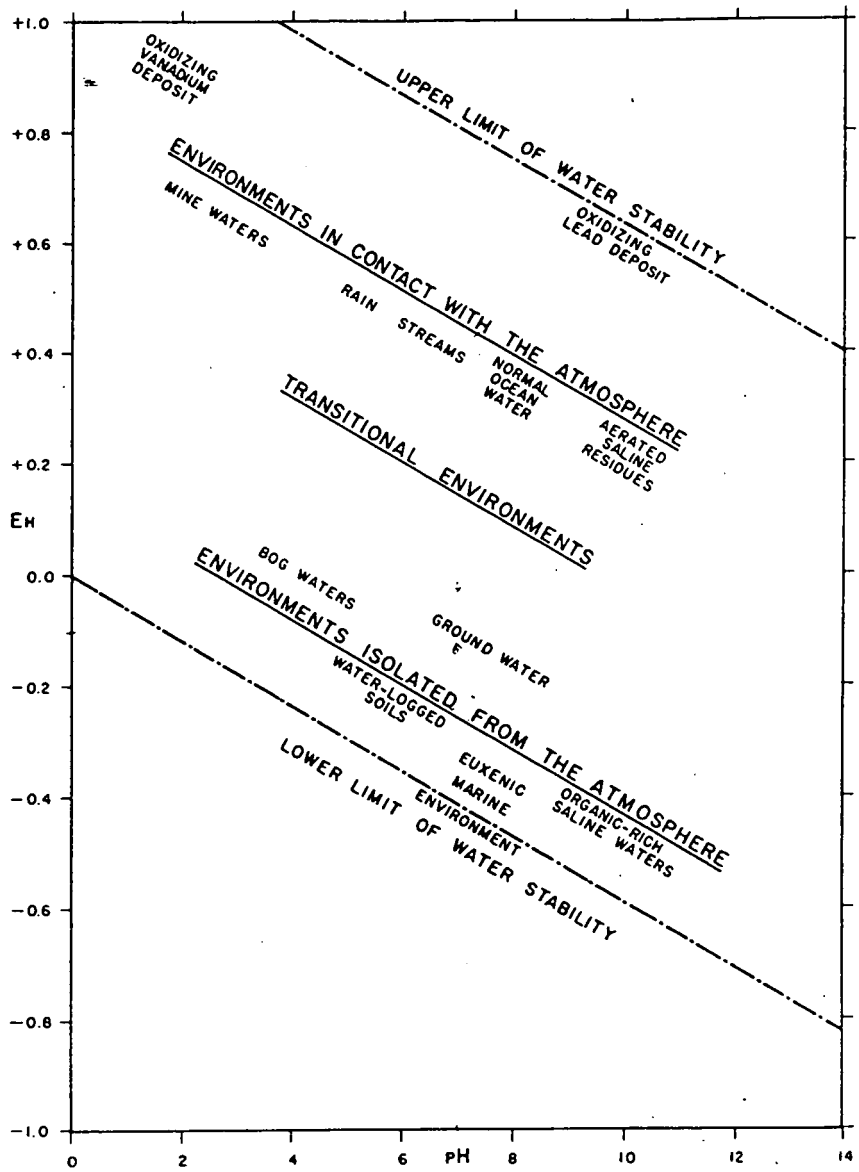

Figure 2. Generalized Eh-pH diagram showing conditions of natural environments. (From Garrels and Christ, 1965).

The hypothetical leachate solution produced model outputs with a reasonable 9.0% charge-balance error, and a distribution of aqueous species that indicates an abundance of nitrate and sodium as free ions. The dominant species in solution, in order of decreasing molality (for the Eh=0.0 case) are listed in Appendix A tables. (Molality is defined as moles of solute per 1000 grams of water; for dilute solutions at normal temperatures, molality is essentially equal to molarity. Molarity is moles of solute per 1000 grams of solution).

For the case the model run with an oxidizing Eh of 0.5 volts, the speciation indicates the importance of uranium-carbonate complexes. In the presence of carbonate, the solubility of uranium is greatly increased (compare Figures 3a and 3b), and the amount of dissolved uranium is much higher than it would be in carbonate-free water (Drever, 1988). In addition, oxyanions of chromium, molybdenum, arsenic, vanadium, and selenium are predicted to be the dominant aqueous species for these constituents. These species are important from a migration perspective because anions are generally more mobile than cations. The mobility of anions is related to the presence of abundant cation-exchange sites on clays and iron oxides, but fewer anion-exchange sites in the substrate. Thus, anionic species such as nitrate, chloride, sulfate, and oxyanions of metals, are generally less retarded as the solution migrates in the subsurface.

Output from the model run with an Eh of 0.0 volts also shows the importance of oxyanion complexes for molybdenum, chromium, selenium, vanadium, and arsenic. In general, the activities of anionic complexes of chromium, selenium are higher in the case of Eh = 0.0 volts, whereas the activities of major-ion species are largely unchanged. In particular, the activities of $Cr(OH)_4^-$, Fe^{+2}, $FeOH^+$, SeO_3^{-2}, Cu^+, $CuCl_2^-$, CuCl, $HSeO_3^-$ are markedly greater under an Eh of 0.0 volts, as compared to an Eh of 0.5 volts.

4.0 SUMMARY AND CONCLUSIONS

Wastes derived from OU4 will constitute approximately 75 percent of the total waste mass in the Waste Cell, with pondcrete and sludge materials comprising 21.7% of the total waste volume, and OU4 vadose-zone soils comprising 24.1% of the total waste volume. Because OU4 contributes the bulk of waste for the Cell, this evaluation focussed on the existing data for OU4 materials. Based on these data, nitrate, sodium, gross alpha, gross beta, tritium, and uranium isotopes appear to be the most mobile constituents in the OU4 wastes.

For subsurface-soil wastes to be stored at the proposed Cell, constituent concentrations in the waste materials were statistically compared to those in background subsurface soils. This comparison highlights those constituents that may be released in concentrations higher than those of background groundwater. However, just because the solid wastes contain constituent concentrations higher than those of background soils, does not necessarily mean that waste leachates will contain proportionately higher levels of those constituents.

Based on the estimated volumes of waste destined for the Cell and the available data for leachates, pore water, and groundwater from the wastes and waste areas, a general leachate composition was calculated (see Table 10). Geochemical modeling of the leachate suggests that iron, aluminum, and manganese

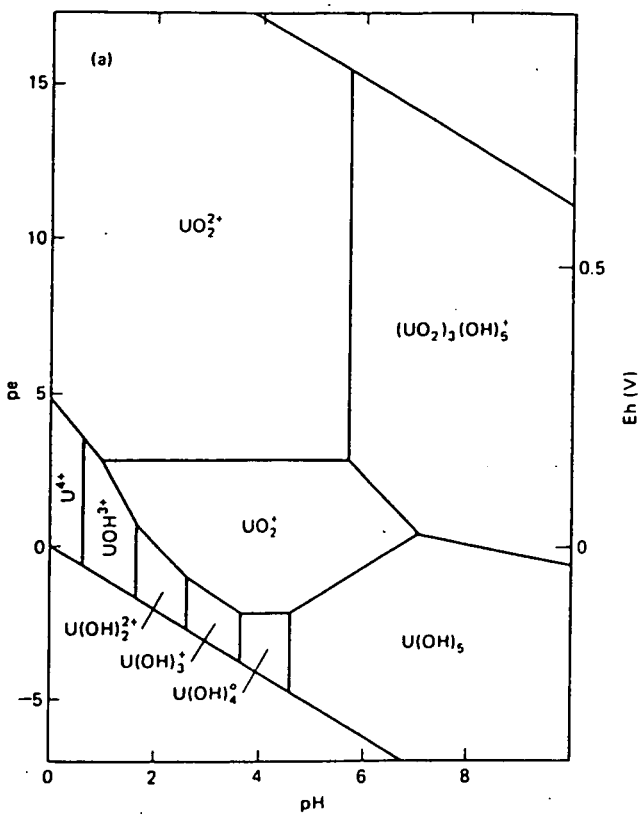

Figure 3a. Distribution of dissolved uranium species in a carbonate-free system at 25°C (Figure from Drever, 1988).

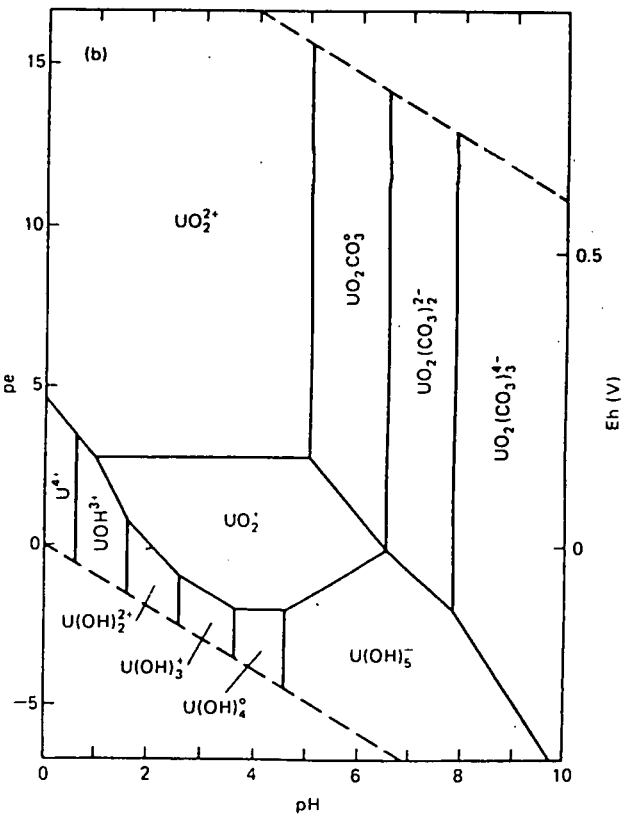

Figure 3b. Distribution of dissolved uranium species in a system containing carbonate, at 25°C. (Figure from Drever, 1988).

oxides and oxyhydroxides, along with clay minerals, calcium carbonate, and compounds containing zinc, copper, barium, chromium, strontium will precipitate from the leachate. Silver, lead, and molybdenum appear to be at approximate equilibrium with the leachate, under the specified Eh-pH conditions. On the other hand, the leachate is undersaturated with respect to uranium, vanadium, arsenic, radium, and selenium phases, so these constituents would still tend to remain in solution. As long as uranium, vanadium, arsenic, and selenium exist as oxyanions, it is unlikely that they will be strongly retarded under the given Eh-pH conditions.

The solubility and behavior of iron is strongly influenced by Eh-pH conditions. The oxidized form of iron (ferric, Fe^{+3}) is much less soluble than the reduced form (ferrous, Fe^{+2}). Ferric oxyhydroxides, generalized as $Fe(OH)_3$, form suspended particulates. The importance of these ferric oxyhydroxide particulate is that their surfaces have a large capacity for the adsorption of trace metals (Hem, 1992). If Eh decreases and the iron is reduced, the adsorbed trace metals, in addition to the iron, will be released into solution. Where the solubility of trace elements is controlled by adsorption onto oxide surfaces, the dissolved concentrations of these elements will be highly sensitive to changes in Eh and pH. At RFETS, much of the plutonium and americium in near-surface waters may be adsorbed onto iron oxyhydroxide particulates, so Eh conditions may have significant impact on both trace metal and radionuclide mobility.

In general, most metals, including plutonium and americium, are less mobile in a neutral, oxidizing environment; however, those metals and radionuclides that tend to form oxyanions or other negatively charged aqueous species tend to remain mobile. Additionally, anions such as nitrate, chloride, and sulfate tend to be mobile under most naturally occurring Eh-pH conditions. Controlling the migration of anionic species probably presents the greatest challenge for wastes contaminated with numerous metals and radionuclides. Uranium tends to be immobilized under reducing conditions, but plutonium and americium are mobilized under these conditions. By modeling the leachate for a range of Eh-pH conditions, the optimum conditions for immobilization can be defined.

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Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
NO3 -	2.88270E+03	4.66967E-02	NO3 -	2.88270E+03	4.66967E-02
NA +	7.80660E+02	3.41067E-02	NA +	7.80660E+02	3.41067E-02
K +	1.65027E+02	4.23906E-03	K +	1.65027E+02	4.23906E-03
HCO3 -	2.16955E+02	3.57133E-03	HCO3 -	2.16955E+02	3.57133E-03
CA 2+	1.00756E+02	2.52497E-03	CA 2+	1.00756E+02	2.52497E-03
CL -	5.33527E+01	1.51153E-03	CL -	5.33535E+01	1.51155E-03
MG 2+	1.64351E+01	6.78994E-04	MG 2+	1.64352E+01	6.78995E-04
SO4 2-	6.16884E+01	6.45010E-04	SO4 2-	6.16901E+01	6.45028E-04
CO3 2-	1.62828E+01	2.72536E-04	CO3 2-	1.62831E+01	2.72540E-04
H4SIO4	2.15717E+01	2.25426E-04	H4SIO4	2.15717E+01	2.25426E-04
CACO3	1.68300E+01	1.68893E-04	CACO3	1.68295E+01	1.68888E-04
LI +	5.27316E-01	7.63285E-05	LI +	5.27316E-01	7.63285E-05
CASO4	8.54916E+00	6.30733E-05	CASO4	8.54901E+00	6.30722E-05
NASO4 -	5.78539E+00	4.88102E-05	NASO4 -	5.78541E+00	4.88104E-05
NAHCO3	3.85061E+00	4.60479E-05	NAHCO3	3.85056E+00	4.60474E-05
NACO3 -	3.37192E+00	4.08052E-05	NACO3 -	3.37190E+00	4.08050E-05
F -	6.17843E-01	3.26644E-05	F -	6.17843E-01	3.26644E-05
MGCO3	2.71445E+00	3.23339E-05	MGCO3	2.71439E+00	3.23331E-05
CAHCO3 +	2.99946E+00	2.98001E-05	CAHCO3 +	2.99941E+00	2.97995E-05
H3SIO4 -	1.92131E+00	2.02907E-05	H3SIO4 -	1.92133E+00	2.02908E-05
SR 2+	1.63998E+00	1.87995E-05	SR 2+	1.63998E+00	1.87995E-05
AL(OH)4 -	1.71114E+00	1.80894E-05	AL(OH)4 -	1.71114E+00	1.80894E-05
FE(OH)4 -	1.79174E+00	1.45278E-05	FE(OH)4 -	1.89406E+00	1.53575E-05
MGSO4	1.80138E+00	1.50310E-05	MGSO4	1.80135E+00	1.50308E-05
MGHCO3 +	1.08704E+00	1.27956E-05	MGHCO3 +	1.08702E+00	1.27954E-05
MN 2+	4.99737E-01	9.13654E-06	MN 2+	4.99738E-01	9.13656E-06
KSO4 -	9.25961E-01	6.88091E-06	KSO4 -	9.25963E-01	6.88093E-06
H2CO3	3.98652E-01	6.45562E-06	H2CO3	3.98649E-01	6.45558E-06
OH -	9.33412E-02	5.51250E-06	OH -	9.33418E-02	5.51253E-06
MOO4 2-	5.03437E-01	3.16156E-06	MOO4 2-	5.03437E-01	3.16156E-06
AL(OH)5 2-	2.25688E-01	2.02907E-06	AL(OH)5 2-	2.25692E-01	2.02910E-06
FE(OH)3	2.09654E-01	1.97045E-06	FE(OH)3	2.21626E-01	2.08297E-06
UO2(CO3)3 4-	8.22000E-01	1.83451E-06	UO2(CO3)3 4-	8.22001E-01	1.83451E-06
CR(OH)3	1.46351E-01	1.42691E-06	CR(OH)3	2.99286E-12	2.91801E-17
CR(OH)4 -	1.55738E-01	1.30327E-06	CR(OH)4 -	3.18482E-12	2.66518E-17
CS +	1.46000E-01	1.10338E-06	CS +	1.46000E-01	1.10338E-06
BA 2+	1.32744E-01	9.70805E-07	BA 2+	1.32744E-01	9.70805E-07
CU(OH)2	8.52646E-02	8.77824E-07	CU(OH)2	8.80314E-02	9.06309E-07
NACL	4.94403E-02	8.49695E-07	NACL	4.94403E-02	8.49696E-07
FE 2+	4.59251E-02	8.25969E-07	FE 2+	7.07058E-11	1.27165E-15

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
MNHCO3 +	8.94985E-02	7.75245E-07	MNHCO3 +	8.94967E-02	7.75229E-07
ZN(CO3)2 2-	1.29407E-01	7.01076E-07	ZN(CO3)2 2-	1.29408E-01	7.01079E-07
HASO4 2-	8.85985E-02	6.35972E-07	HASO4 2-	8.85985E-02	6.35972E-07
MGF +	2.12824E-02	4.93562E-07	MGF +	2.12820E-02	4.93553E-07
CR(OH)2 +	5.23695E-02	6.11561E-07	CR(OH)2 +	1.07095E-12	1.25064E-17
NAF	1.80013E-02	4.30616E-07	NAF	1.80011E-02	4.30611E-07
HVO4 2-	3.62742E-02	3.14233E-07	HVO4 2-	3.62742E-02	3.14233E-07
NAOH	1.02805E-02	2.58165E-07	NAOH	1.02804E-02	2.58163E-07
CACL +	1.93137E-02	2.56828E-07	CACL +	1.93136E-02	2.56826E-07
MGOH +	1.04177E-02	2.53238E-07	MGOH +	1.04175E-02	2.53235E-07
CAF +	1.44848E-02	2.46262E-07	CAF +	1.44845E-02	2.46257E-07
AL(OH)3	1.89591E-02	2.44126E-07	AL(OH)3	1.89589E-02	2.44124E-07
CAOH +	8.53506E-03	1.50169E-07	CAOH +	8.53494E-03	1.50167E-07
ZNCO3	1.43310E-02	1.14797E-07	ZNCO3	1.43308E-02	1.14795E-07
KCL	8.04242E-03	1.08349E-07	KCL	8.04242E-03	1.08349E-07
FEOH +	7.21382E-03	9.94534E-08	FEOH +	1.11061E-11	1.53115E-16
LISO4 -	1.01144E-02	9.86315E-08	LISO4 -	1.01145E-02	9.86318E-08
ZN(OH)2	8.85994E-03	8.95326E-08	ZN(OH)2	8.85985E-03	8.95317E-08
HPO4 2-	7.22895E-03	7.56502E-08	HPO4 2-	7.23126E-03	7.56744E-08
PBCO3	2.00188E-02	7.52488E-08	PBCO3	2.00186E-02	7.52482E-08
MNOH +	4.59498E-03	6.41496E-08	MNOH +	4.59491E-03	6.41486E-08
SEO3 2-	8.03125E-03	6.35383E-08	SEO3 2-	3.96637E-09	3.13794E-14
AGCL	8.22030E-03	5.76091E-08	AGCL	8.22029E-03	5.76090E-08
PB(CO3)2 2-	1.75898E-02	5.39927E-08	PB(CO3)2 2-	1.75900E-02	5.39933E-08
CAPO4 -	6.54477E-03	4.86753E-08	CAPO4 -	6.54662E-03	4.86890E-08
MNSO4	6.98606E-03	4.64709E-08	MNSO4	6.98593E-03	4.64700E-08
AG +	2.72015E-03	2.53287E-08	AG +	2.72014E-03	2.53287E-08
MNCL +	2.25270E-03	2.50318E-08	MNCL +	2.25269E-03	2.50316E-08
H2VO4 -	2.43053E-03	2.08735E-08	H2VO4 -	2.43049E-03	2.08732E-08
UO2(CO3)2 2-	7.66996E-03	1.97511E-08	UO2(CO3)2 2-	7.66948E-03	1.97498E-08
CUCO3	2.24546E-03	1.82540E-08	CUCO3	2.31831E-03	1.88462E-08
MGPO4 -	2.14997E-03	1.81036E-08	MGPO4 -	2.15058E-03	1.81088E-08
H2SIO4 2-	1.68006E-03	1.79329E-08	H2SIO4 2-	1.68010E-03	1.79333E-08
CAHPO4	2.31770E-03	1.71097E-08	CAHPO4	2.31834E-03	1.71144E-08
FESO4	2.51164E-03	1.66069E-08	FESO4	3.86682E-12	2.55673E-17
KOH	8.66068E-04	1.55045E-08	KOH	8.66061E-04	1.55044E-08
CU +	9.59824E-04	1.51711E-08	CU +	1.44324E-12	2.28121E-17
ZN 2+	6.54952E-04	1.00618E-08	ZN 2+	6.54961E-04	1.00620E-08
AGCL2 -	1.70865E-03	9.59980E-09	AGCL2 -	1.70867E-03	9.59993E-09
CUCL2 -	9.97771E-04	7.45378E-09	CUCL2 -	1.50033E-12	1.12081E-17

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
MN(NO3)2	1.26224E-03	7.08480E-09	MN(NO3)2	1.26219E-03	7.08456E-09
CUCL	6.56438E-04	6.66003E-09	CUCL	9.87057E-13	1.00144E-17
CU(CO3)2 2-	1.19969E-03	6.56435E-09	CU(CO3)2 2-	1.23863E-03	6.77745E-09
HSEO3 -	8.18534E-04	6.42473E-09	HSEO3 -	4.04239E-10	3.17290E-15
MGHPO4	7.63872E-04	6.37822E-09	MGHPO4	7.64084E-04	6.37998E-09
FE(OH)2 +	4.32779E-04	4.83733E-09	FE(OH)2 +	4.57496E-04	5.11360E-09
ASO4 3-	6.58950E-04	4.76434E-09	ASO4 3-	6.58969E-04	4.76448E-09
H2ASO4 -	3.87543E-04	2.76194E-09	H2ASO4 -	3.87537E-04	2.76190E-09
ZNOH +	2.23975E-04	2.73057E-09	ZNOH +	2.23974E-04	2.73056E-09
NAHPO4 -	2.70604E-04	2.28462E-09	NAHPO4 -	2.70685E-04	2.28529E-09
ZNHCO3 +	2.60112E-04	2.06697E-09	ZNHCO3 +	2.60109E-04	2.06696E-09
BANO3 +	3.69232E-04	1.86050E-09	BANO3 +	3.69223E-04	1.86045E-09
CANO3 +	1.27154E-04	1.25107E-09	CANO3 +	1.27152E-04	1.25105E-09
PBOH +	2.28733E-04	1.02469E-09	PBOH +	2.28734E-04	1.02469E-09
H +	9.71697E-07	9.68242E-10	H +	9.71703E-07	9.68247E-10
MNF +	7.04473E-05	9.57017E-10	MNF +	7.04459E-05	9.56997E-10
H2PO4 -	5.56854E-05	5.76686E-10	H2PO4 -	5.57022E-05	5.76860E-10
ZNNO3 +	6.78005E-05	5.34599E-10	ZNNO3 +	6.77999E-05	5.34594E-10
LIOH	1.05336E-05	4.41823E-10	LIOH	1.05335E-05	4.41820E-10
ZN(OH)3 -	5.08938E-05	4.39155E-10	ZN(OH)3 -	5.08936E-05	4.39153E-10
CUOH +	3.30841E-05	4.12524E-10	CUOH +	3.41579E-05	4.25913E-10
PB(OH)2	9.75080E-05	4.06022E-10	PB(OH)2	9.75077E-05	4.06021E-10
AGNO3	6.82005E-05	4.03252E-10	AGNO3	6.81995E-05	4.03246E-10
SROH +	2.95709E-05	2.83878E-10	SROH +	2.95703E-05	2.83873E-10
ZNSO4	4.52244E-05	2.81365E-10	ZNSO4	4.52242E-05	2.81363E-10
KHPO4 -	3.76752E-05	2.80139E-10	KHPO4 -	3.76864E-05	2.80222E-10
FE(OH)3 -	2.65027E-05	2.49088E-10	FE(OH)3 -	4.08027E-14	3.83486E-19
ZNOHCL	2.69604E-05	2.29798E-10	ZNOHCL	2.69604E-05	2.29798E-10
FE(OH)2	1.56102E-05	1.74481E-10	FE(OH)2	2.40327E-14	2.68622E-19
HMOO4 -	2.22191E-05	1.38659E-10	HMOO4 -	2.22187E-05	1.38657E-10
AGSO4 -	2.64680E-05	1.30362E-10	AGSO4 -	2.64680E-05	1.30363E-10
CROH 2+	8.49900E-06	1.23712E-10	CROH 2+	1.73807E-16	2.52994E-21
PBHCO3 +	2.62107E-05	9.81533E-11	PBHCO3 +	2.62107E-05	9.81532E-11
PO4 3-	8.32633E-06	8.80591E-11	PO4 3-	8.32924E-06	8.80898E-11
CU(OH)3 -	9.35824E-06	8.20436E-11	CU(OH)3 -	9.66198E-06	8.47064E-11
PB 2+	1.56215E-05	7.57264E-11	PB 2+	1.56219E-05	7.57281E-11
VO4 3-	8.63026E-06	7.54171E-11	VO4 3-	8.63052E-06	7.54193E-11
CU 2+	3.76080E-06	5.94435E-11	CU 2+	3.88292E-06	6.13739E-11
FEHPO4	7.62012E-06	5.04134E-11	FEHPO4	1.17351E-14	7.76371E-20
CUHCO3 +	6.02892E-06	4.86141E-11	CUHCO3 +	6.22456E-06	5.01917E-11

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
AL(OH)2 +	2.79884E-06	4.60881E-11	AL(OH)2 +	2.79884E-06	4.60881E-11
AGOH	3.20726E-06	2.57971E-11	AGOH	3.20724E-06	2.57969E-11
HF	4.96279E-07	2.49157E-11	HF	4.96276E-07	2.49155E-11
CUCL3 2-	4.21272E-06	2.49040E-11	CUCL3 2-	6.33473E-15	3.74485E-20
PBNO3 +	6.34991E-06	2.36918E-11	PBNO3 +	6.34990E-06	2.36917E-11
HSO4 -	1.88935E-06	1.95498E-11	HSO4 -	1.88936E-06	1.95499E-11
AGCL3 2-	3.51977E-06	1.65026E-11	AGCL3 2-	3.51991E-06	1.65033E-11
CAH2PO4 +	1.84222E-06	1.34996E-11	CAH2PO4 +	1.84274E-06	1.35034E-11
UO2CO3	3.40896E-06	1.03746E-11	UO2CO3	3.40868E-06	1.03738E-11
ZNCL +	1.01104E-06	1.00712E-11	ZNCL +	1.01105E-06	1.00712E-11
BAOH +	1.42119E-06	9.24841E-12	BAOH +	1.42117E-06	9.24825E-12
PB(OH)3 -	1.85895E-06	7.23082E-12	PB(OH)3 -	1.85896E-06	7.23085E-12
MNCL2	8.46711E-07	6.75796E-12	MNCL2	8.46705E-07	6.75791E-12
PBSO4	1.70290E-06	5.64007E-12	PBSO4	1.70290E-06	5.64008E-12
MGH2PO4 +	5.72431E-07	4.74000E-12	MGH2PO4 +	5.72594E-07	4.74134E-12
CUNO3 +	4.85693E-07	3.88557E-12	CUNO3 +	5.01453E-07	4.01166E-12
V2O7 4-	6.63632E-07	3.11654E-12	V2O7 4-	6.63664E-07	3.11669E-12
U(OH)5 -	7.40917E-07	2.30352E-12	U(OH)5 -	1.57142E-24	4.88558E-30
ZNF +	1.48919E-07	1.77269E-12	ZNF +	1.48918E-07	1.77268E-12
ZN(SO4)2 2-	4.30731E-07	1.68010E-12	ZN(SO4)2 2-	4.30740E-07	1.68014E-12
AGF	1.97863E-07	1.56650E-12	AGF	1.97860E-07	1.56648E-12
CUSO4	2.32550E-07	1.46344E-12	CUSO4	2.40097E-07	1.51093E-12
PBCL +	3.52103E-07	1.45746E-12	PBCL +	3.52107E-07	1.45748E-12
HV2O7 3-	1.38701E-07	6.48312E-13	HV2O7 3-	1.38702E-07	6.48317E-13
HMNO2 -	3.18962E-08	3.64272E-13	HMNO2 -	3.18957E-08	3.64266E-13
H3VO4	2.08379E-08	1.77428E-13	H3VO4	2.08374E-08	1.77424E-13
H2V2O7 2-	3.58255E-08	1.66672E-13	H2V2O7 2-	3.58247E-08	1.66669E-13
ZN(OH)4 2-	2.10445E-08	1.58440E-13	ZN(OH)4 2-	2.10448E-08	1.58443E-13
H3ASO3	1.38531E-08	1.10480E-13	H3ASO3	2.93825E-26	2.34329E-31
FEH2PO4 +	1.64541E-08	1.08135E-13	FEH2PO4 +	2.53396E-17	1.66530E-22
UO2(HPO4)2 2-	4.70916E-08	1.02383E-13	UO2(HPO4)2 2-	4.71171E-08	1.02438E-13
AGCL4 3-	2.24702E-08	9.03934E-14	AGCL4 3-	2.24719E-08	9.04002E-14
FEOH 2+	5.39072E-09	7.43197E-14	FEOH 2+	5.69869E-09	7.85656E-14
H2ASO3 -	7.62412E-09	6.12939E-14	H2ASO3 -	1.61710E-26	1.30006E-31
CUCL +	5.48892E-09	5.56890E-14	CUCL +	5.66712E-09	5.74969E-14
H3V2O7 -	9.96006E-09	4.61223E-14	H3V2O7 -	9.95968E-09	4.61205E-14
AG(OH)2 -	5.65228E-09	4.00136E-14	AG(OH)2 -	5.65227E-09	4.00135E-14
PB(OH)4 2-	1.03328E-08	3.77082E-14	PB(OH)4 2-	1.03330E-08	3.77090E-14
CU(OH)4 2-	4.88153E-09	3.72645E-14	CU(OH)4 2-	5.04005E-09	3.84746E-14
ALOH 2+	1.46350E-09	3.34165E-14	ALOH 2+	1.46352E-09	3.34171E-14

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
CU2(OH)2 2+	4.60246E-09	2.86939E-14	CU2(OH)2 2+	4.90612E-09	3.05871E-14
PBHPO4	8.60234E-09	2.84990E-14	PBHPO4	8.60486E-09	2.85074E-14
MN(OH)3 -	2.97956E-09	2.82438E-14	MN(OH)3 -	2.97951E-09	2.82434E-14
CUHPO4	3.89586E-09	2.45294E-14	CUHPO4	4.02347E-09	2.53329E-14
FEH3SIO4 2+	3.32854E-09	2.21474E-14	FEH3SIO4 2+	3.51870E-09	2.34127E-14
RA 2+	4.60000E-09	2.04416E-14	RA 2+	4.60000E-09	2.04416E-14
PBF +	4.48706E-09	1.99244E-14	PBF +	4.48705E-09	1.99244E-14
PB(SO4)2 2-	7.78605E-09	1.95842E-14	PB(SO4)2 2-	7.78627E-09	1.95847E-14
V3O9 3-	5.78183E-09	1.95653E-14	V3O9 3-	5.78175E-09	1.95651E-14
CUF +	1.16114E-09	1.41289E-14	CUF +	1.19882E-09	1.45874E-14
UO2H3SIO4 +	3.83563E-09	1.05511E-14	UO2H3SIO4 +	3.83536E-09	1.05503E-14
ZNCL2	1.34653E-09	9.92381E-15	ZNCL2	1.34654E-09	9.92386E-15
UO2OH +	2.35062E-09	8.22547E-15	UO2OH +	2.35046E-09	8.22490E-15
CU2CL4 2-	1.97974E-09	7.39475E-15	CU2CL4 2-	4.47633E-27	1.67201E-32
UO2 + (5 VALEN	1.94987E-09	7.25286E-15	UO2 + (5 VALEN	2.83956E-18	1.05622E-23
CR 3+	3.38668E-10	6.54211E-15	CR 3+	6.92606E-21	1.33792E-25
ALF2 +	3.48883E-10	5.39293E-15	ALF2 +	3.48879E-10	5.39287E-15
MNCL3 -	7.40510E-10	4.61124E-15	MNCL3 -	7.40515E-10	4.61127E-15
CR3(OH)4 5+	6.77241E-10	3.03651E-15	CR3(OH)4 5+	5.79260E-42	2.59720E-47
PBCL2	8.19388E-10	2.95932E-15	PBCL2	8.19398E-10	2.95936E-15
ALF 2+	9.01809E-11	1.96997E-15	ALF 2+	9.01818E-11	1.96999E-15
H2SEO3	1.94371E-10	1.51371E-15	H2SEO3	9.59910E-17	7.47552E-22
FEF 2+	6.12781E-11	8.22344E-16	FEF 2+	6.47786E-11	8.69320E-16
ALF3	5.28175E-11	6.31731E-16	ALF3	5.28162E-11	6.31716E-16
HSE -	4.29605E-11	5.39593E-16	HSE -	2.02456E-70	2.54289E-75
MG4(OH)4 4+	8.72909E-11	5.30569E-16	MG4(OH)4 4+	8.72926E-11	5.30579E-16
CR2(OH)2 4+	5.97102E-11	4.34572E-16	CR2(OH)2 4+	2.49728E-32	1.81753E-37
H3ASO4	3.49089E-11	2.47022E-16	H3ASO4	3.49081E-11	2.47016E-16
ZN2OH 3+	3.37522E-11	2.29423E-16	ZN2OH 3+	3.37534E-11	2.29431E-16
HF2 -	3.65613E-12	1.74752E-16	HF2 -	3.65611E-12	1.74751E-16
U(OH)4	2.27988E-11	7.48207E-17	U(OH)4	4.83540E-29	1.58687E-34
HASO3 2-	7.57406E-12	6.13866E-17	HASO3 2-	1.60651E-29	1.30205E-34
UO2HPO4	2.10021E-11	5.76351E-17	UO2HPO4	2.10067E-11	5.76478E-17
FEF2 +	4.78282E-12	5.11907E-17	FEF2 +	5.05592E-12	5.41138E-17
V(OH)3	4.96009E-12	4.88607E-17	V(OH)3	1.05204E-29	1.03634E-34
H3PO4	4.36920E-12	4.47827E-17	H3PO4	4.37049E-12	4.47960E-17
UO2F +	9.30440E-12	3.23344E-17	UO2F +	9.30370E-12	3.23320E-17
CUCL2	3.43497E-12	2.56607E-17	CUCL2	3.54649E-12	2.64938E-17
VOOH +	1.91911E-12	2.29616E-17	VOOH +	2.79492E-21	3.34404E-26
UO2 2+	4.49144E-12	1.67067E-17	UO2 2+	4.49120E-12	1.67058E-17

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
AL 3+	4.36401E-13	1.62455E-17	AL 3+	4.36420E-13	1.62462E-17
ZNCL3 -	2.65592E-12	1.55332E-17	ZNCL3 -	2.65597E-12	1.55335E-17
PBH2PO4 +	3.69384E-12	1.21969E-17	PBH2PO4 +	3.69495E-12	1.22006E-17
CRCL 2+	1.00995E-12	1.16001E-17	CRCL 2+	2.06540E-23	2.37226E-28
CUH2PO4 +	1.63968E-12	1.02591E-17	CUH2PO4 +	1.69340E-12	1.05952E-17
PBF2	2.15644E-12	8.83357E-18	PBF2	2.15641E-12	8.83345E-18
H2MOO4	1.01877E-12	6.31843E-18	H2MOO4	1.01875E-12	6.31828E-18
UO2F2	1.59818E-12	5.21137E-18	UO2F2	1.59804E-12	5.21092E-18
PB2OH 3+	1.64721E-12	3.83509E-18	PB2OH 3+	1.64730E-12	3.83528E-18
PBCL3 -	1.02136E-12	3.27168E-18	PBCL3 -	1.02138E-12	3.27177E-18
ALF4 -	2.44013E-13	2.38010E-18	ALF4 -	2.44008E-13	2.38004E-18
ALSO4 +	2.21894E-13	1.81134E-18	ALSO4 +	2.21894E-13	1.81135E-18
FEF3	1.07771E-13	9.59273E-19	FEF3	1.13923E-13	1.01404E-18
UO2SO4	3.05405E-13	8.37929E-19	UO2SO4	3.05382E-13	8.37868E-19
VO2 +	3.46573E-14	4.19704E-19	VO2 +	3.46567E-14	4.19697E-19
H4VO4 +	4.57846E-14	3.86539E-19	H4VO4 +	4.57838E-14	3.86532E-19
VO 2+	2.35386E-14	3.53186E-19	VO 2+	3.42814E-23	5.14376E-28
SEO4 2-	4.27668E-14	3.00478E-19	SEO4 2-	9.95778E-03	6.99630E-08
HCL	6.61742E-15	1.82294E-19	HCL	6.61746E-15	1.82295E-19
FE 3+	5.68642E-15	1.02271E-19	FE 3+	6.01146E-15	1.08117E-19
FESO4 +	7.79888E-15	5.15659E-20	FESO4 +	8.24431E-15	5.45111E-20
UO2F3 -	1.38126E-14	4.24239E-20	UO2F3 -	1.38114E-14	4.24203E-20
PB3(OH)4 2+	2.61967E-14	3.81544E-20	PB3(OH)4 2+	2.61972E-14	3.81551E-20
AL(SO4)2 -	6.44660E-15	2.95524E-20	AL(SO4)2 -	6.44664E-15	2.95525E-20
ZN2(OH)6 2-	6.34278E-15	2.73655E-20	ZN2(OH)6 2-	6.34282E-15	2.73656E-20
UO2CL +	5.37984E-15	1.76888E-20	UO2CL +	5.37951E-15	1.76877E-20
UO2(SO4)2 2-	7.51406E-15	1.63310E-20	UO2(SO4)2 2-	7.51372E-15	1.63302E-20
ZNCL4 2-	3.20297E-15	1.55272E-20	ZNCL4 2-	3.20311E-15	1.55279E-20
V(OH)2 +	5.34910E-16	6.32412E-21	V(OH)2 +	1.13456E-33	1.34136E-38
ASO3 3-	6.15942E-16	5.03305E-21	ASO3 3-	1.30649E-33	1.06757E-38
PBCL4 2-	1.08860E-15	3.13286E-21	PBCL4 2-	1.08866E-15	3.13302E-21
H2F2	1.04498E-16	2.62316E-21	H2F2	1.04497E-16	2.62313E-21
PBF3 -	5.56643E-16	2.11624E-21	PBF3 -	5.56637E-16	2.11622E-21
H2SE	1.69995E-16	2.10860E-21	H2SE	8.01117E-76	9.93697E-81
CRCL2 +	1.87853E-16	1.53523E-21	CRCL2 +	3.84164E-27	3.13958E-32
ALF5 2-	1.53693E-16	1.26562E-21	ALF5 2-	1.53691E-16	1.26560E-21
FE(SO4)2 -	2.53604E-16	1.02723E-21	FE(SO4)2 -	2.68090E-16	1.08591E-21
FECL 2+	5.72297E-17	6.29599E-22	FECL 2+	6.04997E-17	6.65573E-22
MOO2 +	7.91494E-17	6.21376E-22	MOO2 +	1.15270E-25	9.04948E-31
SE 2-	4.37757E-17	5.56851E-22	SE 2-	2.06301E-76	2.62427E-81

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
CRO4 2-	5.82198E-17	5.04138E-22	CRO4 2-	3.85425E-01	3.33748E-06
VOSO4	7.44671E-17	4.58875E-22	VOSO4	1.08451E-25	6.68286E-31
U(OH)3 +	1.12456E-16	3.90770E-22	U(OH)3 +	2.38509E-34	8.28789E-40
FEHPO4 +	5.75863E-17	3.80965E-22	FEHPO4 +	6.08932E-17	4.02842E-22
VOF +	1.87099E-17	2.18672E-22	VOF +	2.72483E-26	3.18465E-31
(UO2)2(OH)2 2+	1.23239E-16	2.15623E-22	(UO2)2(OH)2 2+	1.23223E-16	2.15596E-22
CUCL3 -	1.83220E-17	1.08313E-22	CUCL3 -	1.89171E-17	1.11831E-22
SE2 2-	1.23844E-17	7.87683E-23	H2SEO4	2.34132E-17	1.62213E-22
V4O9 2-	2.20125E-17	6.35775E-23	V4O9 2-	9.90257E-53	2.86010E-58
(UO2)3(OH)5 +	4.93402E-17	5.53647E-23	(UO2)3(OH)5 +	4.93294E-17	5.53525E-23
H4ASO3 +	6.78183E-18	5.36565E-23	H4ASO3 +	1.43844E-35	1.13807E-40
UO2F4 2-	1.17273E-17	3.40414E-23	UO2F4 2-	1.17264E-17	3.40389E-23
H2SO4	1.80148E-18	1.84490E-23	H2SO4	1.80148E-18	1.84491E-23
FEH2PO4 2+	1.55319E-18	1.02075E-23	FEH2PO4 2+	1.64241E-18	1.07938E-23
FECL2 +	1.04324E-18	8.26679E-24	FECL2 +	1.10283E-18	8.73906E-24
FE2(OH)2 4+	7.97240E-19	5.49562E-24	FE2(OH)2 4+	8.90976E-19	6.14178E-24
UO2H2PO4 +	1.59390E-18	4.36206E-24	UO2H2PO4 +	1.59427E-18	4.36305E-24
AL2(OH)2 4+	8.36922E-20	9.55490E-25	AL2(OH)2 4+	8.36988E-20	9.55565E-25
V4O12 4-	2.74488E-19	6.96636E-25	V4O12 4-	2.74489E-19	6.96640E-25
HCRO4 -	7.71763E-20	6.62530E-25	HCRO4 -	5.10911E-04	4.38598E-09
VOF2	3.76326E-20	3.60202E-25	VOF2	5.48057E-29	5.24575E-34
ALF6 3-	2.16917E-20	1.54552E-25	ALF6 3-	2.16920E-20	1.54554E-25
HMOO3 +	9.59304E-21	6.64739E-26	HMOO3 +	9.59287E-21	6.64728E-26
PBF4 2-	1.38605E-20	4.91595E-26	PBF4 2-	1.38605E-20	4.91595E-26
VOH 2+	2.39841E-21	3.54532E-26	VOH 2+	5.08718E-39	7.51985E-44
HV6O17 3-	1.41562E-20	2.45724E-26	HV6O17 3-	1.41551E-20	2.45705E-26
FE3(OH)4 5+	2.16811E-21	9.24428E-27	FE3(OH)4 5+	2.56153E-21	1.09217E-26
HSEO4 -	5.65482E-22	3.94524E-27	HSEO4 -	1.31664E-10	9.18590E-16
CUCL4 2-	1.79979E-22	8.80287E-28	CUCL4 2-	1.85830E-22	9.08901E-28
FECL3	1.30862E-22	8.10327E-28	FECL3	1.38338E-22	8.56619E-28
U(OH)2 2+	9.41146E-23	3.47481E-28	U(OH)2 2+	1.99612E-40	7.36990E-46
VOF3 -	3.36711E-23	2.72881E-28	VOF3 -	4.90366E-32	3.97408E-37
H2V2O4 2+	6.56295E-24	3.92619E-29	V2(OH)2 4+	1.91254E-80	1.41356E-85
AL3(OH)4 5+	1.74939E-25	1.17948E-30	AL3(OH)4 5+	1.74960E-25	1.17962E-30
V 3+	4.92052E-26	9.70182E-31	V 3+	1.04370E-43	2.05788E-48
UO2(H2PO4)2	4.03178E-25	8.72750E-31	UO2(H2PO4)2	4.03386E-25	8.73201E-31
MN 3+	5.76598E-27	1.05418E-31	MN 3+	3.95923E-18	7.23853E-23
U(HPO4)4 4-	1.70461E-27	2.75287E-33	U(HPO4)4 4-	3.61994E-45	5.84605E-51
H2V6O17 2-	6.63413E-28	1.14955E-33	H2V6O17 2-	6.63340E-28	1.14942E-33
H2SEO4	1.00558E-28	6.96692E-34			

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

Appendix A
Aqueous Speciation of constituents in Estimated Waste-Cell Leachate

Eh = 0.0 Volts			Eh = 0.5 Volts		
SPECIES	PPM	MOLALITY	SPECIES	PPM	MOLALITY
MOO2 2+	6.78321E-29	5.32528E-34	MOO2 2+	6.78321E-29	5.32528E-34
VOH +	3.81920E-30	5.64552E-35	VOH +	1.17976E-56	1.74392E-61
UOH 3+	1.22294E-29	4.81632E-35	UOH 3+	2.59386E-47	1.02155E-52
H2CRO4	3.10199E-30	2.64020E-35	H2CRO4	2.05352E-14	1.74782E-19
U(HPO4)3 2-	1.10978E-29	2.11929E-35	U(HPO4)3 2-	2.35588E-47	4.49891E-53
V 2+	4.41282E-31	8.70079E-36	V 2+	1.36316E-57	2.68775E-62
PB(OH)6 2-	4.60697E-31	1.49633E-36	PB(OH)6 2-	2.17206E-13	7.05479E-19
U(HPO4)2	1.79503E-31	4.19304E-37	U(HPO4)2	3.80934E-49	8.89829E-55
SIF6 2-	5.59232E-32	3.95353E-37	SIF6 2-	5.59228E-32	3.95350E-37
UO2(H2PO4)3 -	2.60205E-32	4.65881E-38	UO2(H2PO4)3 -	2.60419E-32	4.66263E-38
UF2 2+	5.00518E-33	1.82130E-38	UF2 2+	1.06156E-50	3.86286E-56
UF3 +	3.63191E-33	1.23649E-38	UF3 +	7.70285E-51	2.62245E-56
UF4	3.38219E-33	1.08181E-38	UF4	7.17313E-51	2.29436E-56
UF 3+	8.16813E-34	3.19196E-39	UF 3+	1.73246E-51	6.77015E-57
UHPO4 2+	7.46342E-34	2.24437E-39	UHPO4 2+	1.58343E-51	4.76161E-57
U(SO4)2	8.23956E-36	1.92399E-41	U(SO4)2	1.74754E-53	4.08062E-59
UF5 -	4.42369E-36	1.33422E-41	UF5 -	9.38202E-54	2.82968E-59
USO4 2+	3.34529E-36	1.00574E-41	USO4 2+	7.09522E-54	2.13314E-59
U 4+	3.99321E-37	1.68502E-42	U 4+	8.47000E-55	3.57410E-60
UF6 2-	7.54603E-38	2.15311E-43	UF6 2-	1.60043E-55	4.56649E-61
UCL 3+	1.40145E-39	5.14708E-45	UCL 3+	2.97251E-57	1.09171E-62
CR2O7 2-	7.32216E-42	3.40505E-47	CR2O7 2-	3.20898E-10	1.49228E-15
MO 3+	4.09938E-44	4.29172E-49	MO 3+	1.26637E-70	1.32579E-75
V2(OH)2 4+	4.25093E-45	3.14185E-50	H2V2O4 2+	1.39201E-41	8.32752E-47
U 3+	2.42153E-47	1.02182E-52	U 3+	7.48016E-74	3.15641E-79
MNO4 2-	2.38971E-51	2.01812E-56	MNO4 2-	5.31177E-16	4.48581E-21
V10O28 6-	1.40982E-51	1.47906E-57	V10O28 6-	1.40980E-51	1.47904E-57
PB(OH)8 4-	1.58176E-52	4.62842E-58	PB(OH)8 4-	7.45809E-35	2.18233E-40
HV10O28 5-	1.83567E-55	1.92380E-61	HV10O28 5-	1.83553E-55	1.92365E-61
MNO4 -	7.03952E-62	5.94489E-67	MNO4 -	1.07437E-17	9.07307E-23
PB 4+	9.02677E-62	4.37578E-67	PB 4+	4.25617E-44	2.06320E-49
H2V10O28 4-	1.12304E-61	1.17571E-67	H2V10O28 4-	1.12289E-61	1.17556E-67

Ion speciation in leachate solution modeled using WATEQF (Plummer et al., 1976), using a mean pH of 9.1 and a temperature of 12 degrees C. See text for further discussion.

APPENDIX B: HELP MODEL OUTPUT

To
Wayne Belchel
RMRS T893B
Fx 7193

FAX MEMO
PAGES ____ DATE ____ FAX # ____
TO ____
FROM ____
cc ____
PH # ____ FAX # ____

From
Leon Collins - RMRS
X 6700
3/25/96

6 Pages

output filename Rain1001.out

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	15.44	(2.909)	560443.0	100.00
RUNOFF	0.060	(0.0993)	2176.92	0.388
EVAPOTRANSPIRATION	14.299	(2.5270)	519043.47	92.613
LATERAL DRAINAGE COLLECTED FROM LAYER 6	1.08088	(0.64998)	39236.066	7.00090
PERCOLATION/LEAKAGE THROUGH FROM LAYER 8	0.00000	(0.00000)	0.135	0.00002
AVERAGE HEAD ACROSS TOP OF LAYER 8. Waste Layer in #10	0.001	(0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 13 Compacted Soil	0.00000	(0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH FROM LAYER 14	[illegible]	([illegible])	[illegible]	[illegible]
AVERAGE HEAD ACROSS TOP OF LAYER 14	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 15	0.00000	(0.00000)	0.051	0.00001
PERCOLATION/LEAKAGE THROUGH FROM LAYER 17	0.00000	(0.00000)	0.0848	0.00001

INITIAL SOIL WATER CONTENT = 0.1591 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.370000005000E-01 CM/SEC

LAYER 10

TYPE 1 - VERTICAL PERCOLATION LAYER - compacted Waste
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	204.00	INCHES
POROSITY	=	0.1680	VOL/VOL
FIELD CAPACITY	=	0.0730	VOL/VOL
WILTING POINT	=	0.0190	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 11

TYPE 1 - VERTICAL PERCOLATION LAYER - drainage Net.
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC

LAYER 12

TYPE 1 - VERTICAL PERCOLATION LAYER - Concrete slab with drain Pipes
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	[illegible]	INCHES
POROSITY	=	0.3600	VOL/VOL
FIELD CAPACITY	=	0.0358	VOL/VOL
WILTING POINT	=	0.0210	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0358	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000	CM/SEC

LAYER 13

TYPE 2 - LATERAL DRAINAGE LAYER - Gravel under Slab
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3600	VOL/VOL
FIELD CAPACITY	=	0.0358	VOL/VOL
WILTING POINT	=	0.0210	VOL/VOL

INITIAL SOIL WATER CONTENT	=	0.0358	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	235.0	FEET

LAYER 14

TYPE 4 - FLEXIBLE MEMBRANE LINER — Leachate Collection Membrane
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.08	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 15

TYPE 2 - LATERAL DRAINAGE LAYER — Geocomposite
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	1.00	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	1.00	PERCENT
DRAINAGE LENGTH	=	235.0	FEET

LAYER 16

TYPE 4 - FLEXIBLE MEMBRANE LINER — Leak detection Membrane
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.08	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	4 - POOR	

LAYER 17

TYPE 3 - BARRIER SOIL LINER — Bottom Clay
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 235. FEET.

SCS RUNOFF CURVE NUMBER	=	64.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES — actually only 4½ acres per 100K yd³ cell
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.939	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.438	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.828	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	49.658	INCHES
TOTAL INITIAL WATER	=	49.658	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR — Above Grade

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DENVER COLORADO

MAXIMUM LEAF AREA INDEX	=	1.80	
START OF GROWING SEASON (JULIAN DATE)	=	139	
END OF GROWING SEASON (JULIAN DATE)	=	254	
AVERAGE ANNUAL WIND SPEED	=	8.80 MPH	— slow!
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.00 %	wet
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	50.00 %	
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %	
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	54.00 %	∴ conservative for site.

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DENVER COLORADO

ERAGE HEAD ACROSS TOP OF LAYER 17	0.000	(0.000)		
CHANGE IN WATER STORAGE	0.000	(0.3851)	-13.57	-0.002

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	2.49	90387.000
RUNOFF	0.392	14236.7549
DRAINAGE COLLECTED FROM LAYER 6	0.58248	21143.84180
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000001	0.01920
AVERAGE HEAD ACROSS LAYER 8	0.330	
DRAINAGE COLLECTED FROM LAYER 13	0.00000	0.00001
PERCOLATION/LEAKAGE THROUGH LAYER 14	0.000000	0.00377
AVERAGE HEAD ACROSS LAYER 14	0.000	
DRAINAGE COLLECTED FROM LAYER 15	0.00000	0.00345
PERCOLATION/LEAKAGE THROUGH LAYER 17	0.000000	0.00025
AVERAGE HEAD ACROSS LAYER 17	0.000	
SNOW WATER	1.55	56425.5508

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2237

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0370

****

0.00025 ft^3/day

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      C:\HELP3\RAIN100.D4
TEMPERATURE DATA FILE:        C:\HELP3\RAIN100.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\RAIN100.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\RAIN100.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\RAIN18.D10
OUTPUT DATA FILE:             C:\HELP3\RAIN100N.OUT


TIME:  11:18      DATE:    4/ 7/1996


******************************************************************************

     TITLE:  interim cover (no cover)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   2
          THICKNESS                    =      12.00   INCHES
          POROSITY                     =       0.4370 VOL/VOL
          FIELD CAPACITY               =       0.0620 VOL/VOL
          WILTING POINT                =       0.0240 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.0495 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.579999993000E-02 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0572	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	1.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0981	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4178	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	[illegible]	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	204.00	INCHES
POROSITY	=	0.1680	VOL/VOL
FIELD CAPACITY	=	0.0730	VOL/VOL
WILTING POINT	=	0.0190	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0703	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3600	VOL/VOL
FIELD CAPACITY	=	0.0358	VOL/VOL
WILTING POINT	=	0.0210	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0522	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000	CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 43

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3600	VOL/VOL
FIELD CAPACITY	=	0.0358	VOL/VOL
WILTING POINT	=	0.0210	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0358	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	3.30900002000	CM/SEC
SLOPE	=	3.00	PERCENT
DRAINAGE LENGTH	=	235.0	FEET

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.08	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	2.00	HOLES/ACRE

```
FML INSTALLATION DEFECTS      =       2.00    HOLES/ACRE
FML PLACEMENT QUALITY         =  4 - POOR
```

LAYER 10

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

```
THICKNESS                     =       1.00    INCHES
POROSITY                      =       0.8500  VOL/VOL
FIELD CAPACITY                =       0.0100  VOL/VOL
WILTING POINT                 =       0.0050  VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.0100  VOL/VOL
EFFECTIVE SAT. HYD. COND.     =   10.0000000000       CM/SEC
SLOPE                         =       1.00    PERCENT
DRAINAGE LENGTH               =     235.0     FEET
```

LAYER 11

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

```
THICKNESS                     =       0.08    INCHES
POROSITY                      =       0.0000  VOL/VOL
FIELD CAPACITY                =       0.0000  VOL/VOL
WILTING POINT                 =       0.0000  VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.0000  VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY           =       2.00    HOLES/ACRE
FML INSTALLATION DEFECTS      =       2.00    HOLES/ACRE
FML PLACEMENT QUALITY         =  4 - POOR
```

LAYER 12

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

```
THICKNESS                     =      36.00    INCHES
POROSITY                      =       0.4270  VOL/VOL
FIELD CAPACITY                =       0.4180  VOL/VOL
WILTING POINT                 =       0.3670  VOL/VOL
INITIAL SOIL WATER CONTENT    =       0.4270  VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.100000001000E-06 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 2 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 235. FEET.

SCS RUNOFF CURVE NUMBER	=	73.10	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.740	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.866	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.432	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	35.229	INCHES
TOTAL INITIAL WATER	=	35.229	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM DENVER COLORADO

MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	137	
END OF GROWING SEASON (JULIAN DATE)	=	254	
AVERAGE ANNUAL WIND SPEED	=	8.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	50.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	54.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DENVER COLORADO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.51	0.69	1.21	1.81	2.47	1.58
1.93	1.53	1.23	0.98	0.82	0.55

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR DENVER COLORADO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.50	33.60	38.00	47.40	57.20	67.00
73.30	71.40	62.60	51.90	38.70	32.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DENVER COLORADO

STATION LATITUDE = 39.77 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.53	0.78	1.25	1.75	2.39	1.60
	2.01	1.48	1.32	0.92	0.80	0.61
STD. DEVIATIONS	0.37	0.44	0.66	0.98	1.21	0.94
	1.12	0.84	0.88	0.71	0.55	0.36
RUNOFF						
TOTALS	0.006	0.028	0.023	0.000	0.001	0.000
	0.000	0.000	0.000	0.000	0.000	0.004
STD. DEVIATIONS	0.020	0.076	0.066	0.000	0.005	0.001
	0.000	0.000	0.001	0.000	0.002	0.018
EVAPOTRANSPIRATION						
TOTALS	0.549	0.592	1.076	1.521	2.096	1.703
	2.215	1.372	1.217	0.763	0.717	0.613
STD. DEVIATIONS	0.262	0.338	0.465	0.688	0.913	0.826
	0.932	0.767	0.693	0.512	0.440	0.306
LATERAL DRAINAGE COLLECTED FROM LAYER 8						
TOTALS	0.0521	0.0451	0.0464	0.0415	0.0393	0.0353
	0.0414	0.0479	0.0530	0.0563	0.0548	0.0554
STD. DEVIATIONS	0.0224	0.0211	0.0243	0.0247	0.0263	0.0267
	0.0264	0.0254	0.0190	0.0187	0.0177	0.0198
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0325	0.0284	0.0299	0.0272	0.0262	0.0232
	0.0265	0.0295	0.0325	0.0343	0.0335	0.0340
STD. DEVIATIONS	0.0102	0.0095	0.0110	0.0114	0.0126	0.0137
	0.0136	0.0133	0.0089	0.0085	0.0076	0.0085
LATERAL DRAINAGE COLLECTED FROM LAYER 10						

TOTALS	0.0325	0.0284	0.0299	0.0272	0.0262	0.0232
	0.0265	0.0295	0.0325	0.0343	0.0335	0.0340
STD. DEVIATIONS	0.0102	0.0095	0.0110	0.0114	0.0125	0.0137
	0.0136	0.0133	0.0089	0.0085	0.0076	0.0085

PERCOLATION/LEAKAGE THROUGH LAYER 12

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 9

AVERAGES	0.0010	0.0010	0.0009	0.0009	0.0008	0.0008
	0.0008	0.0010	0.0011	0.0011	0.0011	0.0011
STD. DEVIATIONS	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005
	0.0005	0.0005	0.0004	0.0003	0.0003	0.0004

DAILY AVERAGE HEAD ACROSS LAYER 12

AVERAGES	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003
	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	15.44	(2.909)	560443.0	100.00
RUNOFF	0.062	(0.0998)	2251.85	0.402
EVAPOTRANSPIRATION	14.434	(2.5623)	523949.44	93.488
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.56843	(0.21235)	20634.100	3.68175
ERCOLATION/LEAKAGE THROUGH FROM LAYER 9	0.35784	(0.09918)	12989.652	2.31775
AVERAGE HEAD ACROSS TOP OF LAYER 9	0.001	(0.000)		

LATERAL DRAINAGE COLLECTED FROM LAYER 10	0.35783 (	0.09919)	12989.262	2.31768
ERCOLATION/LEAKAGE THROUGH FROM LAYER 12	0.00001 (	0.00000)	0.0205	0.00004
AVERAGE HEAD ACROSS TOP OF LAYER 12	0.000 (	0.000)		
CHANGE IN WATER STORAGE	0.017 (	0.7303)	618.08	0.110

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	2.49	90387.000
RUNOFF	0.394	14310.1660
DRAINAGE COLLECTED FROM LAYER 8	0.00395	143.20885
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.001778	64.55125
AVERAGE HEAD ACROSS LAYER 9	0.002	
DRAINAGE COLLECTED FROM LAYER 10	0.00169	61.37564
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.000000	0.00078
AVERAGE HEAD ACROSS LAYER 12	0.001	
SNOW WATER	1.55	56425.5508

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.1896
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0146

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	0.3697	0.0308
2	1.8921	0.1577
3	0.4370	0.4370
4	2.5620	0.4270
5	14.8920	0.0730
6	0.0160	0.0800
7	0.9514	0.0793
8	0.4296	0.0358
9	0.0000	0.0000
10	0.0104	0.0104
11	0.0000	0.0000
12	15.3720	0.4270
SNOW WATER	0.000	

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Appendix H

NEPA Values Analysis Backup Documentation

Table H-1 Summary of Criteria Used to Evaluate Environmental Impacts[1]

Criteria	Included in Onsite vs Offsite Screen	Included in Siting Study	Included in Facility Design Screen	Included in Final Comparison	Included in OU 4 February DD
Human Health	§B7.1, Table 7.1		(A1, A2, A4, B1, F6)	NCP threshold: human health & regulatory requirements	§IV.10.1
Environment	§B7.2	§C2.4.1, §C2.4.3	Broken into the following criteria	NCP threshold: human health & regulatory requirements	Table IV.10-22
Ecological Risk	§B7.3.3	§C2.4.1			§IV.10.2
Air Quality	§B7.3.1, §B7.3.2, §B7.3.3		(F5)		§IV.10.3
Water Quality	§B7.3.1, §B7.3.2, §B7.3.3	§C2.4.1	(B1, B5, B10, B11, B12)		§IV.10.4, §IV.10.5
Soils & Sediments	§B7.3.1, §B7.3.2, §B7.3.3				
Irretrievable/Irreversible Commitment of Resources		§C2.4.2, §C2.4.4, §C2.4.6	(C8, E6)		§IV.10.6
Natural Phenomenon Mitigation/ Mitigation Measures		§C2.4.1	(B2, B3)		§IV.10.7
Transportation		§C2.4.2			§IV.10.8
Short-term vs. Long-term		§C2.4.1, §C2.4.2, §C2.4.3	(A5, A6, F7)	NCP primary balancing: long-term and short-term effectiveness, treatment	§IV.10.9
Cultural/archeological Resources					§IV.10.10
Cumulative Impacts		§C2.4.2	(C1, C9)		§IV.10.11
Direct/Indirect Effects[2]					Table IV.10-22

1) This table identifies the selection in this DD containing criteria used to evaluate the NEPA-values in the Onsite vs Offsite Evaluation (Appendix B) and the Remediation Waste Storage Facility Siting Study. For the Facility Design Screen, the criteria alpha-numeric designation is shown; these criteria are noted throughout the screen. For the Final Comparison, the related NCP criteria are listed. The Solar Ponds location was evaluated in the OU 4 February Proposed DD, and the sections where the criteria are discussed are also indicated. Additional criteria were also used in some of the studies (for example, cost); for a complete listing of the criteria used in each study, see the appropriate document section.

2) Direct effects which occur at the same time and place as an action and indirect effects which occur at a later time and greater distance are generally considered by medium in this criterion

Table H-2 Summary of Results: Evaluation of Environmental Impacts Onsite vs. Offsite Waste Management

Criteria	Potential Impact Onsite	Potential Impact Offsite	Potential Impact for No Action
• **Schedule**	The concept of reducing overall risk to the public and the environment [from unremediated locations at RFETS] is more attractive than an extended waste removal process using offsite disposal. §B6.0	-	-
• **Human Health**	After the waste is placed in the cell, the risks associated with onsite and offsite disposal should not be significantly different. During construction, risk to the public will be minimal and worker risks can be tightly controlled. §B7.1	National statistics suggest five accidents would occur during transportation of the waste. The magnitude of risk to the public is difficult to quantify; however these exposures would be involuntary and uncontrolled. §B7.1 & Table 7-1	Presents the greatest human health risk to the community in the long-term, depending on future actions taken to prevent migration and future land uses. These risks are calculated for selected Buffer zone operable units to be low. Industrial Area risks have not been calculated, but are expected to be higher. §B7.1
• **Environmental**	Long-term waste management options onsite and offsite were deemed to be equally effective in containing contaminants because of similar design and similar regulatory requirements. §B7.2	-	-
- **Air Quality**	Vehicle exhausts and potential for spills exists. Fugitive dust during excavation and placement. §B7.3.3	Vehicle exhausts and potential for spills exists. Fugitive dust during excavation and placement. §B7.3.2	There could be local air quality impacts resulting from future events such as construction or erosion. §B7.3.1
- **Ecological**	Impacts would depend on the location of the RWSF. Impacts would be minimized if the selected location was previously developed. Impacts expected to be minimal. §B7.3.3	No direct impact expected. A spill could create impacts. §B7.3.2	Not significant. §B7.3.1
- **Soils & Sediments**	Minimal damage to topsoil, site selection and erosional controls would minimize impacts. Spills could impact surface soils. §B7.3.3	No direct impact expected. A spill could create impacts. §B7.3.2	Contamination could spread. §B7.3.1
- **Water Quality**	No impact on water quality is anticipated. A spill could create impacts, however this risk is lower than the offsite option due to close proximity of an onsite RWSF. §B7.3.3	No direct impact expected. A spill could create impacts. §B7.3.2	Groundwater plumes will continue to spread. §B7.3.1

This table shows which screening-criteria include evaluations of environmental impacts, summarizes the potential environmental impacts of the three alternatives screened, and references the document section where more information is available. See also Table 7-2 in Appendix B for summary of the study results.

Table H-3 Summary of Results: Evaluation of Environmental Impacts Remediation Waste Storage Facility Siting Study[1]

Criteria	Potential Impacts for Onsite Locations	Specific to Proposed Location at Solar Ponds Area
Environment	• All sites have approximately the same geomorphic conditions with the degree of erosion occurring at a predictable rate. (§2.4.2 Public Protection) • A reliable, effective, and protective facility can be engineered at any of the sites being considered. (§2.4.1 CAMU)	none noted
Ecological Risk	• The presence of significant springs and seeps in certain Buffer Zone sites reduces their suitability because of potential impacts to sensitive habitats. (§2.4.2 Public Protection)	none noted
Ground Water Quality	• All the sites are located in recharge areas. (§2.4.2 Public Protection) • All of the sites have minimal groundwater flow. (§2.4.2 Public Protection) • Downward migration from the unconfined aquifer is thought to be nonexistent.. (§2.4.2 Public Protection) • Groundwater flow in fractured claystone bedrock is thought to be minimal. (§2.4.2 Public Protection) • The sites have seasonally shallow water tables that may require engineered barriers. (§2.4.2 Public Protection)	• Local variations in shallow bedrock lithology at the Solar Ponds area is caused by subcropping sandstones, but vertical flow to deeper sandstones and the Laramie/Fox Hills aquifer is minimal. (§2.4.2 Public Protection)

[1]This table summarized the results of the evaluations for the Onsite Remediation Waste Storage Facility Siting Study. References in the table indicate the section of the study where discussion of the criteria are found.

Table H-3 (continued)

Criteria	Potential Impacts for Onsite Locations	Specific to Proposed Location at Solar Ponds Area
Surface Water Quality	• Estimates of lateral groundwater travel times from the proposed sites to their nearest discharge pints are well below 1,000 years. (§2.4.2 Public Protection) • None of the sites are located in areas that will be impacted by surface water. The sites are not expected to have a significant impact on surface water. (§2.4.2 Public Protection)	none noted
Irretrievable/ Irreversible Commitment of Resources	• Alluvial thicknesses greater than 40 feet are potentially economic for the gravel resource. Portions of the Buffer Zone have alluvial thicknesses of 40 feet or more. (§2.4.3 RFETS Special Issues) • Minimization of the land area upon which remediation wastes would remain in place is generally dependent on the design selected rather than location. (§2.4.3 RFETS Special Issues) • Jefferson County has stated a desire to maintain the Buffer Zone as undeveloped open space; sites in the Buffer Zone would impinge on this. (§2.4.6 Other Stakeholder Concerns)	• Solar Ponds area do not constitute an economical gravel resource. (§2.4.3 RFETS Special Issues) • The Solar Ponds site coincides with the Site Vision by locating the WMF within the larger footprint of the final cap cove. (§2.4.3 RFETS Special Issues & §2.4.4 Regulator Support) • Sites within the Industrial Area, including the Solar Ponds area, would be more readily acceptable. (§2.4.6 Other Stakeholder Concerns)
Natural Phenomenon Mitigation/ Mitigation Measures	• Geotechnical stability of foundation soils is not expected to be a problem at any of the sites. (§2.4.2 Public Protection) • The inferred bedrock faults are not considered to pose a seismic risk. (§2.4.2 Public Protection)	none noted

Table H-3 (continued)

Criteria	Potential Impacts for Onsite Locations	Specific to Proposed Location at Solar Ponds Area
Transportation	• Most of the waste targeted for the RWSF originates in the Industrial Area; haul distances would be shorter to sites inside the Industrial Area. (§2.4.3 RFETS Special Issues)	none noted
Short-term vs. Long-term	• The presence of significant clay fraction provides a relatively favorable environment for waste disposal, especially for strongly sorbed contaminants such as metals. (§2.4.2 Public Protection) • Several locations would require construction or upgrade of the onsite roads and site preparation, including building demolition, subsurface line removal, and rerouting access. (§2.4.3 RFETS Special Issues) • The timing of remedial activity implementation is more dependent on the WMF design and the permitting process than on the site selected. (§2.4.1 CAMU)	• Site preparation costs for the Solar Ponds area are at the upper end of the range for the various sites. (§2.4.3 RFETS Special Issues)
Cumulative Impacts	•Impacts from plutonium consolidation or residue stabilization activities are not a factor for siting the WMF. (§2.4.3 RFETS Special Issues)	•Solar Ponds would be an ideal candidate to support the Site Vision (i.e., Buffer Zone as open pace and Industrial Area as industrial/waste management) (§2.4.3 RFETS Special Issues)

Table H-4 Summary of Results: Evaluation of Environmental Impacts Facility Design Screen

Attributes	Design										
	Above-grade Landfill	**Concrete Lined Cell with Bulk Placement**	**Concrete Lined Cell with Cargo Containers**	**Hardened Concrete Vault**	**Silo Design**	**Slab on Grade**	**Metal Buildings**	**Entomb-ment**	**Pyramid Design**	**Waste Pile**	**No Action**
Ground-water Protection	waste isolated from substrate and ground-water, run-off diverted to edges	provides reasonable assurances substrate and ground water protected, drainage around cap	see previous column; containers provide an additional barrier	drainage around cap	drainage around cap, includes a liner system	temporary facility, maintenance to avoid cracks	adequate for 30 years	numerous barriers	could require more maintenance to maintain protectiveness	adequate for 30 years	equivalent to better than landfill
Consistency	relatively larger footprint, supports Site Vision	relatively smaller footprint, supports Site Vision	relatively smaller footprint, supports Site Vision	footprint not as large as some options, some resource competition with TYP activities	small footprint, ties well to Site Vision	large footprint, short-term support to Site Vision	large footprint, short-term support to Site Vision	very large footprint, could negatively impact other Site activities	large footprint, timing could impact RFCA and TYP activities	does not support RFCA	consistent with RFCA

The facility design screen compared designs independent of location. This screen addresses technical issues and is not a primary source of environmental evaluation. Potential impacts are inherent in some of the criteria. The potential impacts to the environment cluster around a few attributes:

- Some designs offer more protection to the groundwater; the presence or absence of a liner and leachate collection system being an important design feature.
- Designs that are consistent with the Site Vision tend to reduce commitment of land. Location of the facility would also effect the consistency.

Table H-5 Summary of Results: Evaluation of Environmental Impacts Proposed Facility Design at Solar Ponds Location[1]

Criteria	Potential Impacts
Human Health §IV.10.1	Minimize existing risks due to long-term potential exposure to surficial soil, vadose zone soil, materials from D&D, and other remediation waste*(including all soils and materials noted in the list of wastes tentatively planned for placement in the RWSF)*. Short-term risks due to worker exposure to remediation waste that exceed PRGs during remediation. Potential adverse effects to workers as a result of encountering unknown utilities or uncharacterized areas of high contamination. Risks to workers associated with soil excavation, relocation, treatment processes and construction activities (e.g., increased fugitive dust generation, increased transportation requirements)
Environment Table IV.10-22	Temporary physical disruption of industrial area during construction; *approximately 10 acres for RWSF* affected by soil excavation, material staging, and construction activities Temporary physical disruption of borrow area used for clean fill material Increased local traffic requirements, increased dust generation during construction *and possibly during operation*, and increased potential for erosion due to changes in surface topography at *both the construction area* and borrow area Three small wetlands *may* require protection during construction, *depending on the details of the RWSF construction*. Wetlands banking *may be* considered as a mitigation measure *if the detailed design or in-field activities indicate impacts to the wetlands occur*. Mitigation measures may be required for the Prebles Meadow Jumping Mouse, which is being considered for listing as a federal endangered species. No floodplains will be affected
Ecological Risk §IV.10.2	*The area* has been characterized as a highly disturbed industrial area which can support only the most hardy species of plants and animals. The natural environment at and adjacent to *the RWSF site* has been significantly altered by construction and operation of the SEPs *(Solar Evaporation Ponds)* and other industrial facilities.... It is highly probable that these construction activities will interfere with any existing vegetation and animal use of the site.
Air Quality §IV.10.3	*Atmospheric dispersion calculations were prepared for the project proposed in the OU 4 Proposed IM/IRA-EA Decision Document. Those calculations demonstrate little risk due to exposure to site contaminants to remediation workers, on-site workers, or the public during construction. The original project included considerable excavation; the RWSF as currently envisioned will be constructed with less excavation and so should create less fugitive dust.* Potential increase in PM_{10} emissions at both *the construction area* and the borrow areas during construction
Ground Water Quality §IV.10.4	Potential effect on local hydrogeology by reducing percolation and changing topography in a potential recharge area *(Impacts specific to the design from the OU 4 DD have been omitted)*

[1]This table summarized the results of the evaluations at the Solar Ponds location. For further information, see indicated portion of Section IV.10 and Table IV.10-22 from the *OU 4 Proposed IM/IRA-EA Decision Document* (February, 1995). Some modifications from the OU 4 document are included in the RWSF; those modifications are noted by *italics*.

Table H-5 (continued)

Criteria	Potential Impacts
Surface Water Quality §IV.10.5	No surface water bodies exist within *the construction area* Consolidation of soil contamination *in the RWSF* will minimize or eliminate precipitation run-off *potentially contaminated by remediation wastes* *(Impacts specific to the design from the OU 4 DD have been omitted)*
Irretrievable/ Irreversible Commitment of Resources §IV.10.6	Clean fill from borrow areas, construction materials, and area underneath and adjacent to *the RWSF. No significant impact is expected in the selected site east of Solar Ponds since it is an IHSS and has already been impacted by previous and current industrial uses.*
Natural Phenomenon Mitigation/ Mitigation Measures §IV.10.7	*The design proposed in the OU 4 DD and the final, capped form of the RWSF are similar. The OU 4 DD considered damage from excess snow loading, lightning strikes, tornado generated missile impacts, meteorite impacts, volcanism: these were found to be incredible or unlikely to cause damage. Glacial activity and reactivation of the alluvial fan would not effect the site within the timespan of 1,000 years used in the evaluation. Wind erosion and flooding would not damage the site. Earthquake analysis suggested the conditions under which a seismically induced slope failure could occur. Several faults are known to exist in the vicinity of Rocky Flats. None of the faults investigated to date have been found capable (movement within the last 1 million years displacing alluvial sediments). DOE will investigate the RWSF for capable faults before finalizing the design and proceeding to construction.*
Transportation §IV.10.8	Minor increase in traffic volume and patterns during construction activities; negligible impact on surrounding transportation infrastructure
Short-term vs. Long-term §IV.10.9	Short-term interruption of industrial area and borrow area required to minimize potential risks associated with exposure to site contamination Construction of *RWSF* will preclude unrestricted use of area underlying and adjacent to *the RWSF*
Cultural/ Archeological Resources §IV.10.10	No resources present
Cumulative Impacts §IV.10.11	Implementation of the preferred IM/IRA is consistent with the long-term mission of remediating the RFETS Implementing may interfere slightly with other activities in progress at the RFETS *(Impacts specific to the design from the OU 4 DD have been omitted)*
Direct/Indirect Effects Table IV.10-22	As described above Remediation of OU 4 sludges *and other remediation wastes to be placed in the RWSF* currently stored onsite will be expedited Short-term direct increase in remediation jobs; indirect job loss due to eliminating production functions at RFETS

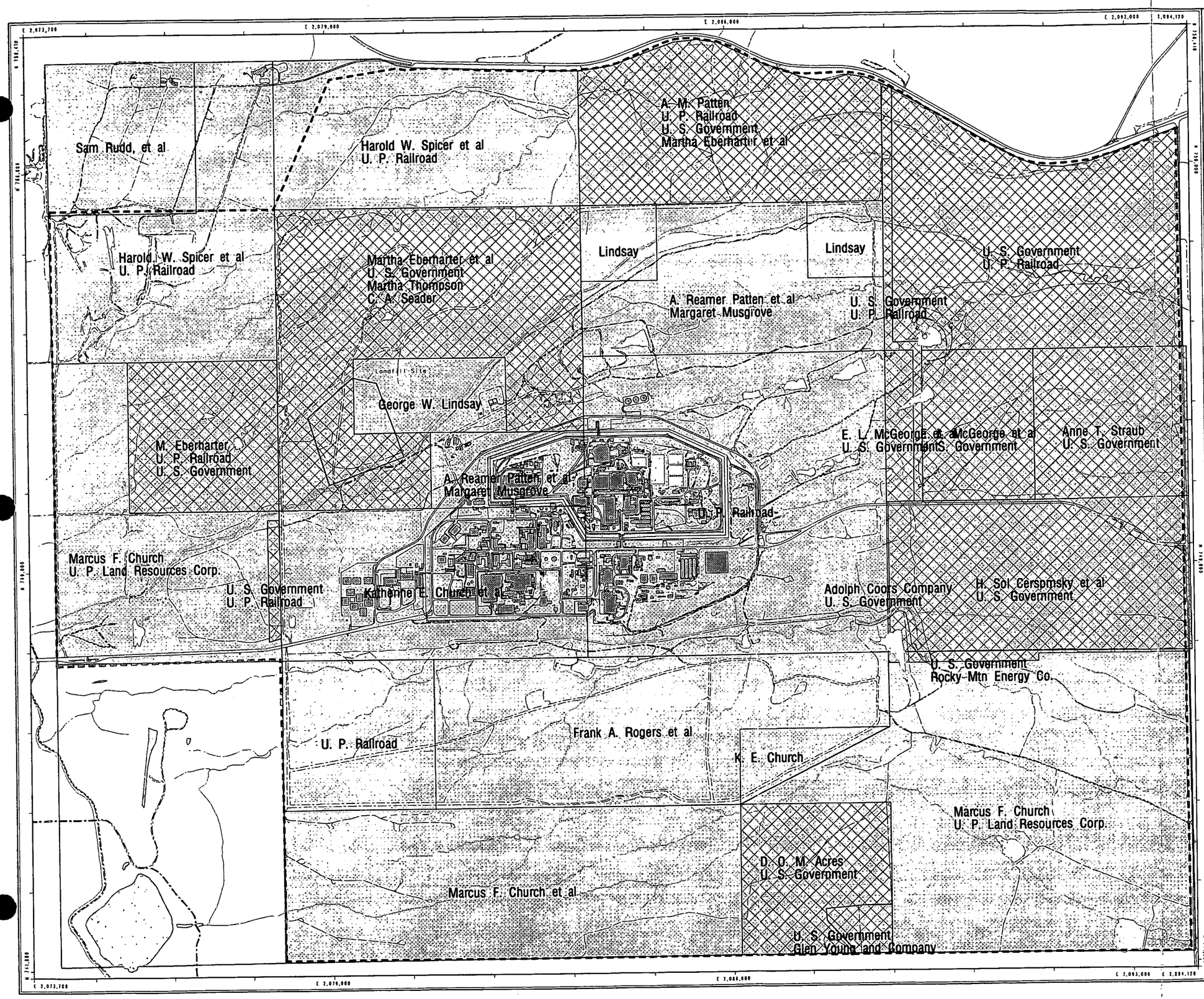

Figure 8
Mineral Ownership Map

EXPLANATION

- Private
- Government
- Both Government and Private

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

N

Scale = 1 : 19640
1 inch represents approximately 1637 feet

800 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

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August 14, 1996

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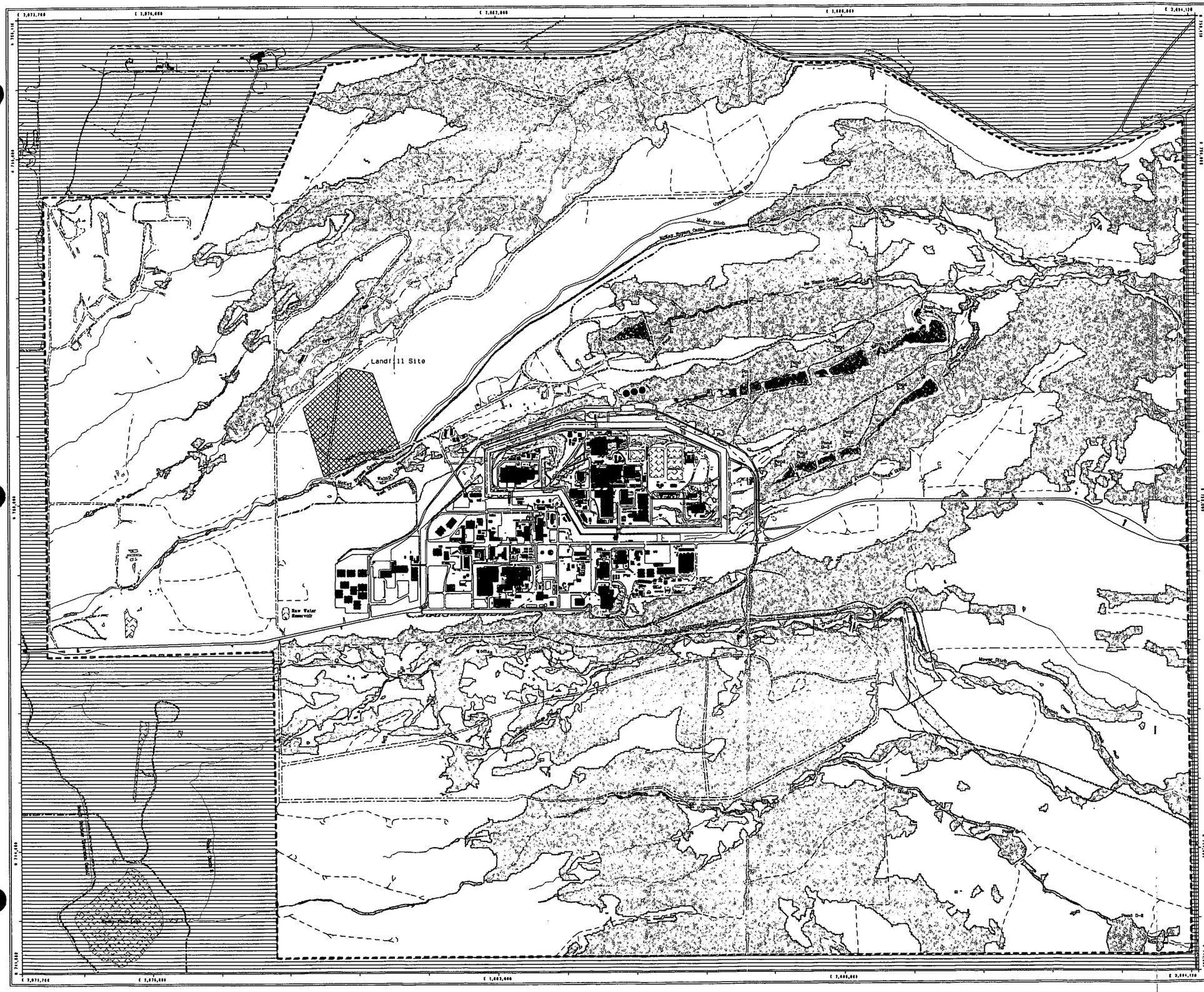

Figure 7
Adverse (for RWSF siting) Conditions Map

EXPLANATION

NOTE:
This map was created using the analytical capabilities of ARC/INFO. Three data layers (coverage's) were combined, representing physical restraining criteria, each given an equal weighting factor: wetlands, 100-year floodplain, and slopes greater than 15%. The surface was color coded based on the number of criteria present.
Point and line wetland features have a 50 foot buffer around them for better visibility.

WMF = Waste Management Facility

- Lands best suited for the placement of a Waste Management Facility, based on criteria stated above
- One criterion present
- Two criteria present
- Three criteria present (least suitable location)

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
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MAP ID: x7707 October 15, 1996

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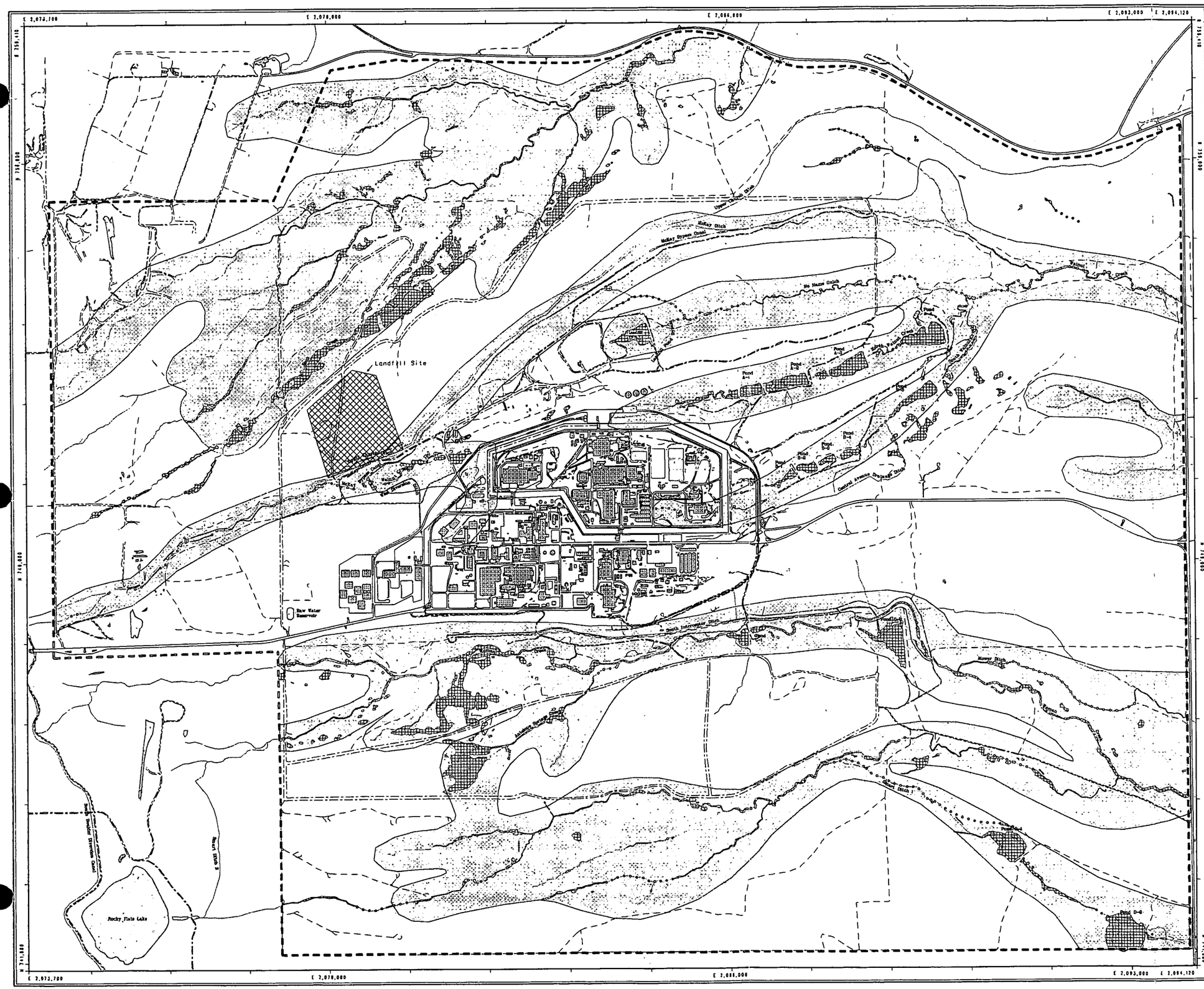

Figure 6

Ecology and NEPA Map

EXPLANATION

Wetland Features

- Wetlands
- Point Wetlands (< 10ft Diameter)
- Linear Wetlands (< 10ft wide)

Preble's Meadow Jumping Mouse

- Probable Range

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

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Scale = 1 : 19840
1 inch represents approximately 1637 feet

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August 08, 1996

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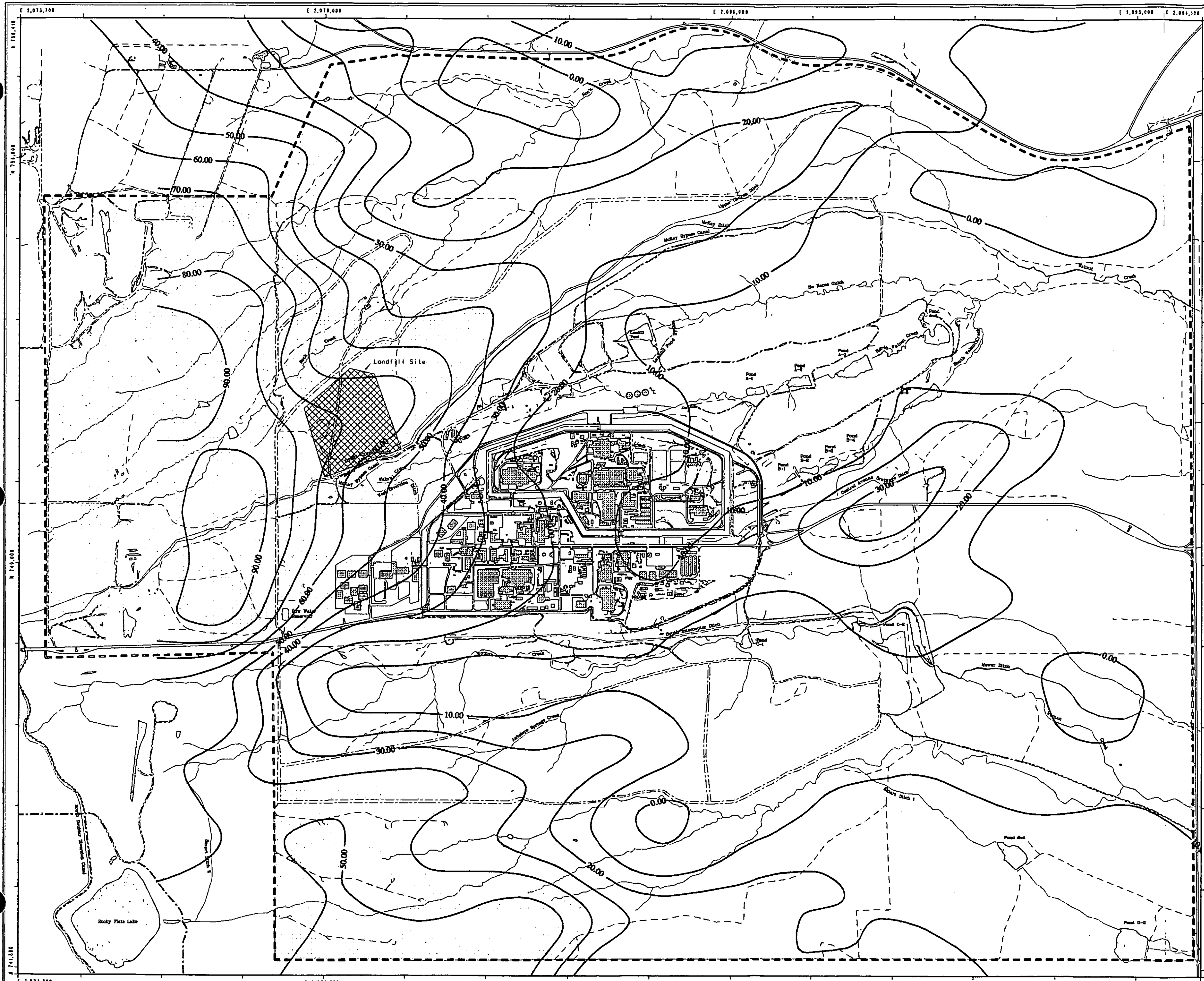

Figure 5
Thickness of Alluvium

EXPLANATION

- Thickness of alluvium
- Alluvium thickness greater than or equal to 40 Ft.

NOTE:
Potential economic thickness is 40 feet plus

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
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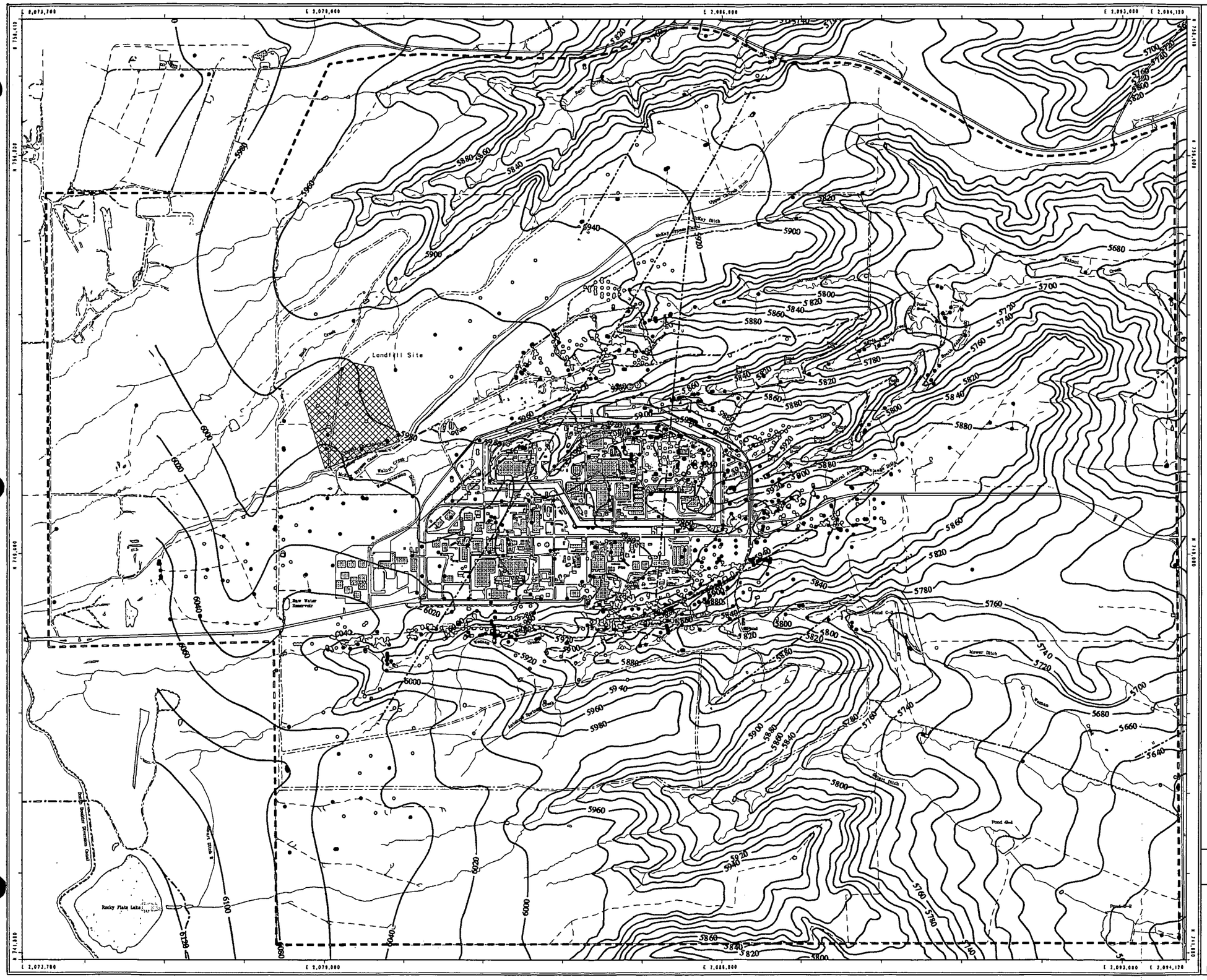

Figure 4

Structure Base of Alluvium

EXPLANATION

- Structure base of alluvium (top of bedrock elevation)
- Fault line - dashed where inferred
- Groundwater wells
- Boreholes

Standard Map Features

- Buildings or, other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
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Hydrology provided by USGS - (date unknown)

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600 0 1000 2000ft

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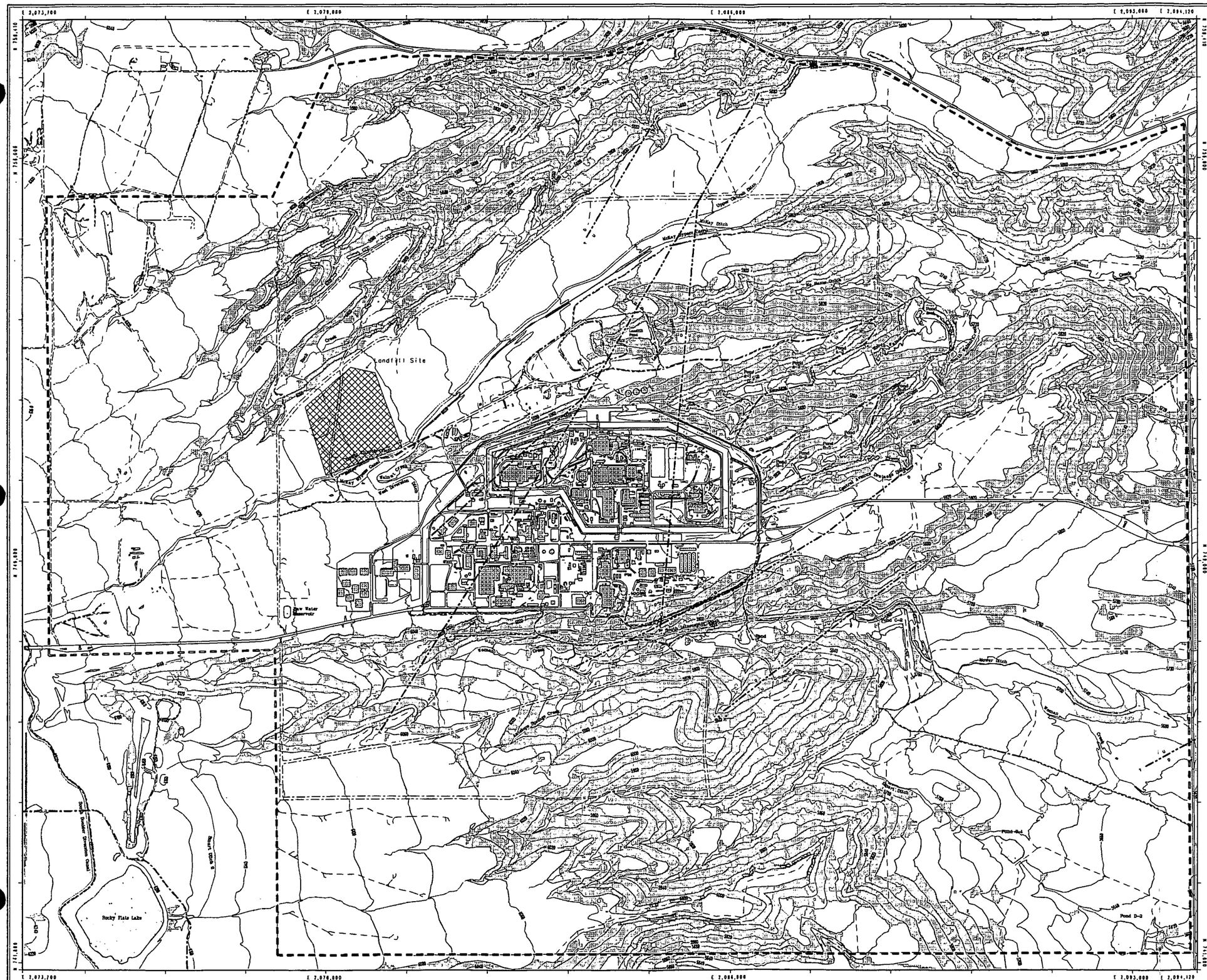

Figure 3

Geological and Geotechnical Conditions

EXPLANATION

Fault line - dashed where inferred

Slope Categories

- Slope = 15% - 20%
- Slope = 20% - 30%
- Slope > 30%

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

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August 08, 1996

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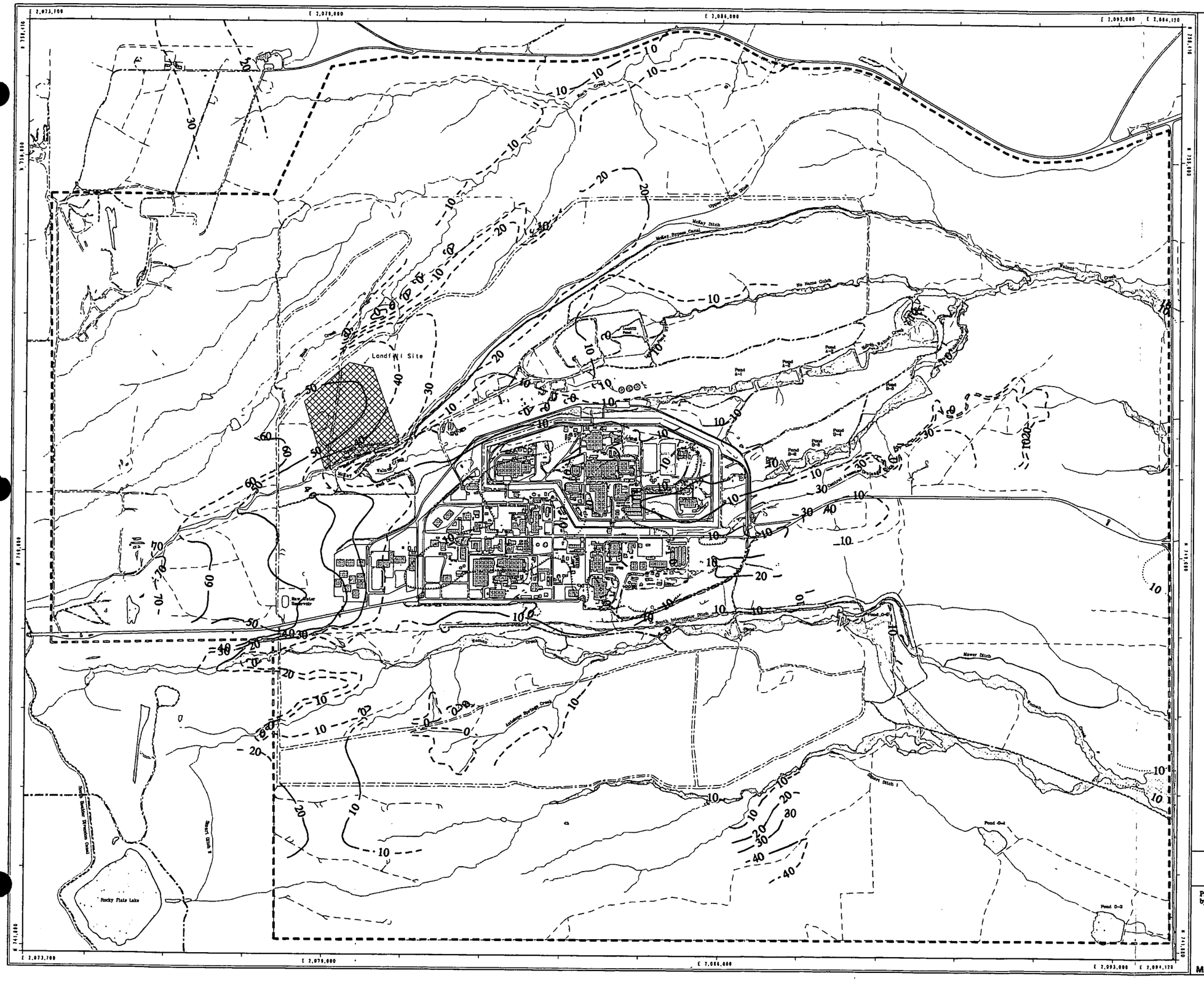

Figure 2
Hydrogeological Conditions

EXPLANATION

- Line of Equal Depth to Water (in feet)
- (dashed where inferred)
- Decreasing Line of Equal Depth to Water (in feet)
- (dashed where inferred)

Standard Map Features

- Buildings or other structures
- 100 year floodplain
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
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Hydrology provided by USGS - (date unknown)

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State Plane Coordinate Projection
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August 08, 1996

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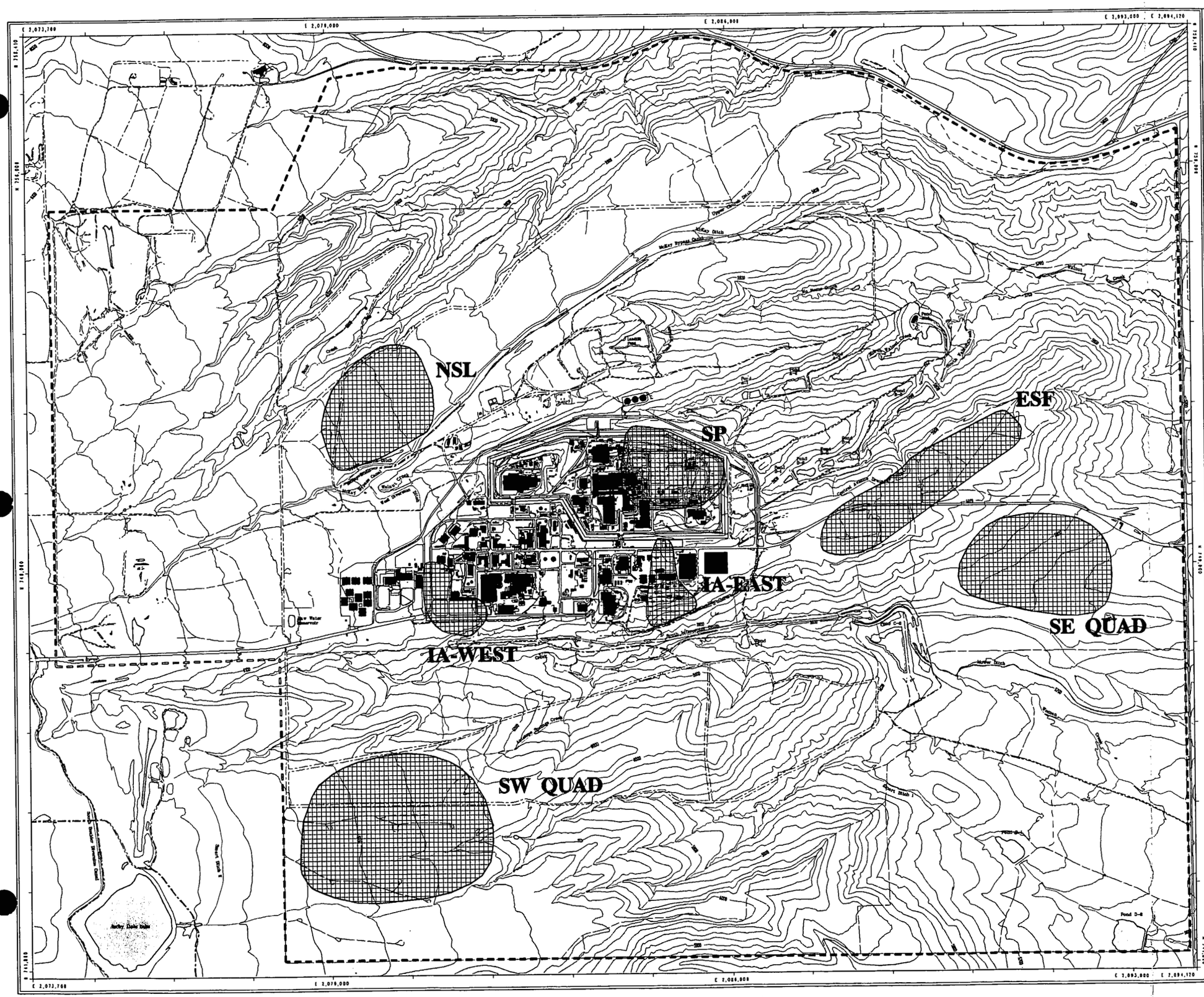

Figure 1
Location Map

EXPLANATION

Potential RWSF Sites

NSL - New Sanitary Landfill
ESF - East Spray Field
SP - Solar Ponds plus IHSS 165 and 176

SW QUAD - Southwest Quadrant
SE QUAD - Southeast Quadrant
IA WEST - Industrial Area West
IA EAST - Industrial Area East

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, or other drainage features

Fences

Contours (20' Intervals)

Rocky Flats boundary

Paved roads

Dirt Roads

Trails

DATA SOURCE:
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Hydrology provided by USGS - (date unknown)

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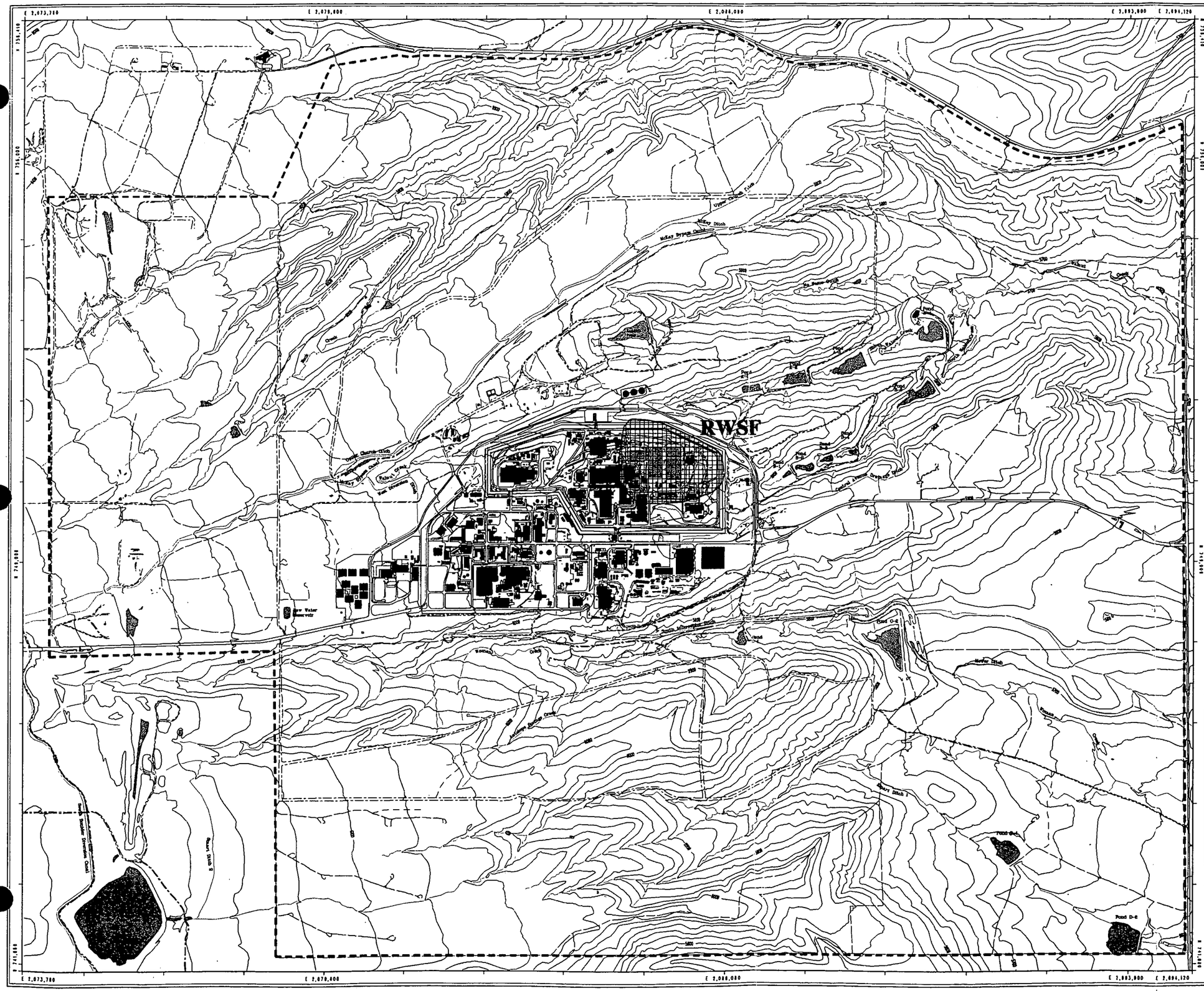

Selected Figure 7-1
Site Location Map

EXPLANATION

Potential RWSF Sites

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
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MAP ID: x8682

November 04, 1996

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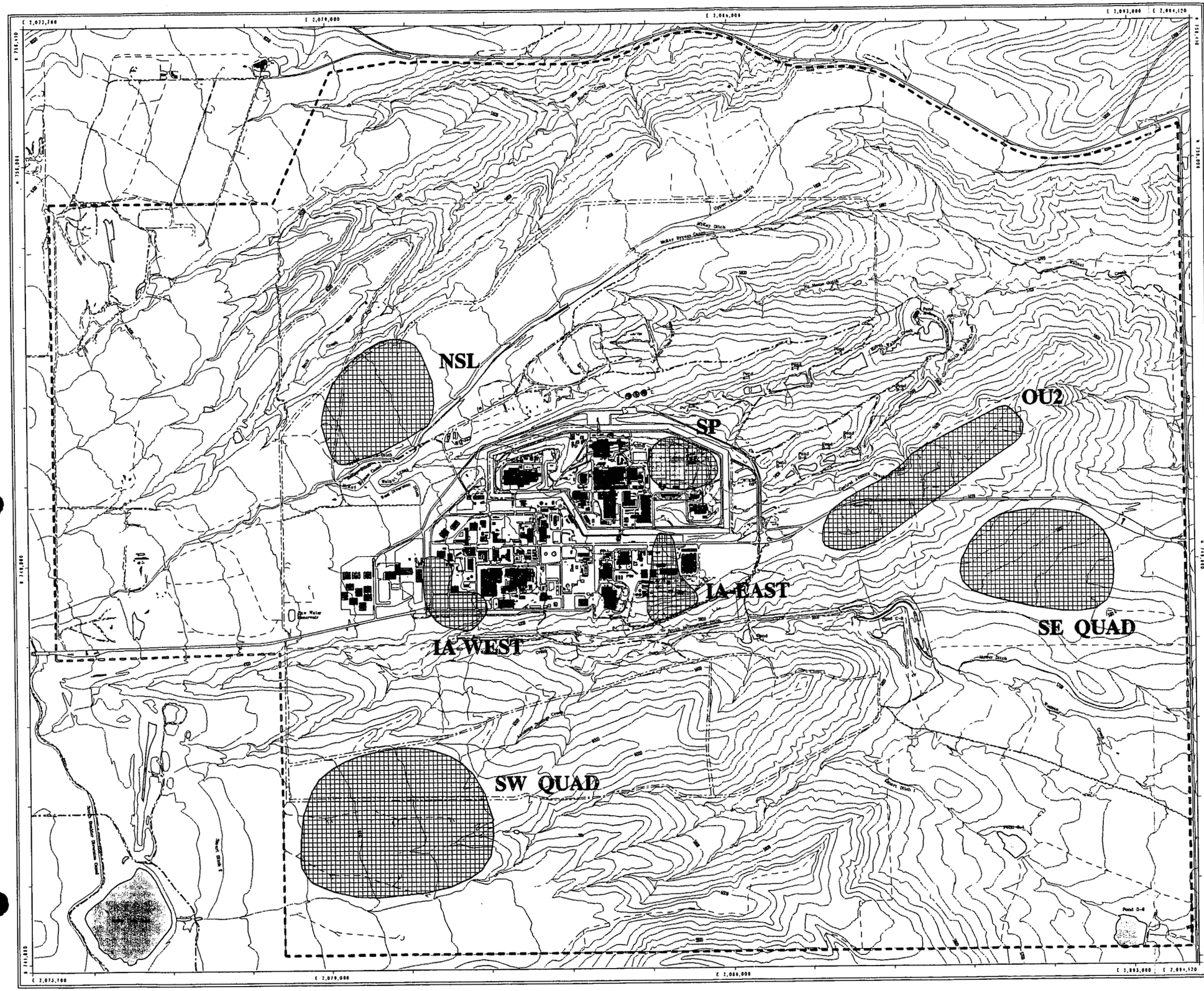

Figure 5-2
Location Map

EXPLANATION

Potential RWSF Sites

NSL - New Sanitary Landfill
ESF - East Spray Fields
SP - Solar Ponds plus IHSS 165 and 176

SW QUAD - Southwest Quadrant
SE QUAD - Southeast Quadrant
IA WEST - Industrial Area West
IA EAST - Industrial Area East

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt Roads
- Trails

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)

Scale = 1 : 19640
1 inch represents approximately 1637 feet

600 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

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MAP ID: 97-0014

October 28, 1996

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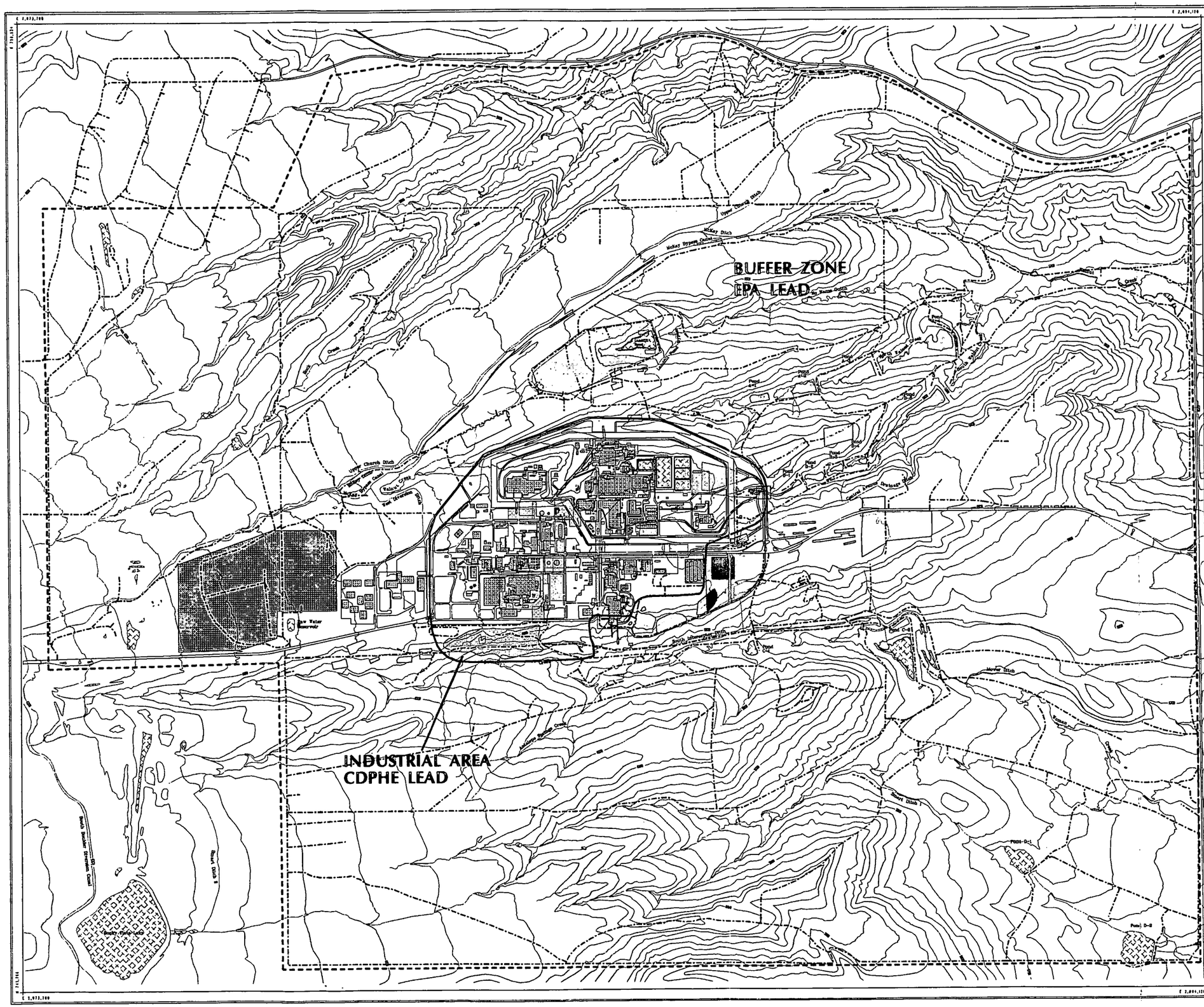

Figure 1-2
Proposed Consolidated Operable Units

Conceptual Strategy Purposes for Discussion Only

See paragraph 67 of RFCA

EXPLANATION

Note: OU3 not shown

- Industrial Area OU
- Buffer Zone OU
- Operable Unit 1
- Operable Unit 5
- Operable Unit 6
- Operable Unit 7
- Operable Unit 11 Closed through CAD/ROD Process
- Operable Unit 15 Closed through CAD/ROD Process
- Operable Unit 16 Closed through CAD/ROD Process
- Individual Hazardous Substance Sites (IHSS)

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, roads, and fences provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology provided by USGS - (date unknown)
Proposed Consolidated OU's data provided by Annette Primrose of RMRS/SA - 8-1996.

Scale = 1 : 19910
1 inch represents approximately 1659 feet

800 0 1000 2000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

MAP ID: x8882 August 14, 1996

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