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Environmental Restoration Program

Removal Action
Engineering Evaluation/Cost Analysis
Operable Unit 4, Miami-Erie Canal

Mound Plant
Miamisburg, Ohio

Final

Prepared For:
EG&G Mound Applied Technologies
and
The U.S. Department Of Energy

Prepared By:

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April 1994

FOR CIRCULATION

ENVIRONMENTAL RESTORATION PROGRAM

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FINAL

ACRONYMS

AEC	Atomic Energy Commission
AL	Albuquerque Operations Office
ALARA	As Low As Reasonably Achievable
ARAR	Applicable or Relevant and Appropriate Requirements
ARCL	Allowable Residual Contamination Level
ATSDR	Agency for Toxic Substances and Disease Registry
BRC	Below-Regulatory-Concern
BVA	Buried Valley Aquifer
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Ci	Curies
COC	Contaminant of Concern
CWA	Clean Water Act
DAO	Dayton Area Office
DCF	Dose Conversion Factor
DCG	Derived Concentration Guide
D&D	Decontamination & Decommissioning
DOD	Department of Defense
DOE	U.S. Department of Energy
DOT	Department of Transportation
EE/CA	Engineering Evaluation/Cost Analysis
EG&G	EG&G Mound Applied Technologies, Inc.
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ER	Environmental Restoration
FFA	Federal Facility Agreement
FRA	Focused Risk Assessment
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	Fiscal Year
GRA	General Response Actions
HDPE	High Density Polyethylene
ICRP	International Commission on Radiological Protection
MCL	Maximum Contaminant Level
MOU	Memorandum of Understanding
MRC	Monsanto Research Corporation
mrem/yr	Millirems per year
nCi/g	Nanocuries per gram
nCi/L	Nanocuries per liter
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
OAC	Ohio Administrative Code
O&M	Operation and Maintenance

ODH	Ohio Department of Health
OEPA	Ohio Environmental Protection Agency
O&P	Overhead and Profits
ORC	Ohio Revised Code
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
pCi/g	Picocuries per gram
pCi/L	Picocuries per liter
RAGS	Risk Assessment Guidance for Superfund
RAO	Removal Action Objectives
RCRA	Resource Conservation and Recovery Act
RESRAD	Residual Radioactivity
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RSE	Removal Site Evaluation
SACM	Superfund Accelerated Cleanup Model
SAFER	Streamlined Approach for Environmental Restoration
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SFMP	Surplus Facilities Management Program
SM/PP	Special Metallurgical/Plutonium Processing
SNAP	Space Nuclear Auxiliary Power
SVOC	Semivolatile Organic Compound
SDWA	Safe Drinking Water Act
TBC	To be considered
TSCA	Toxic Substances Control Act
USEPA	U.S. Environmental Protection Agency
uCi/kg	Microcuries per kilogram
uCi/mL	Microcuries per mililiter
VOC	Volatile Organic Compound
WD	Waste Disposal
WTS	Waste Transfer System

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EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) has been prepared by the U.S. Department of Energy (DOE) under authorities delegated by Executive Order 12580 under Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and is consistent with 40 Code of Federal Regulations (CFR) Part 300.415 (Removal Action) of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). This EE/CA evaluates removal action alternatives to reduce or eliminate the concentration of plutonium-238 and tritium contamination within the soils and sediments of the Miami-Erie Canal (Operable Unit (OU) 4) as a result of past operations and accidental releases from Mound Plant. The purpose of this EE/CA is to identify and evaluate potential alternatives in order to determine the preferred removal action.

OU4 encompasses the canal west of Mound Plant, the overflow creek, the drainage ditch from the site boundary to the canal, the runoff hollow, and the north and south ponds in the Miamisburg City Park.

Prior to determining that a removal action in the canal is appropriate, the DOE evaluated the conditions in the canal by preparing a Removal Site Evaluation (RSE) (DOE 1993a). The RSE concluded that plutonium-238 and tritium have been released into the Miami-Erie Canal soils and sediments as a result of Mound Plant activities. However, field studies and risk assessments (including the recent Agency for Toxic Substances and Disease Registry (ATSDR) study (ATSDR 1993)) conclude that there is no current significant risk to the public or the environment as a result of these releases. The DOE next solicited an independent evaluation of the appropriateness of a removal action in the canal. This evaluation consisted of the consensus of the following parties associated with the Mound Environmental Restoration (ER) Program:

- ATSDR
- Ohio Environmental Protection Agency (OEPA), Southwest District Office
- United States Environmental Protection Agency (USEPA), Region V
- Miamisburg City Officials
- DOE/Dayton Area Office (DAO)

Although all parties agreed that DOE is committed to the eventual assessment and, if needed, remediation of the contaminated portion of the canal, the consensus of this review group was that a removal action would be beneficial for the canal for the following reasons:

1) A release has occurred off-site.

2) The DOE, as lead agency responsible for the Mound ER Program, can proceed with a removal action in accordance with Section 104(b) of CERCLA.

3) The EPA's guidance encourages accelerated cleanup at sites, particularly through the mechanism of non-time-critical removal action.

4) Additional studies and investigations of the conditions in the canal, as would be required under the terms of the Mound Federal Facility Agreement (FFA), are not expected to provide any new or different information relative to environmental or public health risks.

5) The change in Mound's mission as a result of the recent DOE decision to eliminate the Defense Programs at Mound Plant may lead to a change in the future land use and ownership, both on the Mound site and off-site.

Although the actual known risks do not present an immediate or imminent threat to public health or welfare or to the environment, DOE has determined that a removal action (non-time critical) as specified in 40 CFR Part 300.415 of the NCP, is an appropriate response to the contamination in the canal. Therefore, an EE/CA is required to identify a preferred removal alternative.

The removal action objectives (RAOs) are to comply with all applicable or relevant and appropriate requirements (ARARs) to the extent practicable and to minimize any public health or environmental impacts during the performance of the removal action.

In support of the RAOs, a series of general response actions (GRAs) with associated remedial technologies and process options were assembled and screened in accordance with the USEPA EE/CA guidance document (EPA 1993) regarding removal actions.

The selected GRAs for OU4 included no action, institutional controls, containment, collection and treatment actions. Each GRA was assigned a number of remedial technologies. The assigned technologies were further defined by identifying associated process options or sub-technologies. As allowed under the EE/CA guidance, experience and best professional judgement were used to screen all technologies and associated process options. After screening, the remaining technologies and process options were assembled into the following remedial action alternatives:

Alternative 1 - No Action
Alternative 2 - Institutional Controls
Alternative 3a - Containment: Limited Use
Alternative 3b - Containment: Beneficial Use
Alternative 4 - Excavation and Disposal
Alternative 5 - Excavation, Treatment, and Disposal

The alternatives were evaluated using three criteria: effectiveness, implementability, and cost. A comparative analysis for each evaluation criterion was performed for each alternative relative to the other alternatives. Scoring index values of 1 through 5 (low through high, respectively) were assigned to each criterion as a relative measure of each alternative's strengths and weaknesses. (Note that for cost, a low cost would rate a high scoring index of 5). See Table ES.1.

Conclusion

Based on a comparison of the alternatives, the preferred alternative is excavation and off-site disposal at Nevada Test Site (NTS) (Alternative 4). This alternative essentially eliminates the exposure pathways from the contaminated soil to the public and the environment, while reducing its mobility by placing it into a permanent (off-site) disposal facility. This alternative is judged to be equally or more effective in the long term than the other alternatives, while being moderately feasible to implement. However, the cost to implement this alternative is among the highest evaluated.

TABLE ES.1. COMPARATIVE EVALUATION OF SITE-WIDE ALTERNATIVES 1-5
Page 1 of 2

CRITERIA	ALTERNATIVE 1 NO ACTION		ALTERNATIVE 2 INSTITUTIONAL CONTROLS/ ENVIRONMENTAL MONITORING		ALTERNATIVE 3 CONTAINMENT			
					(3a) Limited Use		(3b) Beneficial Use	
· Effectiveness								
Short-Term (15) Health Impacts	5	No additional impact if no action taken.	5	Negligible impacts associated with site security and monitoring.	5	Unlikely risk due to undisturbed contamination.	5	Unlikely risk due to undisturbed contamination.
Environmental Impacts	5	No additional impacts if no action taken.	5	Negligible impacts associated with site security and monitoring.	4	Environmental controls during construction.	4	Environmental controls during construction.
Long Term (35) Contamination Levels/Compliance with ARARs/Meets RAOs/Reduces Toxicity, Mobility, Volume	1	Contaminants remain.	3	Site restrictions provide some risk reduction to public	3	Public access unlimited. Contaminants remain.	3	Public access unlimited. Contaminants remain.
Environmental Impacts	1	Contaminants remain. Site management controls remain.	1	Monitoring provides assessment capability but contaminants remain.	3	Contaminants remain. Maintenance required.	3	Contaminants remain. Maintenance required.
Criterion Weighted Subtotal	2.2		2.9		3.4		3.4	
· Implementability								
Technical Feasibility (10)	5	No Action	5	Standard techniques and processes.	5	Standard technologies.	5	Standard technologies.
Availability (10)	5	No Action	5	Services & materials readily available.	5	Services & materials readily available.	5	Services & materials readily available.
Administrative Feasibility (10) Permits, Waivers and Access/State Acceptance/Community Acceptance	2	Public/regulators may demand reduction of contamination.	2	Public/regulators may demand reduction of contamination.	3	Public/regulators may demand reduction of contamination.	3	Public/regulators may demand reduction of contamination.
Criterion Weighted Subtotal	1.2		1.2		1.3		1.3	
· Cost (20)	5	<$1M	5	<$1M	4	$<4M	4	$<4M
Criterion Weighted Subtotal	1.0		1.0		0.8		0.8	
Summary Score	4.4		5.1		5.5		5.5	

( ) - Weighted Value, %
5 - High
4 - Moderate High
3 - Moderate
2 - Low-Moderate
1 - Low

TABLE ES.1. COMPARATIVE EVALUATION OF SITE-WIDE ALTERNATIVES 1-5
Page 2 of 2

CRITERIA	ALTERNATIVE 4 - EXCAVATION AND DISPOSAL		ALTERNATIVE 5- EXCAVATION, TREATMENT AND DISPOSAL	
· **Effectiveness**				
Short-Term (15) Health Impacts	3	Public risk unlikely in construction. Worker exposure to fugitive dust.	3	Handling requirements increase worker exposure.
Environmental Impacts	4	Environmental controls for dust and runoff applicable.	3	Increased requirements for monitoring higher concentrations.
Long Term (35) Contamination Levels/Compliance with ARARs/Meets RAOs/Reduces Toxicity, Mobility, Volume	5	Waste removal from site of canal reduces public exposure.	5	Waste removal from site of canal reduces public exposure.
Environmental Impacts	5	Storage facility provides isolation. Contamination removed.	5	Facility maintenance assures protection.
Criterion Weighted Subtotal	4.6		4.4	
· **Implementability**				
Technical Feasibility (10)	3	Facility already exists. Shipping logistics add complexity.	2	Treatment requirements must be developed site specific.
Availability (10)	5	Capacity available to accept waste.	4	Generic technology available for soil washing.
Administrative Feasibility (10) Permits, Waivers and Access/State Acceptance/Community Acceptance	3	Permits needed for transport and disposal.	3	Permits required for transport and disposal.
Criterion Weighted Subtotal	1.1		0.9	
· Cost (20)	2	<25M	1	<33M
Criterion Weighted Subtotal	0.4		0.2	
Summary Score	6.1		5.5	

( ) - Weighted Value, %
5 - High
4 - Moderate High
3 - Moderate
2 - Low-Moderate
1 - Low

1. INTRODUCTION

This Engineering Evaluation/Cost Analysis (EE/CA) report documents the evaluation of proposed removal action alternatives for the contaminated soils and sediments of the portion of the Miami-Erie Canal adjacent to Mound Plant in Miamisburg, Ohio. The U.S. Department of Energy (DOE) is responsible for cleanup activities at the Mound site under the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

1.1. OBJECTIVES

The objectives of this EE/CA report are as follows: (1) identify and evaluate potential removal action alternatives, (2) evaluate the impacts of the proposed removal action on public health and the environment, and (3) recommend a proposed removal action alternative for the Miami-Erie Canal soils and sediments.

1.2. BACKGROUND

Mound has established the Environmental Restoration (ER) program to fulfill its CERCLA and Resource and Conservation and Recovery Act (RCRA) cleanup responsibilities. Currently, this effort is guided by a Federal Facility Agreement (FFA), which became effective October 12, 1990 between the U.S. Environmental Protection Agency (USEPA) and DOE. A revised FFA between the DOE, USEPA and Ohio Environmental Protection Agency (OEPA) became effective September 22, 1993. Under this agreement the Mound ER program is assessing and evaluating the current risks, as necessary, for more than 125 potential release sites.

The ER activities at Mound consist of performing site/facility investigations to determine the nature and extent of contamination, assessing potential technologies and alternatives for remediation, defining and selecting remedial actions, and implementing the preferred alternatives. Each of these steps requires review and input from various regulatory agencies and the public. Currently, the Mound ER program is conducting Remedial Investigations/Feasibility Studies (RI/FS) in all on-site operable units (OU). OU4 has been designated to address potential contamination in the Miami-Erie Canal area adjacent to Mound Plant.

A Removal Site Evaluation (RSE) for OU4 was prepared in accordance with CERCLA, Section 104, to determine whether the presence of radiological contamination in the canal soils warrants a removal action (DOE 1993a). Removal action alternatives could range from administrative controls, such as posting warning signs, to complete excavation, treatment and removal of all hazardous substances. While the RSE and other studies by Mound and various health agencies (see Section 2, Site Characterization) indicate that the current conditions in the canal do not present an immediate or imminent threat to public health or the environment, the DOE has decided to proceed with a removal action to expedite the remediation of the canal.

Since there is no immediate threat to the public or the environment, it is not critical to implement a removal action in the canal. When a non-time-critical removal action (a period of greater than six months before on-site activities must begin) is determined to be appropriate, the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) requires that an EE/CA be prepared to evaluate alternatives and recommend a preferred removal action alternative. This document represents the EE/CA for the OU4 removal action.

The EE/CA process is identified in guidance from the EPA that addresses removal actions at sites subject to CERCLA (EPA 1993). The EPA, through its Superfund Accelerated Cleanup Model (SACM), and the DOE, through its Streamlined Approach For Environmental Restoration (SAFER) program, encourage the prompt reduction of risks through early action (such as removal) that serves to expedite the cleanup process.

1.3. EVALUATION CRITERIA

The EPA's EE/CA guidance specifies three criteria under which removal action alternatives should be evaluated: effectiveness, implementability and cost. These criteria are briefly defined below (see Section 5.1. for a detailed discussion of each criteria).

Effectiveness is the degree of protection that a removal action gives to the community and site workers. It is measured by (1) the extent to which the removal action can reduce any threat, (2) the time in which the removal action is completed, (3) compliance with Applicable or Relevant and Appropriate Requirements (ARARs), (4) the long-term reliability, (5) the use of alternatives to land disposal, and (6)

the short and long-term impact on public health and the environment. In general, preference is given to removal action alternatives that immobilize, destroy or recycle the hazardous materials.

Implementability is determined by the removal action's technical feasibility, administrative feasibility and availability. Administrative feasibility addresses the degree of acceptance by regulatory agencies and the public.

Cost is the sum of direct and indirect capital costs of implementing the removal action alternative. Cost is a determining factor when choosing among alternatives that have similar effectiveness and implementability.

Upon completion of each alternative's criteria evaluation, a qualitative assessment of the strength and weakness of each alternative relative to the others is performed. Based on that assessment, a proposed removal action alternative is identified.

1.4. REPORT ORGANIZATION

Sections 2 through 7 of this EE/CA follow the format of the EPA guidance (EPA 1993). Section 2, Site Characterization, furnishes a site description and background information for Mound Plant and the Miami-Erie Canal. It also provides analytical data for plutonium, tritium and non-radiological contamination. The conditions that justify a removal action are also listed in Section 2.4.

Section 3, Identification of Removal Action Objectives (RAO), discusses the objectives which are the basis for identifying and evaluating the appropriate removal technologies. Section 3 also covers statutory limits on removal actions, the removal action scope, removal action schedule, ARARs and planned remedial activities.

Section 4, Identification and Initial Screening of Removal Action Alternatives, discusses the general response actions (GRAs) applicable to OU4. The GRAs discussed are no action, institutional control actions, containment actions, collection actions and treatment actions. Remedial technologies and process options are identified and screened. The remedial technologies which pass the initial screening are developed into a list of removal action alternatives and discussed at the end of Section 4.

Section 5, Analysis of Removal Action Alternatives, begins by defining the evaluation criteria of effectiveness, implementability and cost. The remainder of Section 5 presents a detailed analysis of each alternative developed in Section 4 on the basis of effectiveness, implementability and cost.

Section 6, Comparative Analysis of Removal Action Alternatives, qualitatively assesses the removal action alternatives in relation to each other based on effectiveness, implementability and cost.

Section 7, Recommended Removal Action Alternative, describes the recommended removal action alternative, reiterates the basis for its selection for OU4, and summarizes the alternative by task.

2. SITE CHARACTERIZATION

This section presents information to characterize that portion of the Miami-Erie Canal adjacent to the Mound Plant that has plutonium and tritium contamination.

2.1. SITE DESCRIPTION

The Mound Plant is located within the city limits of Miamisburg, Ohio, approximately 10 miles south-southwest of Dayton and 45 miles north of Cincinnati (see Figure 2.1). The plant site overlooks Miamisburg, the Great Miami River, and the river flood plain area to the west. The site is located on two hills divided by a minor valley that drains toward the river in a southwesterly direction. Most of the Mound Plant buildings are located atop the northwest hill (Main Hill). A smaller group of buildings are located on the second hill (Special Metallurgical/Plutonium Processing (SM/PP) Hill) and a few others in the valley and on the valley slopes. Mound Plant is owned by the DOE and operated by EG&G Mound Applied Technologies, Inc. (EG&G). The primary function at the plant is the manufacturing of non-nuclear explosive components for nuclear weapons assembled at other DOE sites. Other work includes the development and manufacturing of small chemical heat sources; handling and development of tritium-containing materials and processes; recovery and purification of tritium from other DOE sites; development and fabrication of radioisotopic heat sources fueled with plutonium-238 for the National Space Program and the Department of Defense (DOD); and the commercial separation and purification of nonradioactive noble gas isotopes. In 1993 a decision was made by the DOE to eliminate the Defense Program at the Mound Plant and make the site available for commercial use.

OU4 is defined as 1) the abandoned Miami-Erie Canal west of Mound Plant; 2) the overflow creek, which connects the canal to the river; 3) the drainage ditch from the site boundary to the canal; and 4) the north and south ponds in the Miamisburg City Park. The primary feature of OU4, and the main region of concern in this study, is a portion of the abandoned Miami-Erie Canal. The north-south trending canal area lies between the Conrail Railroad right-of-way to the east and the Dayton-Cincinnati Road to the west (see Figures 2.2 and 2.3). A portion of this canal is used as a drainage pathway for surface water runoff from Mound Plant to the Great Miami River. Runoff from the site flows westward from National Pollutant Discharge Elimination System (NPDES) Outfall 002, into a drainage ditch, and through a pair of concrete box culverts running beneath the Conrail railroad tracks prior to joining a segment of the abandoned canal. The confluence of the drainage ditch and the canal is defined as the point of separation

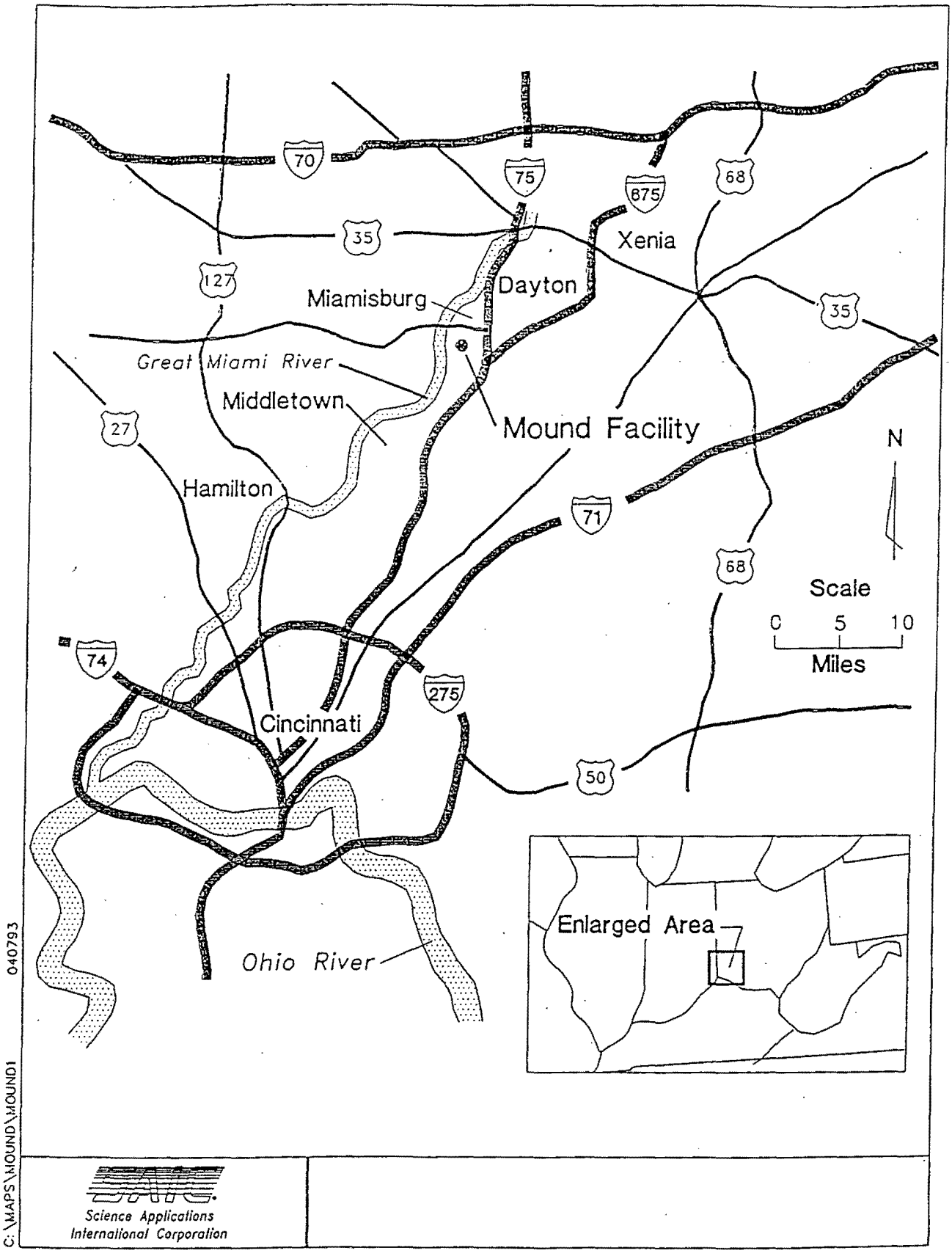

Figure 2.1. Location of Mound Plant, Miamisburg, Ohio

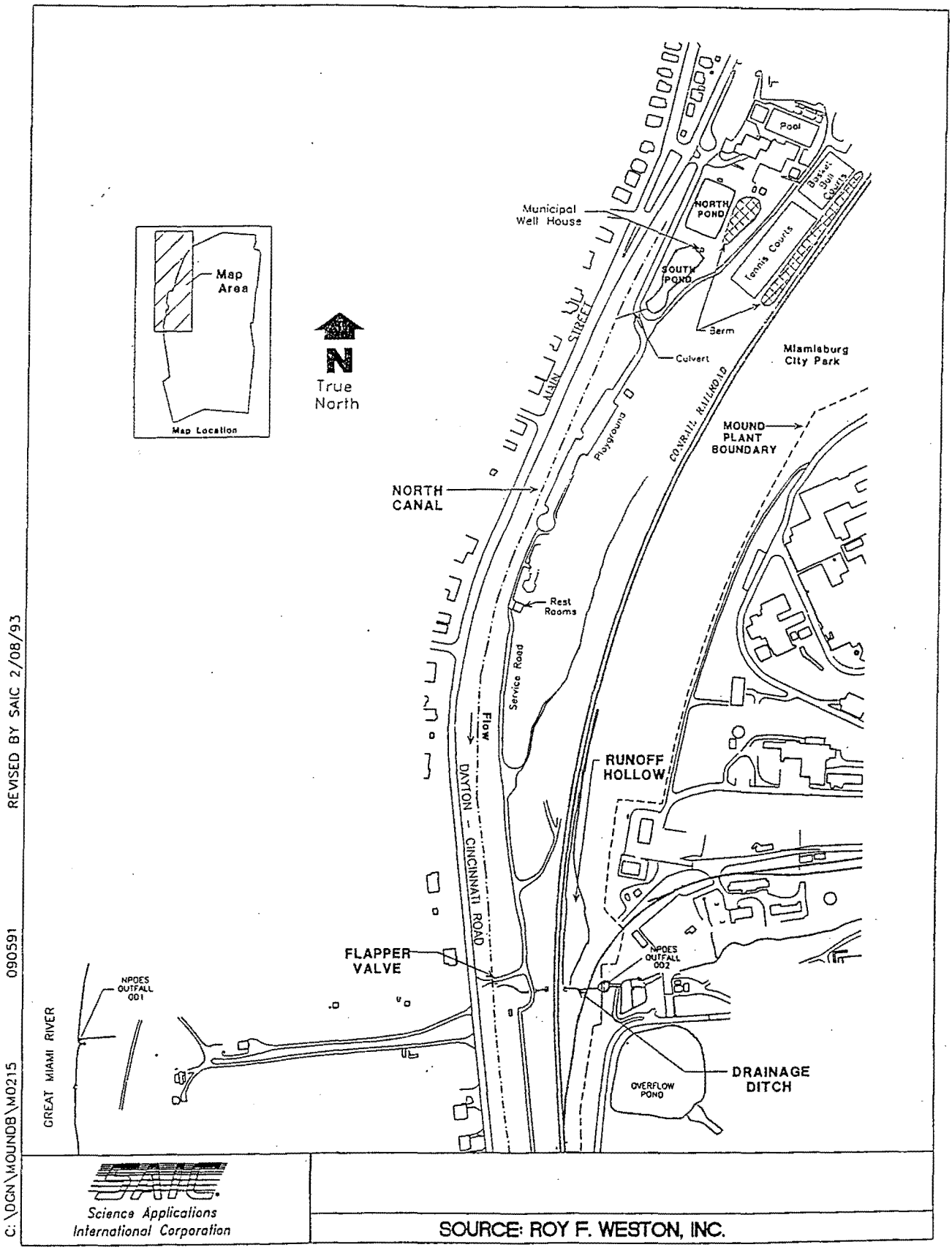

Figure 2.2. Location of Miami-Erie Canal and Associated Waterways Within OU4 - Northern Half

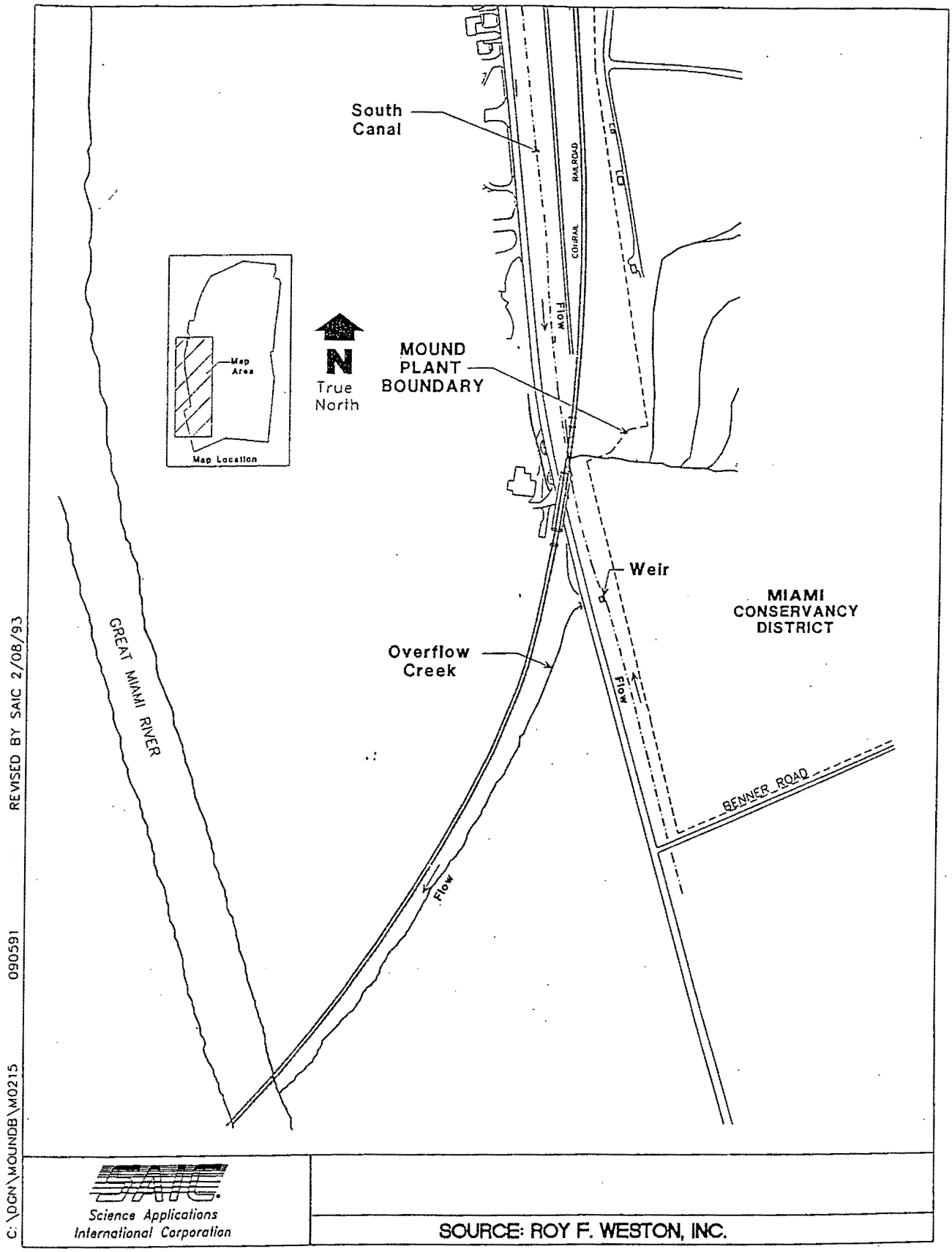

Figure 2.3. Location of Miami-Erie Canal and Associated Waterways Within OU4 - Southern Half

between the north canal and the south canal. Currently, runoff flows from the site via the drainage ditch into the south canal, and flows into the overflow creek which empties into the Great Miami River. The Great Miami River is approximately 2,000 feet from the plant's west fenceline.

The Miami-Erie Canal bed is approximately 40 ft wide and varies in depth from 4 to 10 ft from its banks. Normally, the north canal is totally dry and heavily vegetated with grass and brush, while the south canal contains a meandering channel with a stream of water four to eight inches deep, which is primarily the plant runoff. The banks of the south canal are also heavily vegetated. After periods of heavy rainfall in the vicinity of the canal, flow through the south canal may increase, and portions of the north canal may become inundated. During such instances, water may drain from the north canal, through the flapper valve, and into the south canal. A city park is located northeast of the north canal. The portion of the north canal that is within the city park is a wide grassy ditch. The City of Miamisburg continues beyond the park to the north and is primarily residential. The land to the west of the north canal is a combination of residential housing and non-industrial commercial businesses.

Additional features of the northern half of OU4 include the runoff hollow, the north and south ponds, and the underground sanitary sewers. The runoff hollow, located between the plant fenceline and the Conrail railroad track, is a shallow depression with no surface flow path to the canal. The north pond has been drained and backfilled. The south pond is relatively small and overgrown with cattails. The City of Miamisburg has a sanitary sewer line buried within the north canal. The sanitary sewer line runs approximately the entire length of the north canal, underneath the west berm. At the northern end, it connects to a pump station in the City Park. At the south end, it connects to a line running under Cincinnati-Dayton Road, via another pumping station located immediately north of the canal/drainage ditch intersection. Several manhole access risers protrude from the sanitary sewer line several feet above the canal bed.

The south canal is overgrown and not as easily accessible as the north canal. The south canal supports a perennial flow of water and is still used to drain surface water runoff from the plant. Water flowing from the plant into the canal is monitored under an OEPA NPDES permit. The land to the west of the south canal is characterized by residential housing and light commercial businesses.

In the vicinity of houses and trailer parks, the overflow creek conveys surface water from the south canal (at a point just south of the intersection of the canal and the railroad overpass) westward to an outfall at

the Great Miami River. The south canal and overflow creek are located on land controlled by the Miami Conservancy District. The overflow creek has vegetation similar to that of the south canal and is similar in size.

The hydrogeologic regime at Mound Plant consists of two different geologic environments: flow through bedrock and flow within unconsolidated glacial deposits and alluvium (see Figure 2.4). The latter is associated with the Buried Valley Aquifer (BVA) in the Great Miami River valley. Since the Miami-Erie Canal lies above the BVA, OU4 relates primarily to that regime. The BVA occupies a deep bedrock channel that roughly follows the course of the present river. The bedrock channel is up to 142 ft deep near its center. Outwash extends from the edge of the buried valley along tributaries, such as the Mound Plant valley that separates the Main Hill and the SM/PP Hill. The approximate boundary of the BVA is depicted in Figure 2.5. The depth to groundwater varies along the length of the canal. The depth to the water table in the center of the canal is estimated to be between four to eight feet. The degree of interconnection between the bedrock flow system and the BVA is limited.

The climate of the Miamisburg area is continental, with moderate extremes in temperature. Summers are rather warm and humid, with an average daily maximum of 86.9°F. The average relative humidity ranges from 50% in the winter to 85% in the summer. Winters are moderately cold, with an average of about two days of subzero weather and frequent periods of extensive cloudiness. The average daily minimum temperature in January is 23.1°F. Autumns are predominantly cool and dry. Spring is the wettest season. Severe weather is mostly associated with heavy thunderstorms in the summer, resulting in damaging winds and local flash flooding. The average annual rainfall is about 40 inches, including 27 inches per year of snow. The surface wind flow at Dayton is predominantly from the southwest quadrant. Average annual wind speeds range from about 7 to 10 miles per hour.

The 1990 census reported the population of Miamisburg as 17,834, of Dayton as 182,044, and of Montgomery County as 573,809. There are no major landmarks or tourist attractions that draw a significant seasonal transient population to the Mound area. There is, however, a significant seasonal variation in the number of community members using the city park, which has a swimming pool and water slide and is a popular summer gathering place for Miamisburg residents.

Known records do not show that any species on federal or State of Ohio lists of endangered and threatened species exist on the Miami-Erie Canal site. The habitats present are generally not supportive of these

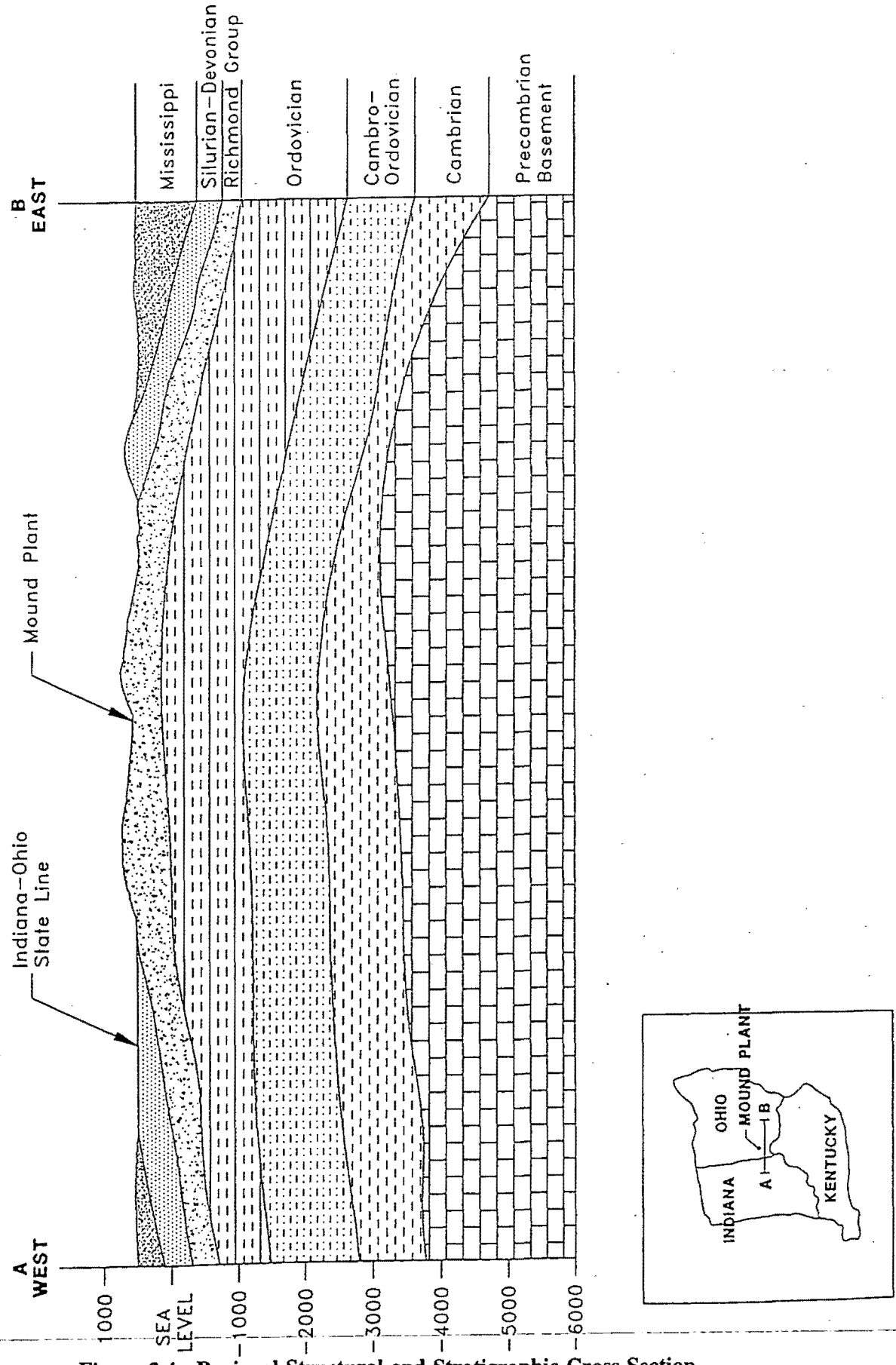

Figure 2.4. Regional Structural and Stratigraphic Cross Section Along Southeastern Indiana and Southwestern Ohio

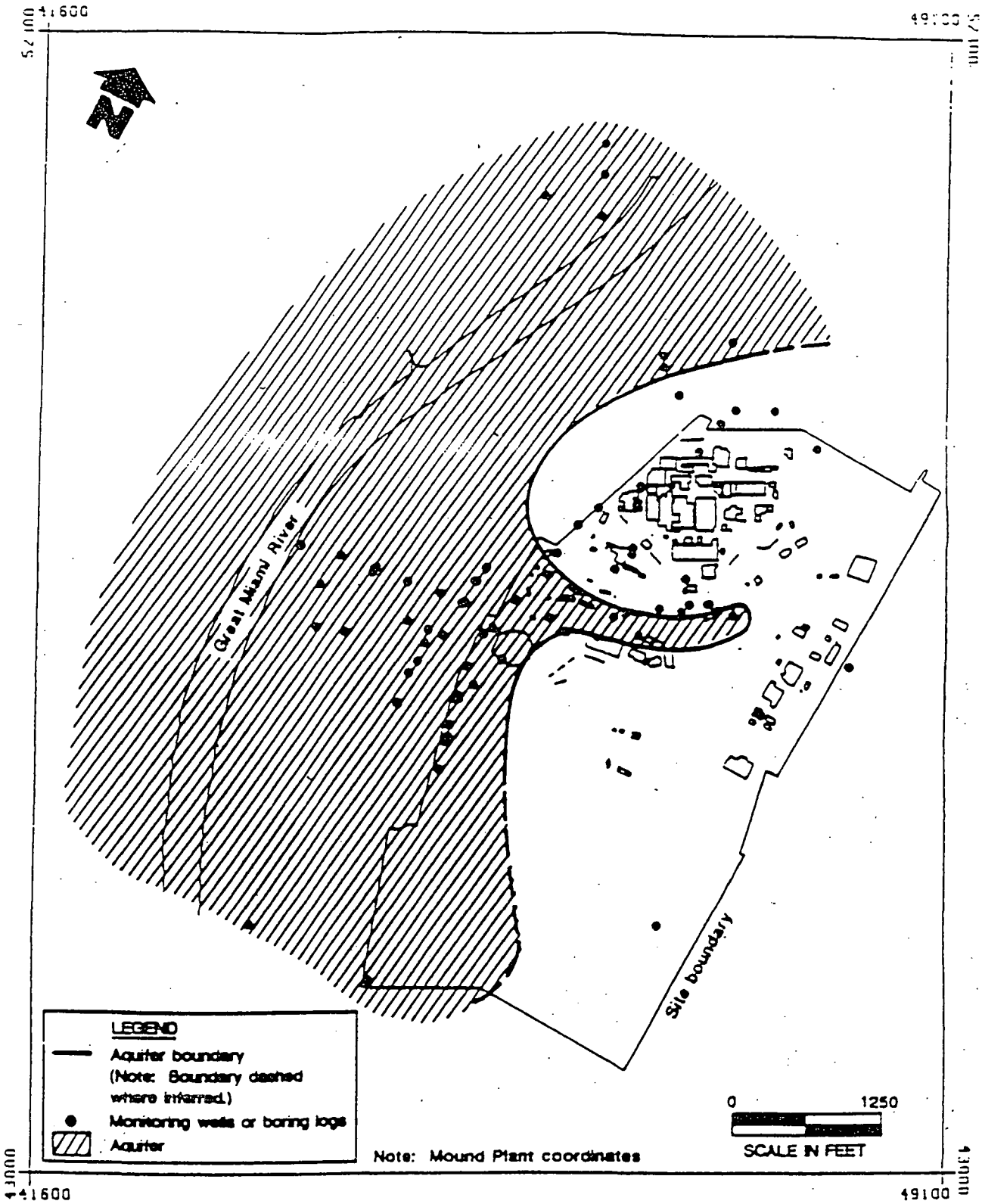

Figure 2.5. Boundary of the Buried Valley Aquifer Near Mound

species. One exception is the shagbark hickory, which may host the Indiana Bat. During the bat's breeding season, from May through September, areas to be cleared will be inspected for the shagbark hickory prior to clearing. Should shagbark hickories be present, further examination to determine the presence or absence of the bats will be made to avoid disturbing any breeding bats. No Indiana Bats have been reported at Mound to date. No impacts on threatened or endangered species are expected.

While the Mound plant area does harbor many species of wildlife, including large animals, small game, and predatory birds, the proposed action will, for the most part, affect non-unique and previously disturbed habitats. Minor areas of natural, undisturbed habitat may be affected.

2.2. SITE BACKGROUND

The background of Mound Plant and the Miami-Erie Canal, as related to the contamination in the canal, are described below.

2.2.1. Mound Plant

Mound is a government-owned and contractor-operated facility, assigned to the Albuquerque Operations Office (AL). Construction of Mound Plant began in 1947 on a 182-acre site on the outskirts of the town of Miamisburg, Ohio. Operations involving nuclear materials began in 1949. In 1977, the plant was incorporated into the DOE complex and the facility designation changed to Mound Plant. Monsanto Research Corporation (MRC) was the sole operating contractor until 1988, when EG&G became the operating contractor.

Early Mound programs included the fabrication of neutron and alpha sources such as uranium, protactinium-231, and plutonium-239 for weapons and non-weapons use. In 1954, a program to separate thorium-230 was begun.

In 1961, the development of plutonium-238 heat sources for the space nuclear auxiliary power (SNAP) generator was started at Mound. Plutonium-238 was used because of its high specific activity and relatively short half-life (87.74 years). Since that time, heat sources fueled with plutonium-238 have been developed and fabricated for use in thermoelectric generators and for lunar experiments, weather satellites, navigational satellites, and spacecraft.

The first of several programs requiring tritium-handling technology was initiated at Mound in the mid-1950s. Before 1967, liquid waste discharges from Mound Plant operations using tritium were collected in sumps and analyzed. If tritium concentrations in planned releases exceeded the existing radioactivity concentration guideline of 1000 nCi/L (Federal Radiation Council 1959), the sump water was metered into a stream of potable water and diluted. After reducing the tritium concentrations to acceptable levels, the sump water was discharged through the plant sewer system, which directed it into the Great Miami River via the drainage ditch, canal, and overflow creek (Styron and Meyer 1981). A waste disposal facility, built in 1967, provided a centralized system for processing tritiated liquid waste. The combined waste stream was collected in holding tanks for assay and then discharged in batches with dilution water to the effluent pipeline (NPDES Outfall 001) that leads directly to the river. In 1970, an automated monitoring system was installed in the NPDES Outfall 002 which leads to the canal and eventually to the river. In 1971, a similar monitoring system was installed in the NPDES Outfall 001.

Low-flow retention basins and an overflow pond were constructed on the lower reach of the plant drainage ditch (on Mound site) to control surface water discharge from the plant and to provide settling for suspended sediment in the plant runoff. Surface water is retained in the ponds to reduce peak runoff volume and velocity. Retention basin effluent is discharged through a standpipe in the western basin to NPDES Outfall 002. NPDES Outfall 002 carries zeolite softener backwash and most of the plant storm runoff (EG&G 1992). Prior to 1976, a small stream gauging station on the lower reach of the plant drainage ditch served to monitor stream flow. In 1976, the storm water retention and discharge system was built (see above). Effluents are monitored daily for flow rates and weekly for total nonfilterable residues. Effluent samples, collected automatically, are composited over a 24 hour period and are proportional to flow volume. The effluents are released to the south canal and travel to the overflow creek that outfalls to the Great Miami River. In 1970, discharge of all tritium process waste liquids was discontinued in favor of collection, solidification, packaging, and shipment to an off-plant burial ground approved by the Atomic Energy Commission (AEC) (now DOE).

In the early 1970s, as national concerns about the environment and the conservation of resources escalated, Mound expanded its programs in environmental monitoring and waste management. In 1972, the waste management program became a formal part of the Mound organization. The program produced plans for managing and reducing the amount of wastes generated, reported results of treatment facilities, reported waste management accomplishments, and reported actual and projected budget requirements. These plans and reports have been produced annually since 1972.

Mound initiated the Comprehensive Environmental Assessment and Response Program (CEARP) in 1984 pursuant to CERCLA. This program was superseded by the ER program, whose mission is to identify, assess, and remediate sites where environmental releases have occurred as a result of handling hazardous substances.

Based on preliminary results from Mound's ER program, Mound Plant was placed on the National Priorities List (NPL) in November 1989. Pursuant to Sections 120 and 105 of CERCLA, the DOE and the U.S. EPA signed the FFA in August 1990. A revised agreement, which added the OEPA, became effective in September 1993.

In 1992, the DOE announced a proposal to change the mission of Mound Plant. According to this plan, by 1995 all of Mound Plant's weapons production capabilities will be consolidated into other DOE locations, and the site will be made available for commercial use. The remaining Mound site activities would include site environmental restoration. This change in Mound's mission creates additional uncertainty about and probable change in the future land use and ownership, both on the Mound site and off-site (e.g., the Miami-Erie Canal). Although this situation does not change the nature of contamination in the canal, it can affect assumptions concerning future risks and the timing of any necessary cleanup activities.

2.2.2. Miami-Erie Canal

The Miami-Erie Canal was constructed during the 1800s as a north-south transportation route. It was used extensively for a time but was finally abandoned in 1915. Some sections of the canal are maintained as historic locations, but the segment west of Mound Plant (with the exception of the portion within the Miamisburg City Park) appears to have gone untended since its abandonment. All of the south canal and a portion of the north canal are considered a floodplain/wetland and/or lie within the 100-year floodplain of the Great Miami River.

The current relationship between Mound Plant, the canal and the local region began to form in the 1940s when the site to the east of the canal was chosen as the location for a government facility in support of weapons production. Needs for drainage and process effluent runoff from the elevated plant site resulted in the utilization of the site's drainage ditch. The confluence of the drainage ditch and the canal is defined as the demarcation between the north canal and south canal. From this discharge point, the plant drainage

originally flowed both north and south along the canal, but flow to the northern portion was structurally blocked in 1976, when a flapper valve was installed in the canal just north of this position to control the flow of water. This valve allows water to flow from the north canal to the south canal, but restricts its flow northward. A portion of the abandoned canal is now used for runoff from the plant's drainage ditch. Except for modest residential and commercial growth around the Miami-Erie Canal, there has been little significant change in the landscape and function of the region since Mound Plant began operation.

The area in the vicinity of the northern portion of the canal is marked by two ponds and a municipal swimming pool located in the city park. Earlier an electric power plant existed to the north and east of the ponds. In the mid-1970s the power plant was dismantled and removed, and the site was converted to a city park. In 1977, the north pond was deepened by 10 feet, reshaped, equipped with a plastic liner, and converted into a solar heating pond for the municipal swimming pool. In addition, the south pond was deepened for use as a fishing pond. Excavated soil from these pond alterations was used as fill material beneath the nearby city park tennis courts and also stockpiled into two berms: one lying between the north pond and the tennis courts, and the other between the tennis courts and the railroad tracks. Due to the extensive reconstruction work by the City of Miamisburg from May 1977 to October 1978, the remnant north canal and the north and south ponds became part of Miamisburg's City Park. No soil was removed from the park area during this reconstruction (Farmer and Carfagno 1979). From 1990 to 1993, the north pond was removed from service, drained, and backfilled by the City of Miamisburg. During high water conditions, the south pond can discharge via a culvert to the north canal.

2.3. ANALYTICAL DATA

Historic operations and accidental releases from Mound Plant have resulted in the discharge of contamination into the Miami-Erie Canal. The extent of this contamination is described in the following sections.

2.3.1. Assessment of Plutonium Release

A major source of plutonium contamination in OU4 was the waste line break at Mound which released a dilute nitric acid solution. In January 1969, an underground pipeline, leading from the plutonium processing building to the waste disposal (WD) building ruptured, releasing the solution to the surrounding soils. Plant workers noted brown fumes (probably a nitric-oxide gas) emanating from the ground surface

as the acidic plutonium-238 solution was being neutralized, adsorbed, and immobilized by the soils around the pipeline (Rogers 1975). The waste transfer system (WTS) was shut down and excavation of the contaminated soil commenced. However, excavation efforts were hampered by three days of heavy rain. The heavy rain eroded plutonium- contaminated soils into the site drainage system, which carried the soils into the drainage ditch and off Mound Plant property. The excessive rainfall also washed loose soil from drums containing contaminated soil, resulting in an overland flow and subsequent plutonium-238 deposition at the runoff hollow. Contaminated soil particles carried by the surface water runoff were discharged directly to the Miami-Erie Canal. Since this event occurred prior to installation of the flapper valve in the canal, both the north and south canal segments were affected by the discharge. Runoff entering the north canal flowed into the north and south ponds, which, at that time, drained to the Miamisburg storm sewer system and into the Great Miami River. Runoff entering the south canal flowed down the canal to the overflow creek and discharged into the Great Miami River.

Plutonium transported into the canal waterway by the release in 1969 was strongly adsorbed onto the soils resulting in the deposition of plutonium in the canal sediments. Natural erosion of lesser-contaminated or uncontaminated surface soils from the Mound Plant followed the same pathways, covering portions of the contaminated canal soil with up to four feet of sediment (Rogers 1975).

An extensive study was conducted to determine the impacts of the 1969 release of plutonium-238 into the abandoned Miami-Erie Canal and adjacent waterways (Rogers 1975). Approximately 1,750 sediment, biota, water, air, and soil samples were collected and analyzed. The maximum plutonium-238 concentrations found are presented by their locations in Table II.1. The highest sediment concentration was 4.56 nCi/g (4.6×10^3 pCi/g) at a depth of two to three feet in the north canal. A breakdown of the total inventory of plutonium-238 in the Miami-Erie Canal is shown in Table II.2. These data indicate a total plutonium-238 inventory of 5.2 Ci (approximately 0.3 grams), with the majority of the inventory occurring in the south canal (3.17 Ci).

The maximum "very surface" plutonium-238 concentration in the canal soils and sediments is presented in Table II.3. The maximum "very surface" plutonium-238 concentration measured was 0.45 nCi/g (450 pCi/g) in the drainage ditch. "Very surface" refers to plutonium-contaminated sediments suspended in the natural surface waters near the canal sediment/water interface. Rogers 1975, refers to these samples as the "...very surface of sediment, which is under water, is subject to easy suspension in water or if the sediment dries, then it could be subject to suspension in air" and thereby be available for inhalation

exposure. Likewise, the "very surface" contamination on dry land is also available for suspension in air. This term is used to distinguish very surface and subsurface contamination because they pose different risks to the public health and the environment.

The maximum plutonium-238 concentration in water reported by Rogers (Rogers 1975) was 0.006 nCi/L (6 pCi/L). Green algae from the north canal exhibited the maximum plutonium-238 concentration of 0.00239 nCi/g (2.4 pCi/g) in biota sampled in the canal.

Table II.1. Maximum Plutonium-238 Concentrations in Sediments of Waterways Associated with the Miami-Erie Canal

Waterways	Depth (ft)	Maximum Any-Depth Concentration nCi/g ± 2σ
Runoff hollow	1	0.0314 ± 0.0066
North pond	0	0.0223 ± 0.0051
South pond		
North basin	0	0.653 ± 0.0114
South basin	0	0.208 ± 0.028
North canal	3	4.56 ± 0.20
Drainage ditch	1	0.749 ± 0.013
South canal	1	3.8 ± 0.025
Overflow creek	0	0.0270 ± 0.034
River		
East bank near canal	2	0.0415 ± 0.0081
East bank downstream	7	0.0037 ± 0.0013
Away from east bank	4	0.0006 ± 0.0002

Reference: (Rogers 1975 and Robinson et al. 1974)

Table II.2. Inventory of Plutonium-238 in Sediments of Waterways Associated with the Miami-Erie Canal

Location	Plutonium Inventory (Ci)
Runoff Hollow	0.0018
Drainage ditch	0.082
North canal	1.65
South pond	0.0058
North pond	0.0020
South canal	3.17
Overflow creek	0.076
Overflow creek outfall	0.260
Total	5.2

Reference: (Rogers 1975)

Table II.3. Maximum "Very Surface" Plutonium-238 Concentration of Sediments in Waterways Associated with the Miami-Erie Canal

Waterway	Maximum "Very Surface" Concentration nCi/g ± 2σ
Runoff hollow	0.0286 ± 0.0061
North pond	0.0223 ± 0.0051
South Pond	
North Basin	0.0653 ± 0.114
South Basin	0.208 ± 0.028
North canal	0.267 ± 0.033
Drainage Ditch	0.450 ± 0.050
South canal	0.395 ± 0.045
Overflow creek	0.0270 ± 0.034

Reference: (Rogers 1975 and Robinson et al. 1974)

The plutonium-238 concentration in the north pond ranged from less than 0.0001 to 0.002 nCi/g (0.1 to 2 pCi/g) with an average value of 0.00036 nCi/g (0.4 pCi/g). The levels of plutonium-238 concentration found in the south pond ranged from less than 0.0001 to 0.0063 nCi/g (0.1 to 6.3 pCi/g), with an average

value of 0.0023 nCi/g (2.3 pCi/g) (Robinson et al. 1974). Sediment and water samples were also taken from the south pond in March of 1990. The highest concentration of plutonium-238 in sediment was 0.0021 nCi/g (2.1 pCi/g), while the highest in water was 0.18 pCi/L (Halford 1990).

A risk assessment based on the 1974 canal study concluded that the contaminated sediments did not present a current or future hazard to human health, considering the then-current conditions, future predicted worst-case conditions, and allowable exposure guidelines (Rogers 1975).

Results of an updated risk assessment indicate that current plutonium-238 concentrations at the site present no imminent danger to human health. The incremental health risk to the maximally exposed individual from plutonium-238 contamination in the canal is estimated to be in the acceptable risk range (10^{-4} to 10^{-6}) (DOE 1993b). The committed effective dose equivalent to the maximally exposed individual is estimated as 0.17 mrem/yr for children and 0.039 mrem/yr for adults. The most important pathways, in terms of contribution to committed dose equivalent, are ingestion of contaminated soil from incidental hand-to-mouth contact (for children only), ingestion of contaminated drinking water, and inhalation of resuspended contamination. The USEPA, OEPA, and the Ohio Department of Health (ODH) all concurred with the following conclusions of the Rogers (1975) study: (1) the plutonium contaminated sediments do not present a credible risk to the public or environment based on existing conditions; and (2) Mound should perform continuous monitoring in the canal area.

In 1975, as a result of discussions between the DOE Dayton Area Office (DAO) and the City of Miamisburg, a memorandum of understanding (MOU) was issued stating the agreed-upon positions and responsibilities of all parties in regard to the 1969 release. As a condition of the MOU, DOE committed to monitoring the environmental conditions of the canal area on a continuous basis. The environmental monitoring activities in the canal include periodic sampling and monitoring of the air, soil, silt, water and vegetation in the city property containing the canal and ponds (DOE 1988).

In 1986, Mound published the CEARP Phase I Report as part of the first phase of Mound's CERCLA program (DOE 1986). This report summarized existing data on contamination from Mound and concluded that there were no issues presenting a health risk great enough to require immediate remediation.

During 1992-1993, the Agency for Toxic Substances and Disease Registry (ATSDR) conducted a health consultation of the canal area. Their preliminary review of existing environmental data concluded that

"the total radiation dose a person might receive from all pathways considered is likely to be less than 100 mrem per year and would indicate that there is no public health hazard." (ATSDR 1993).

During 1992-93, the soils and sediments of the Miami-Erie Canal were investigated for radiological contamination (SAIC 1993a). Approximately 90 soil/sediment samples were collected and analyzed at locations that were representative of previous investigations. The results confirmed the distribution of plutonium-238 contamination observed in previous studies (Rogers 1975). The maximum concentration of plutonium-238 was measured as 1000 pCi/g. At most locations sampled the maximum plutonium-238 concentrations tended to be in the 0 to 1 foot depth interval. The plutonium-238 concentration distribution in the 0 to 1 foot depth intervals started at 20 pCi/g near the north end of the canal, increased to a range of 500 to 1000 pCi/g in the canal region bounding the drainage ditch intersection, and dropped to 0.95 pCi/g at the south end of the canal. The concentration of plutonium-238 contamination decreased at locations away from the drainage ditch intersection. Canal cross-section results of the plutonium concentrations at 0 to 1 foot depth intervals all showed distributions having higher concentrations in the center of the canal than the sides. This distribution and spatial variability is similar to the one observed in the Rogers (1975) canal study.

2.3.2. Assessment of Tritium Release

The tritium contamination in OU4 primarily resulted from the pre-1970 disposal of tritiated process liquids. Such effluents were collected and assayed, and if found to contain less than the allowable concentration of tritium, released into the drainage system. Samples in excess of the limit were diluted and then released into the drainage system. This practice ceased after the WD facility was built in 1967 to provide a centralized system for handling tritiated process liquid waste.

The tritiated water that entered the canal may have percolated into the substrata where it could potentially migrate into the BVA. As part of an investigation into potential tritium contamination in the BVA, ten borings were drilled in the area of the Miami-Erie Canal and sampled on a continuous basis to determine the depth and activity level of tritium. These borings ranged in depth from 20 to 32 feet. In a 1976 investigation, the highest concentration of tritium detected in the distillate fraction of soil samples was 189,396 nCi/L (1.89×10^8 pCi/L) in the north canal at a depth of four feet, and 10,291 nCi/L (1.03×10^7 pCi/L) in the south canal at a depth of two feet. (Note: Soil distillate fractions represent a highly concentrated form of the sample. Therefore, the results should not be compared to drinking water standards.) On the basis of the soil distillate measurements, the total tritium contamination in the north

and south portions of the canal are estimated to be 300 Ci and 30 Ci, respectively (Dames and Moore 1976a).

The highest concentration of tritium in canal soil samples taken during the 1974 study (Rogers 1975) was 700 nCi/g (7.0×10^5 pCi/g). The depth distribution profiles for the tritium contamination were found to resemble those of the plutonium contamination. Later, Kershner and Rhinehammer (1978) estimated that the highest concentration of tritium measured in the canal soils taken in 1976 was 110 nCi/g (1.1×10^5 pCi/g).

Most of the tritium in the canal does not freely migrate into the BVA. Approximately 90 percent of the tritium in the canal is bound up with the soil, from which it is slowly released to seep into the aquifer (Kershner and Rhinehammer 1978). Investigators concluded that, of the estimated total tritium inventory of 200 Ci in the 5,200-foot length of the canal (in 1976), only about 30 Ci would have been released to the aquifer in a year's time if no remedial action were taken. Nevertheless, a high-volume pumping program was initiated in 1976 to assure tritium levels in drinking water remained in compliance with the Safe Drinking Water Act (SDWA) limits of 20 nCi/L (2.0×10^4 pCi/L). The results from groundwater samples collected from monitoring wells in the BVA during 1991 and 1992 indicate that, the annual average tritium concentrations are below the SDWA standard (EG&G 1992). Tritium concentrations in all drinking water wells are also below the SDWA standard.

Canal soils were analyzed for tritium (SAIC 1993a) and it was found that tritium concentrations are generally higher in the north canal than in the south canal. Except for one sample, the higher tritium concentrations are near the surface. The maximum concentration of tritium found in the canal was 180 pCi/g at a location in the north canal at the 0 to 1 foot depth interval. The maximum tritium concentrations across the canal tend to occur in the center of the canal. The distribution of tritium along the canal shows a broad maximum near the mid-way location in the north canal, decreasing steadily in the southward direction, then increasing to a maximum in the southern end of the south canal. The tritium distribution is indicative of deposition and is probably a result of complex interaction between liquid discharge from the Mound Plant drainage ditch and airborne tritium releases coupled with different patterns of deposition in the north and south canal. The higher deposition in the north canal is likely a result of the higher sedimentation built up in the north canal.

There are currently no EPA or DOE standards for tritium concentrations in soil (see Appendix A). Since the concentration profiles of plutonium-238 and tritium were found to be similar (Kershner and Rhinehammer 1978), any action taken to reduce the potential threat of plutonium-238 in the canal soils will also reduce any potential threat of tritium contamination. A comparison of the results of the tritium concentration among the 1974, 1976, and 1993 studies indicates that the concentration of tritium is decreasing with time, as is expected on the basis of its short (12.5-year) half-life.

The estimated maximum exposure concentrations for plutonium and tritium in the various media of the canal are summarized in Table II.4.

2.3.3. Assessment of Nonradiological Contamination

The combination of hazardous substances (i.e., chemical contamination) and radiological contamination is defined as "mixed waste" (EPA 1989). The supplemental investigations to further characterize the canal with regard to potential hazardous chemicals are important because the presence of mixed waste contamination in the canal would also have a significant impact on the removal action process options and alternatives developed in this EE/CA.

The Mound Plant utilizes a number of hazardous chemicals in its various plant operations. Since the Mound Plant drainage ditch was used in the past to collect surface water runoff and discharge it directly into the Miami-Erie Canal, there is a potential for the presence of non-radioactive chemical contamination in the canal, if any surface releases have occurred.

Information regarding the presence of chemical contaminants in the canal is limited. Samples were taken from the south pond by Halford (Halford 1990) to determine the presence of hazardous chemical and plutonium-238 contamination. (The results of the plutonium-238 analyses are described in Section 2.3.1.). A total of ten sediment samples were collected from the pond in March 1990 and analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, herbicides, polychlorinated biphenyls (PCBs), metals, and plutonium-238. Concentrations of analytes in all of the sediment samples were reported to be below the detection limits for chemical analytes. Three surface water samples were obtained from the south pond as part of the 1990 investigation. All chemical concentrations were reported to be within the established standards of the SDWA maximum contaminant levels (MCLs).

Table II.4. Summary of Estimated Maximum Plutonium and Tritium Exposure Concentrations in the Various Media of the Miami-Erie Canal

Source Media	Maximum Exposure Concentration	Appropriate Guideline
Soil/Sediment[a]		
Plutonium	4.56 nCi/g	b
Tritium	700 uCi/kg	b
Surface Water		
Plutonium[c]	1.8×10^{-4} nCi/L	0.04 nCi/L (DOE)
Tritium[d]	10 nCi/L	20 nCi/L (EPA)
Groundwater[e]		
Plutonium	n.d.	0.04 nCi/L (DOE)
Tritium	4.47 nCi/L	20 nCi/L (EPA)
Air[f]		
Plutonium	54.4×10^{-17} uCi/mL	3×10^{-14} uCi/mL (DOE)
Tritium	2.41×10^{-12} uCi/mL	1×10^{-7} uCi/mL (DOE)
Biota[a]		
Plutonium	0.1 nCi/g	b
Tritium	g	b

a - Rogers, 1975
b - A regulatory standard does not exist for plutonium or tritium in soil or biota. It must be calculated on a site-by-site basis based on a pathways analysis. Mound is currently using 100 pCi/g for a plutonium cleanup guideline.
c - Halford, 1990
d - Dames & Moore, 1976b
e - EG&G, 1992
f - Farmer & Carfagno, 1978
g - No significant uptake by biota
n.d. - not detected (detection limit = 17.4×10^{-6} uCi/L)
EPA - Safe Drinking Water Act (SDWA), tritium
DOE - DOE Order 5400.5 (DOE 1990)

In 1993, additional sediment and soil sampling in the canal was conducted to confirm the results of previous radiological investigations and to determine the existence of potentially hazardous chemical substances (SAIC 1993a). The maximum concentration of PCBs and polynuclear aromatic hydrocarbons (PAHs) found in the canal was 19 ppm (Aroclor-1248) and 53 ppm (fluoranthene), respectively. No VOCs were detected. The majority of the canal sampling locations that contain PCBs have relatively low concentrations (less than 1 ppm). PCBs by definition are not hazardous wastes, but they are hazardous constituents regulated under the Toxic Substances Control Act (TSCA). Remediation of PCBs usually depends on the initial source of the PCBs, when the contamination occurred, and the concentration found in the environment. For example, EPA's PCB Spill Cleanup Policy (40 Code of Federal Regulations (CFR) Part 761.125) applies to spills of PCBs at concentrations greater than 50 ppm.

For inorganics listed as having toxicity characteristics that were detected in the canal soils, concentrations for arsenic, and lead were found to exceed preliminary limits (EPA proposed subpart S, 40 CFR Part 264). Lead exceeded the preliminary limit (53 ppm) at several locations along the north and south canal, with a maximum concentration of 579 ppm. Only one sample exceeded the arsenic preliminary limit (80 ppm) with a value of 127 ppm.

Measurable concentrations of SVOCs are in the canal, but without a regulatory or other standard (e.g., background), it is not known whether this qualifies as hazardous waste. The highest concentrations of PCBs and SVOCs were detected in the northern portion of the north canal. Conversely, the radiological concentration is lowest at this location. This combination of contamination lends support to a determination that the canal is not contaminated with mixed waste.

Evidence suggests there is metal contamination in the canal, primarily lead, at levels above a "national" background standard. In addition, it is likely that the highest levels of lead contamination would still be above a site-specific background. Lead contamination is highest on the west bank of the canal (e.g., closest to the Dayton-Cincinnati Road and associated automobile emissions) and may be typical of near-road soils samples. These lead levels will be compared to background levels, when available, in order to evaluate whether the levels are low along the canal banks. Consequently, the combination of lead and radiological contamination is similar to the trend indicated by the PCB and SVOC contamination, i.e., the highest chemical and radiological contamination are not coincidental. This information will be used to enhance the existing risk assessments and to aid in the evaluation of remedial action alternatives.

Based on information gathered from interviews with long-time residents of the City of Miamisburg, it is suspected that up to three tanks, or portions thereof, were buried in the north canal during the 1960s, apparently to serve as runoff basins, or reservoirs, to collect water during periods of high flow in the canal bed. (No information has been discovered to date which suggests that the tanks might have been placed in this location by Mound Plant operators or DOE). The tanks probably came from a nearby power plant (owned by the city), which was itself dismantled and removed in the mid-1970s. The tanks did not perform their role as expected due to extensive silt buildup. An electromagnetic and magnetometer/gradiometer geophysical survey was conducted in 1992 for the purpose of locating objects buried in the canal (SAIC 1993b). Preliminary interpretations of the geophysical survey identified the presence of two metallic anomalies near the surface of the canal bed just north of the point where the plant drainage ditch enters the canal. These anomalies are suspected of being caused by buried metallic objects such as the tanks. The presence of the buried tanks is hypothesized to be the cause of the maximum plutonium-238 concentrations in this location, due to the tendency of the tanks to trap the plutonium-contaminated runoff released from the Mound site in 1969.

2.4. SITE CONDITIONS THAT JUSTIFY A REMOVAL ACTION

Prior to determining that a removal action in the canal is appropriate, the DOE evaluated the conditions in the canal in the OU4 RSE (DOE 1993a). The RSE concluded that plutonium-238 and tritium have been released into the Miami-Erie Canal soils and sediments as a result of past Mound Plant activities. However, field studies and risk assessments conclude that there is no current significant risk to the public or the environment as a result of these releases. The DOE next solicited an independent evaluation of the appropriateness of a removal action in the canal. This evaluation consisted of the consensus of the following parties associated with the Mound ER Progam:

- ATSDR
- OEPA, Southwest District Office
- USEPA, Region V
- Miamisburg City Officials
- DOE/DAO

Although all parties agreed that DOE is committed to the eventual assessment and, if needed, remediation of the contaminated portion of the canal, the consensus of this review group was that a removal action would be beneficial for the canal, for the following reasons:

1) A release has occurred off-site.

2) The DOE, as lead agency responsible for the Mound ER Program, can proceed with a removal action in accordance with Section 104(b) of CERCLA.

3) The EPA's guidance encourages accelerated cleanups at sites, particularly through the mechanism of non-time-critical removal action.

4) Additional studies and investigations of the conditions in the canal, as would be required under the terms of the Mound FFA, are not expected to provide any new or different information relative to environment or public health risks.

5) The change in Mound's mission as a result of the recent DOE decision to eliminate the Defense Programs at Mound Plant may lead to a change in future land use and ownership, both on the Mound site and off-site.

In order to determine the appropriate removal action alternative, Section 40 CFR Part 300.415 of the NCP requires that an EE/CA be performed if time is available to do so. This EE/CA provides an evaluation of the removal alternatives for the Miami-Erie Canal.

3. IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

This section describes the RAOs for the Miami-Erie Canal proposed removal action alternatives. These objectives are the basis for identifying and evaluating appropriate removal technologies (Section 4).

The RAOs relative to OU4 are aimed at maintaining human health and the environment through medium-specific or OU-specific goals. They specify the contaminants of concern (COCs), the exposure routes and receptors, and an acceptable contaminant level or range of levels for each exposure route (i.e., a preliminary remediation goal).

Based on the analytical historical information available at the time this document was developed, the COCs in OU4 have been identified as plutonium and tritium. The contaminated media are the soils and sediments in the canal. The potential pathways, exposure routes, and human/environmental receptors are described in the OU4 RSE (DOE 1993a). As indicated in the RSE, the pathways of concern in the Miami-Erie Canal and associated waterways include transport of plutonium and tritium from the contaminated soil/sediment by direct contact, wind, surface water, and possibly groundwater. Potential receptors include area residents, site visitors, site employees, and aquatic and terrestrial biota.

The most direct pathway for the plutonium to reach humans is by direct contact with contaminated soils and sediments. Even though direct contact could conceivably occur for members of the general public if they were to frequent the canal, this pathway is not considered a significant hazard due to the very low dermal absorption rate of plutonium, the relative inaccessibility of the contaminated soil, and the ability of the human skin to shield the radiation emitted from plutonium. Consequently, the primary exposure pathways for plutonium to reach humans are (1) ingestion of contaminated soil, (2) ingestion of contaminated food and water, and 3) inhalation of airborne contaminated particles.

For tritium, the pathways of concern, exposure routes and receptors are much like those for the plutonium-contaminated media, with the addition of the groundwater pathway for tritium due to its high solubility.

The remediation goals must satisfy the EPA Risk Assessment Guidance for Superfund (RAGS) excess cancer target risk level of 10^{-4} to 10^{-6} and must meet all ARARs to the extent practicable. Preliminary

ARARs that may serve as remediation goals are discussed in Section 3.4 (below) and presented in Appendix A.

The RAOs for the purposes of this EE/CA are as follows:

- Establish conditions in the canal that comply with all ARARs to the extent practicable.
- Minimize potential health hazards to the public and to on-site personnel with regard to the plutonium-238 and tritium contamination found in canal soils.
- Minimize environmental impacts with regard to the plutonium-238 and tritium contamination in canal soils.

3.1. STATUTORY LIMITS ON REMOVAL ACTIONS

The DOE, through Executive Order 12580 and Section 104 of CERCLA, has the authority to conduct studies and tests to assess the threat posed by present or potential contamination for conditions arising on DOE sites. DOE also has the authority to undertake planning, engineering, and other studies to determine appropriate response actions such that the risk to public health and the environment can be limited. The FFA between USEPA, OEPA and DOE reaffirms DOE's authority to conduct removal actions pursuant to Section 104 of CERCLA. Since the funding to perform this work does not come from the SARA program trust fund, this project is not subject to the 12-month, $2 million statutory limits of CERCLA.

3.2. REMOVAL ACTION SCOPE

The scope of the proposed removal action is to restore the canal bed and sediments to comply with all ARARs to the extent practicable. The specific media that are the focus of this removal action are the soils/sediments in the canal, the drainage ditch and the overflow creek.

The contaminated portion of the canal is defined as that segment of the canal, starting from a point just south of the access road to the city park (adjacent to the former north pond), and extending south to Benner Road (see Figures 2.2. and 2.3.). The drainage ditch within the scope of the removal action is defined to start at the point where the ditch emerges from the western boundary of the Mound site, extending west to the canal. The overflow creek is defined as the entire creek, i.e., from its origin at the canal (just south of the railroad trestle) to its entrance into the Great Miami River.

The physical dimensions (volume, mass, concentration) of the contaminated media are detailed in Section 5 of this report.

The scope of this removal action does not include any surface water or groundwater in the vicinity of the canal. Consequently, the surface waters in the south pond, the canal, and the overflow creek are excluded. Based on the results of the special sampling study, the COCs are plutonium and tritium (SAIC 1993a).

The potential impact of the selected removal action on future (final) site remediation is addressed in Sections 6 and 7.

3.3. SCHEDULE

The current schedule for the OU4 removal action is to issue the approved EE/CA in late fiscal year (FY) 94 and complete the 12 month removal action design/planning. This planning period of 12 months is longer than the typical removal action planning due to the complexity and range of issues associated with the canal. It is also anticipated that during this time there will be ongoing discussion and review with the stakeholders concerning the issues. Start of the removal action is currently planned for late FY 95 subject to available funding and stakeholder prioritization. Performance of the removal action is estimated at approximately 24 months.

3.4. ARARs

Any removal action conducted must be done in compliance with all ARARs to the extent practicable. Section 40 CFR Part 300.400 of the NCP states that the lead and support agencies shall identify all ARARs associated with the contaminant, location, and the action considered. Section 40 CFR Part 300.415 further states that two additional factors should be considered in determining the "practicability" of complying with ARARs: the exigencies of the situation and the scope of the removal action to be taken. A promulgated regulation (i.e., published in the CFR) is an applicable requirement if it meets all of the criteria for application of that law. Promulgated regulations deemed relevant and appropriate may not be directly applicable, but may still serve as guidance during the removal action. Additionally, other "to be considered" (TBC) criteria may be identified. These are non-promulgated regulations or guidances (e.g., DOE Orders) that do not qualify as ARARs, but may still be considered in the event the ARARs are not health protective.

ARARs can be federal or state regulations. A state regulation cited as an ARAR must be enforceable, identified in a timely manner, and more stringent than the federal regulations. Local laws are generally not promulgated state requirements, and therefore are TBCs. If the local requirement is developed under explicit state authority or if compliance is a requirement of a promulgated state statute, the local requirement may be an ARAR.

Three subgroups of ARARs can typically be identified: contaminant-specific, location-specific, and action-specific. Contaminant-specific ARARs address the particular pollutant under consideration, usually by way of a concentration limit. Location-specific ARARs are effective if the site conditions qualify for special consideration under a particular regulation (e.g., floodplains or wetlands). Some regulations, cited as action-specific ARARs, control the way in which a contaminated medium is handled.

Chemical studies in OU4 indicate no significant concentrations of hazardous chemicals in the soils and sediments. Sampling tests have shown, as expected, the presence of tritium and plutonium-238 concentrations in the soils and sediments of the Miami-Erie canal and some of OU4's associated waterways. Accordingly, this EE/CA addresses only tritium and plutonium-238 (i.e., radiological) contamination. This eliminates the applicability of the RCRA as a contaminant-specific ARAR; however, it still may be considered relevant and appropriate for action- and location-specific activities.

A list of potential Mound site ARARs was developed for the OU9 RI/FS (DOE 1992). This list has been a basis for identification of ARARs for OU4. Those pertinent to this removal action are listed in Appendix A.

3.5. PLANNED REMEDIAL ACTIVITIES

Although no remedial investigation (RI) activities have been initiated for OU4, significant historical data and evaluations exist to partially document the nature and extent of contamination in the canal area. Pending the implementation of this removal action, per the FFA schedule, RI activities are planned to commence in 1996. As discussed in the removal action alternative evaluation (Section 5), the removal action should, to the extent practicable, be consistent with proposed remedial action alternatives. This consistency will be ensured by compliance with ARARs.

4. IDENTIFICATION AND INITIAL SCREENING OF REMOVAL ACTION ALTERNATIVES

This section summarizes the process and rationale used to identify alternative removal actions by considering relevant and proven technologies as well as technologies that may be implemented to achieve the objectives developed in Section 3. The identified alternatives are evaluated in Section 5. The selected removal action alternative should constitute a solution that is protective of the public health and the environment and can be readily initiated and completed to meet the scheduling objectives established by DOE (Section 3.3).

Due to the nature of the radioactive contamination at the Mound site, the number of practicable and suitable treatment technologies that can be applied to the contaminants is limited. The technologies considered in selecting removal action alternatives are consistent with those given in interim final EPA guidance (EPA 1993) regarding removal actions. The alternatives are evaluated for their ability to satisfy the removal action objectives based on the criteria of (1) effectiveness, (2) implementability, and (3) cost. These criteria are discussed further in Section 5.

4.1. GENERAL RESPONSE ACTIONS

This section describes the GRAs in terms of remedial technologies potentially applicable to OU4. GRAs for Mound Plant were based on the media of concern and were designed to satisfy the RAOs. The GRAs involve activities that directly impact the source of contaminated materials at Mound Plant to minimize the potential hazard to human health and the environment. Each GRA may include several technology options. GRAs for Mound OU4 include no action, institutional controls, containment, collection (removal), and treatment.

4.1.1. No Action

In this response, no action would be taken to implement remedial technologies to reduce the hazard to potential human or ecological receptors. This alternative represents the current response to the canal contamination (i.e., environmental monitoring of the canal area.) The No Action response has also been included as a basis of comparison for the other GRAs.

4.1.2. Institutional Control Actions

Institutional control actions could be taken to prevent exposure to residual contaminants by eliminating possible pathways of exposure. Institutional controls, such as fencing, site security, and deed restrictions, could protect human health and the environment when implemented as a sole remedy by restricting access to contaminated media. This action may be implemented with other remedial actions (e.g., containment, in-situ physical and chemical treatment technologies). Environmental monitoring is included as part of institutional control actions. Monitoring itself does not prevent or minimize exposure; however, it does provide information for the assessment of the migration of residual contaminants and is thus an important part of preventing unacceptable exposures.

4.1.3. Containment Actions

Containment actions considered for OU4 involve the use of caps. Capping involves covering an area with a low-permeability material to ensure that COCs are sealed in-place to prevent migration and exposures from intrusion activities. Capping 1) reduces the infiltration of surface water through contaminated soils to the groundwater [but does not reduce the toxicity associated with the source material (soils)], 2) minimizes the release into the atmosphere of contaminated surface soil as dust particles which could potentially be inhaled or re-deposited onto other areas, and 3) reduces the potential for direct contact with the contaminated materials.

4.1.4. Collection Actions

Collection of contaminated material for subsequent disposition can be accomplished with conventional equipment. This process reduces the potential for human exposure in the long term, at the expense of increased short-term worker exposure. Soil can be excavated using conventional earth-moving equipment. Manual excavation techniques may be required in areas with limited access for conventional equipment. Appropriate worker safety measures would be required in these locations. Complete excavation would remove all soil where the contamination exceeds target cleanup levels.

Removal of contaminated soil by excavation would require the use of dust control and surface runoff control measures to ensure worker safety and to protect the general public and environment during

remediation activities. After removal, all release mechanisms and pathways of exposure will have been eliminated. This action, therefore, gives the greatest amount of long-term risk reduction.

4.1.5. Treatment Actions

The treatment actions evaluated for OU4 include a variety of physical and chemical processes. These processes may be applied either ex-situ (physically removed from original location) or a combination of both in-situ (in place) and ex-situ to the contaminated soils. Treatment of the soils would serve to either reduce the concentration or immobilize the contaminants in the soils, lowering the risk associated with exposure to the soils.

The treatment actions that can be performed both in-situ and ex-situ are as follows:

- In-situ grouting, solidifying the soil matrix through the injection of grouting material. Ex-situ grouting (or cementation), involving use of various cement and silicate mixtures to act as physical solidifying agents.

- In-situ vitrification, involving placement of a system of electrodes to electrically heat the soil to form a molten block of the contaminated media which solidifies upon cooling to form a stabilized mass. In-furnace vitrification (ex-situ), involving immobilization of inorganic constituents by melting the waste into a glass-like matrix through a high-temperature process.

- In-situ soil washing, involving the flushing of the contaminants from the soil by using water injection and removal by pumping through extraction wells. Ex-situ soil washing, involving the washing of the waste material with a water solution to separate the COCs based on the particle size.

- Chemical extraction processes where dilute, environmentally benign chemicals are used to selectively remove heavy metals and radionuclides from contaminated soils. With ex-situ chemical extraction, these liquids are added to the soils in multi-stage operations tailored to the cleanup levels desired to obtain separation of the contaminants into a smaller volume waste stream and "cleaned" soils in the larger volume stream. In-situ applications of these techniques provide for

the addition of these liquids directly to the contaminated soils and removal through extraction wells.

- Chemical stabilization and fixation techniques, using chemicals to form an organic polymer with the waste materials, binding the contaminants of concern, and thereby reducing potential mobility. Additional chemical processes, including chemical oxidation, reduction, neutralization, chelation, and solvent flushing.

The treatment actions which can be performed ex-situ are as follows:

- Encapsulation/solidification processes, including surface microencapsulation and thermoplastic solidification. Surface microencapsulation is the physical enclosing of wastes in an organic binder of resin. Thermoplastic solidification is the sealing of contaminants in an asphalt bitumen, paraffin, or polyethylene matrix.

- Solids separation processes, employing physical separation techniques to segregate waste materials based on size, type, or levels of contamination.

- Size reduction processes, involving the mechanical grinding, shredding, or dismantling of waste materials to obtain a physical reduction in size.

4.2. IDENTIFICATION AND SCREENING OF TECHNOLOGIES

The GRAs identified for OU4 include several potential technology options. This section describes the identification and initial screening of potential technologies to meet the RAOs defined in Section 3.0.

4.2.1. Identification of Remedial Technologies and Process Options

Remedial technologies and process options were selected on the basis of their applicability to the contaminated environmental media and geologic and hydrogeologic characteristics at OU4. The contaminated media is soil contaminated with radionuclides. Technologies considered to be too difficult to implement at the site, that would not be commercially implementable in a reasonable amount of time, that are not applicable to the contaminants of concern, or that were determined to be unreliable were

eliminated from further consideration. Table IV.1 provides a specific summary of the OU4 GRAs, remedial technologies, and process options identified for the COCs prior to screening.

4.2.2. Initial Screening of Process Options

Process options for soil are evaluated for each response action identified earlier. The rationale for either retaining or eliminating certain options is summarized in Table IV.2 and explained in more detail in the following paragraphs.

4.2.2.1. No Action

The No Action response includes no technologies or process options. No efforts to modify the existing conditions are undertaken under this response. The results of studies performed on the Canal and surrounding soils to date indicate no risks to the public or the environment based on current land use. The environmental monitoring program presently in force would continue to be applicable under the No Action response.

4.2.2.2. Institutional Control

The remedial technologies identified for institutional control at OU4 are access restriction and environmental monitoring. Access restrictions include denial of entry to the canal area or restriction of access to residual contaminated media (e.g., surface and subsurface contaminated soil). Process options are site security/isolation and deed restrictions. Site security/isolation involves the use of fences, berms, signs and/or surveillance of the surrounding site to help prevent unauthorized access. The site security/isolation process option lowers the potential for direct human contact and to a lesser extent inhalation of contaminated soil and sediments; therefore, it is potentially applicable.

Deed restrictions can be applied to the properties in the canal areas of contamination to require permits for digging, building, or any activity that can disturb the soils. The deed restriction process option can lower the potential for direct human contact and to a lesser extent inhalation of contaminated soil; therefore, it is potentially applicable.

TABLE IV.1. Mound OU4 Site General Response Actions, Remedial Technologies, And Process Options Considered Prior to Screening

ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGIES	PROCESS OPTIONS
Soil	No Action	None	None
	Institutional Controls	Access Restrictions	Fencing, guards, deed restrictions
		Monitoring	Environmental sampling
	Containment	Capping	Clay, concrete, asphalt, synthetic, multimedia
	Collection	Excavation	Soil excavation
		On-Site Disposal	Interim storage, land encapsulation facility
		Off-Site Disposal	Commercial disposal site, Nevada Test Site
	Treatment	In-situ	Soil washing, vitrification, grouting, chemical stabilization/fixation, solvent extraction
		Ex-situ	Encapsulation/solidification, solids separation/size reduction, soil washing, vitrification grouting, chemical stabilization/fixation, solvent extraction

Table IV.2. Initial Screening of Technologies and Process Options For The EG&G Mound OU4 Site
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General Response Action	Remedial Technology	Process Options	Description	Screening Comments
No Action	No Action			Retained for comparison purposes
Institutional Control	Access Restriction	Site Security/Isolation	Fences, berms, and signs surrounding sites. Guards, for authorized access control	Potentially applicable berms already in place at some portions of the sites
	Monitoring	Sampling	Environmental monitoring	Potentially applicable
Containment	Capping	Synthetic	Synthetic liner installed over contaminated areas.	Applicable; minimal damage expected if properly maintained
		Multilayered Caps	Multiple layers of different media over areas of contamination	Potentially applicable
		Native Soils	Soil spread over contaminated areas	Not applicable for containment
		Asphalt	Layer of asphalt applied over areas of contamination	Potentially applicable for minimizing or eliminating direct human contact; high potential of cracking due to freeze/thaw, if not properly maintained
		Concrete	Concrete placed over contaminated areas	Not/Applicable. Eliminated in favor of asphalt

Table IV.2. Initial Screening of Technologies and Process Options For The EG&G Mound OU4 Site
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General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Containment (cont'd)	Capping (cont'd)	Clay	Compacted clay covered with soil over contaminated areas	Potential for cracking of cap due to freeze/thaw if not properly maintained. Applicable as a component of multilayered cap
Collection	Excavation	Complete Excavation	Excavation of large amounts of soil from the site	Potentially applicable
		Partial Excavation	Excavation of soils from discrete areas where contamination exceeds target levels	Not applicable. Distribution of contamination appears to be fairly uniform rather than discrete hot spots in the canal.
Treatment	Ex-situ Physical	Surface Microencapsulation	Physical microencapsulation of wastes in an organic binder or resin	Not applicable due to high costs and technical implementability concerns
		Thermo-plastic Solidification	Waste sealed in asphalt bitumen, paraffin, or polyethylene matrix	Not applicable due to high costs and technical implentability concerns
		Soil Washing	Excavated soil washed to remove and concentrate contaminants	Potentially applicable

Table IV.2. Initial Screening of Technologies and Process Options For The EG&G Mound OU4 Site
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General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont'd)	Ex-situ Physical (cont'd)	Particle Solids Separation	Mechanical separation of contaminant material, concentrating contaminants of concern. contaminants associated with a specific particle size are mechanically separated out.	Potentially applicable in conjunction with soil washing
		Solidification	Excavated soil solidified using various cements and silicatebased mixtures as solidifying agents. The resulting solids are resistant to leaching	Not applicable due to increase in volume. Although potentially applicable for immobilization, it has not been proven effective for contaminated soils
		Vitrification	Soil and contaminants fused to a glass-like form	Potentially applicable for immobilization. Not applicable due to increase in volume. Not commercially implementable at this time. Therefore, screened from further consideration

Table IV.2. Initial Screening of Technologies and Process Options For The EG&G Mound OU4 Site
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General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont'd)	Ex-situ Chemical	Chemical oxidation, reduction, neutralization, chemical leaching, chelation, soil aeration, soil flushings, and separation	Addition of strong acids or bases to extract metals from the solid matrix. All processes involve a form of chemical addition to mitigate the contaminants in the soil	Not applicable because significant development is required to demonstrate feasibility in field. Large amounts of waste would be generated requiring additional treatment
	In-situ Physical	Grouting	Soil matrix solidified through pressure injection grouting	Not applicable because of high potential for cracking due to freeze/thaw cycles and high grout permeation coefficients in unconsolidated sediments
		Vitrification	Soils and contaminants fused into a glass-like form	Potentially applicable for volume reduction and immobilization. However, not applicable due to implementability concerns primarily based on high groundwater table at the site and difficulty in evaluating performance

Table IV.2. Initial Screening of Technologies and Process Options For The EG&G Mound OU4 Site
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General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont'd)	In-situ Physical (cont'd)	Soil Flushing	Contaminants washed from soils by injection of water in area of contamination and removed by pumping	Not applicable to contaminants of concern. Difficult to implement with significant quantities of groundwater
	In-situ Chemical	Chemical Stabilization/Chemical Fixation	Stabilization/fixation of hazardous substances through the use of chemicals which form organic polymer with the waste	Not applicable due to high groundwater table and difficulty in evaluating performance
		Chemical oxidation, reduction neutralization, precipitation, chelation, and solvent flushing, etc.	All processes involve a form of chemical addition to mitigate the contaminants in the soil	Not applicable because significant development required to demonstrate feasibility in field
Disposal	On-Site Disposal	Construct a new encapsulation facility on site	Transport contaminated materials to new on-site engineered low-level radioactive encapsulation disposal facility	Not applicable due to inconsistency with commercialization efforts at the site
	Off-Site Disposal	Existing Facilities	Transport contaminated materials to an existing off-site disposal facility	Potentially applicable

Since DOE does not own the property, it will be necessary to make an agreement with the current landowner to place restrictions on current and future activities on the property and to modify the deed to the property to reflect these restrictions. Another option is for the municipality and the Miami Conservancy District to place restrictions on land use or activities on properties that contain residual contamination.

The actions of environmental monitoring and analysis of contaminated air, soil, surface water, and groundwater are retained as applicable. Evaluation of the environmental monitoring program is required every 5 years on sites containing residual contamination to determine the need for remediation and/or continued monitoring (40 CFR 300, Subpart E.)

4.2.2.3. Containment

The primary objective of containment technologies is to reduce or eliminate the mobility of the contamination. The process options screened for containment include clay, asphalt, concrete, geosynthetic, multilayered and native soil caps.

Capping techniques can be applied over contaminated soil to prevent the escape of contaminated particles into the atmosphere, infiltration of surface water potentially leading to contaminant migration, and direct human contact. Clay caps over the contaminated areas are potentially applicable but have a potential for cracking from the heaving of the ground in the freeze/thaw cycle. Proper maintenance of the clay cap would mitigate this concern. Synthetic liners or multilayered caps (e.g., synthetic liner overlying a clay cap) over the areas of contamination are not as susceptible to cracking and, therefore, are potentially applicable. Asphalt and concrete covers for multilayered caps are also susceptible to cracking if not properly maintained. Native soil might be used in areas of relatively low radioactivity to provide an exposure barrier against direct human contact and, in conjunction with surface controls, could reduce contaminant migration by wind and water erosion. Native soil was eliminated in favor of clay or other specified soil due to lower permeability characteristics. A concrete cover layer was eliminated in favor of an asphalt cover layer, due to lower maintenance requirements.

The objectives of the containment actions will dictate whether the site should be restricted for access or developed for possible beneficial use (e.g., bike trail). If the objective of the removal action is to limit access, a multilayered cap consisting of a synthetic liner overlying a clay base would be an appropriate

containment action. If the site were to be developed for the dual purposes of containment and possible recreational (beneficial) use, an appropriate response would be the installation of a multilayered cap consisting of clay, synthetic liner, and asphalt. Additionally, the beneficial use option would tend to ensure that regular maintenance would occur more than in the limited use option, which under CERCLA regulations only requires re-evaluation every five years.

4.2.2.4. Collection

The primary criteria for choosing collection technologies is removal of contaminated soil. The technologies screened for collection of contaminants include excavation and disposal. Excavation involves the removal of untreated contaminated soils by a number of mechanical means including back/track hoes, cranes with clamshell, dredging attachments or other such equipment. The process options screened for collection of contaminants include soil excavation, interim storage facilities, land encapsulation facilities, and off-site disposal facilities [such as Nevada Test Site (NTS)].

Disposal technologies are defined, for the purposes of this evaluation, as permanent off-site disposal. An on-site (i.e., at Mound Plant) interim storage concept would be similar to DOE's conceptual design of an above-ground land encapsulation facility (BNI 1989). Although, technically feasible, this concept was eliminated because it would be incompatible with the changing mission for the Mound site.

Off-site disposal options available for this removal actions consist of the federal NTS and a commercial facility in Utah. Both sites are able to receive, handle, and emplace radioactive-contaminated soils. Although the commercial facility accepts mixed waste, NTS currently does not accept mixed waste pending approval of a RCRA Part B permit for a mixed waste disposal cell. Current DOE policy (DOE Order 5820.2A) for disposal of low-level waste is to use either on-site or off-site DOE facilities. For this reason, and because both sites are located similar distances from Mound Plant, the NTS was chosen as the representative off-site disposal location for purposes of evaluating alternatives.

Although other sites have been licensed by the Nuclear Regulatory Commission (NRC) to handle low-level radioactive waste, the NTS radioactive waste disposal operation has been designated for wastes generated through DOE Defense Program operations. Although the site has no specific restrictions against plutonium-contaminated waste, for the purposes of this evaluation it is assumed that shipments of contaminated waste will be in containerized form. In addition, extensive certification and preshipment

approval requirements are specified in the waste acceptance criteria. Provided that the excavated soils from OU4 are determined to be Defense Program waste, NTS is a viable disposal option. Rail transport is not available for NTS shipments.

4.2.2.5. Treatment

The primary criteria for choosing treatment technologies for radionuclide contaminants are volume reduction and immobilization. The selection of volume reduction technologies for soils contaminated with radionuclides is predicated upon particle size separation. Radionuclides tend to adhere to fine-grained particles because of a higher surface area to volume ratio. If coarse- and fine-grained materials can be separated, treatment may be beneficial to lower the transportation and disposal costs through volume reduction. Success of reducing the volume of radionuclide-contaminated soils also depends on the options available to dispose of the less-contaminated material (e.g., coarse-grained material). Immobilization processes would adequately bind the radionuclides in a matrix to prevent their availability for transport through the media of concern.

The process options screened for treatment included both in-situ and ex-situ physical and chemical options. Surface microencapsulation and thermoplastic solidification (encapsulation/solidification) were both eliminated from further consideration due to difficulty in implementation and the inherent stability of the plutonium/soil bond. Vendors for these technologies are not readily available and treatability studies would be required to select an appropriate binder.

Solid separation and size reduction techniques can be used to separate solids by mechanical screening, gravity separation, flotation, magnetic separation, etc. This technology option has been used to extract radionuclides from ores. Generally, this option has been used as a pretreatment for a primary treatment process. The success of solids separation techniques varies with the soil/radionuclide particle size distributions. Treatability studies must be conducted to determine if there is a relationship between radionuclide concentrations and particle-size distribution on a site by site basis, and to determine the feasibility of separating the clay soil mixture in the canal sediments. For the purposes of this evaluation, assuming that the radionuclides at OU4 adhere to fine-grained particles, this technique is potentially applicable.

In-situ soil washing, or flushing, is the injection of a wash solution or water into the contaminated soil and removal by pumping for ex-situ treatment or disposal. In-situ soil washing was eliminated because this technology is not applicable to the contaminants of concern, and may be difficult to implement with significant quantities of groundwater.

Ex-situ soil washing separates and concentrates COCs by mechanically and/or chemically scrubbing soils to remove contaminants. This technique removes contaminants by dissolving them in a solution or by separation through particle-size distribution. Soil washing can be used alone or in combination with other treatment options. This method could reduce the volume of contaminated soils if the soils contain a large quantity of coarse-grained particles.

Solids/particle separation also involves the separation of contaminated material to concentrate the COCs; contaminants associated with a specific particle size can be mechanically separated out of the soil media. Chemicals may be added in small amounts to adjust pH and to improve efficiency of the process. This process option is potentially applicable especially in conjunction with ex-situ soil washing and has been retained for further consideration.

Vitrification involves the immobilization of inorganic constituents by dissolving the contaminated material into a glass-like matrix. Vitrification is a high temperature process (1100° - 1400°C); therefore, any organics present will be volatilized during the process. Afterburners may be required on the exhaust stream to convert any partially burned organics to carbon dioxide. For in-furnace vitrification (ex-situ), glassmaking constituents and the waste are blended and then fed into a glassmaking furnace. In the high-temperature furnace, the contaminated materials are dissolved or suspended in the molten glass. Upon cooling, a solid mass forms that contains the dissolved or suspended contaminants. In-situ vitrification involves the placement of a system of electrodes to heat the soil to form a molten block of the contaminated media which solidifies upon cooling to form a stabilized mass. Waste soil would possibly require a drying pretreatment step prior to vitrification depending on furnace design to reduce the moisture content based on the amount of free moisture expected in the contaminated subsurface soils in the canal.

After vitrification, the contaminants are unavailable for reaction due to the chemical bonding and entrapment within the glass matrix. Both alpha and beta radiation emitters would be sealed in the glass matrix formed during the vitrification process (EPA 1991). However, in the case of in-furnace vitrification, the vitrified material will still require interim storage on the Mound site or disposal at an off-

site disposal facility. The immobilization benefits offered by the glass matrix would be redundant to containment provided by the storage or disposal cell. Therefore, ex-situ vitrification will not be considered further.

In-situ vitrification was eliminated from further consideration due to site surface water and groundwater conditions and difficulty in evaluating performance. This process option also may inhibit potential future groundwater remediation activities at OU4.

Solidification techniques, known as stabilization or fixation, can be applied to solid, liquid, or sludge waste. Although solidification techniques are effective in reducing the mobility of contaminants as opposed to reducing the volume of contamination (as other treatment technologies do), solidification does reduce the potential hazards to human health and the environment. Solidification combines a formulated reagent with the waste to create a solidified matrix. Stabilization technologies can be categorized by the primary stabilizing agent used, i.e., thermoplastic-based or organic polymer-based. Stabilization has been used effectively to stabilize soils contaminated with inorganic wastes.

Other solidification technologies used for excavated soil involve the use of various cement- and silicate-based mixtures to act as physical solidifying agents (ex-situ grouting). Cement solidification may significantly increase the volume of waste needing disposal. The resulting solids resist leaching, thereby minimizing the potential for migration of contaminants to groundwater. However, solidification has not been proven completely effective for soil contaminated with certain radionuclides, and due to the increased volume requiring disposal, this physical process option will not be considered further.

In-situ grouting involves injecting cement grout at high pressures directly into the contaminated soil, forming a mechanical bond. Cement grouts are better suited for coarse-grained materials. In-situ grouting was determined not to be applicable due to the high potential for cracking from freeze/thaw cycles.

Chemical stabilization/fixation process options evaluated include a variety of processes such as chemical leaching, chemical oxidation, reduction, neutralization, precipitation, chelation, soil aeration, solvent flushing, etc. In general, all these processes involve adding chemicals to treat the contaminants in the soil; therefore, there is a high potential for generating larger volumes of hazardous constituents and by-products in the resulting waste stream. Recently, however, advances have been made in the use of environmentally benign extraction solvents with selective affinity for radionuclides and/or heavy metals. Although the

potential exists for these techniques to significantly reduce the volume of waste to be contended with, the processes still require further development before they are ready for full-scale field implementation. Chemical stabilization/fixation processes are therefore considered not applicable without extensive treatability studies.

4.3. DEVELOPMENT OF ALTERNATIVES

In this section, the technologies that passed initial screening in Section 4.2 are combined into alternatives that represent a range of treatment, containment, and disposal options. The GRAs and process options considered potentially applicable to OU4 include the following:

- No action (considered for the purpose of comparing to other alternatives)
- Institutional controls (site security/isolation; deed restrictions and monitoring)
- Containment (multi-media cap and monitoring)
- Collection (complete excavation)
- Treatment (soil washing and particle/solids separation)

Based on consideration of the various benefits and liabilities from the range of possible response actions above, the alternatives developed for remediating the contaminants at OU4 are as follows:

- No Action
- Institutional Controls
- Containment
- Excavation and Disposal
- Excavation, Treatment and Disposal

Specific process options will be paired and discussed in detail with the developed alternatives for the detailed analysis in Section 5.

4.3.1. Alternative 1 - No Action

The No Action alternative provides a comparative basis for the other alternatives developed below and presents an option for evaluation which examines the benefits and disadvantages of continuing with the

current course of action. The No Action alternative would allow the continued unrestricted access to the Miami-Erie canal in its current state. The environmental monitoring program as currently scoped would continue to provide information for the public, Mound site operators and DOE to maintain surveillance on the contaminants and their potential transport through the soil and groundwater.

4.3.2. Alternative 2 - Institutional Controls

This alternative would provide further access restriction through the installation of a security fence around the perimeter of the Miami-Erie Canal. Signs prohibiting entry would be prominently placed upon the fence. Deed restrictions for those parcels of land containing radionuclide contaminants would preclude digging or drilling. The environmental monitoring program as currently scoped would continue to provide information for the public, Mound site operators and DOE to maintain surveillance on the contaminants and their potential transport through the soil and groundwater.

4.3.3. Alternative 3 - Containment

This alternative involves capping the contaminated soils and conducting environmental monitoring and a 5-year statutory-required review to determine whether the remedy is still protective of human health and the environment. Containment would involve capping areas of the North and South Miami-Erie Canal containing radionuclide contaminants. Two options exist for the containment alternative which are dependent upon the objective of the removal action. The first option would consist of utilizing clean fill to raise the grade in the canal in preparation for applying a clay layer, a synthetic liner, a sand drainage layer, and topsoil and hydroseed. Stone-lined drainage swales would need to be constructed to protect the integrity of the cap and facilitate existing drainage from the Dayton-Cincinnati Road. Radionuclide contaminants within the drainage ditch from the Mound property line to the canal would be excavated and incorporated into the soils beneath the capped areas. A second option provides for remediation with beneficial use and involves a multilayered cap consisting of asphalt overlying a synthetic liner and clay to facilitate potential recreational use. In either case, Mound-site drainage (NDPES outfall 002) would need to be re-routed from the canal-site area.

4.3.4. Alternative 4 - Excavation and Disposal

This alternative involves excavation of all surface and subsurface soils contaminated above DOE guidelines for residual soil contamination (see Appendix A) and off-site disposal at a DOE or commercially licensed facility. Clearing and grubbing of all woody vegetation would be required prior to excavation and removal of contaminated soils and sediments with conventional earth-moving equipment. All excavated soil and sediments would be containerized for transport to the off-site disposal facility. All excavated areas would be restored with clean backfill and loam, and hydroseeded. The drainage channel would be reconstructed and any flood plain/wetlands restored as appropriate.

4.3.5. Alternative 5 - Excavation, Treatment and Disposal

This alternative is similar to Alternative 4, but includes on-site treatment of contaminated soils as a pre-disposal step. Treatment options screened in the process of developing the alternative include solvent extraction and soil washing based on promising developments in solvent extraction techniques which employ dilute solvents with selective affinity for the COCs. These solvents have proven to be environmentally benign, rendering a great percentage of soil clean or suitable for unrestricted return to the environment. The timing for this removal action, however, may preclude its use due to the need to perform further treatability studies at Mound or verify successful implementation of removal actions using these technologies at Superfund sites which are not federal facilities (such as Mound).

The treatment technology retained for detailed evaluation is soil washing with particle solids separation. The treatment facility would be constructed within proximity to the Miami-Erie Canal. Excavated soils would be put through a coarse-separation-sizing screen to remove debris or large stones. The soils would then enter the treatment train to be agitated via counter-current flow. The counter-current flow system separates soils into fine- and coarse-grained particle sizes. The fine-grained particles are considered "contaminated" and the coarse-grained particles are considered "uncontaminated." The coarse-grained particles are carried with wash water into clarifiers. Surfactants are added to the wash water to further remove particles from the wash water. Fine-grained soil particles are removed from the clarifier as sludges and dewatered in a filter press. The wash water is treated via a granulated media filter and recycled into the wash system. The dried fine-grained soils are contained or loaded for transport to an off-site disposal facility. The coarse-grained soils could be disposed in a conventional industrial landfill as solid waste, or replaced in the canal as clean backfill.

5. ANALYSIS OF REMOVAL ACTION ALTERNATIVES

5.1. EVALUATION CRITERIA

The alternatives described in Section 4.3. were evaluated according to the following criteria:

- Effectiveness
- Implementability
- Cost

To achieve consistency with regulatory requirements and removal objectives summarized in Section 3.0, the effectiveness and implementability criteria are divided into several evaluation components which are described below. These criteria are similar to the evaluation criteria detailed in Chapter 6 of EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA 1988). For the purposes of this report, these criteria are modified somewhat since the removal action is not intended to be the final and permanent remedial action. The action selected, however, will be consistent with the final remedy established in the ROD such that impacts from the removal action are minimized.

Section 121 of SARA identifies a strong statutory preference for remedies that are highly reliable and provide long-term protection. The principal requirements for a selected remedy are that it be both protective of human health and the environment and cost-effective. Additional selection criteria include the following:

- Preferred remedies are those in which the principal element consists of treatment to permanently and significantly reduce the volume, toxicity, and mobility of hazardous substances, pollutants, or contaminants.

- Where practical treatment technologies are available, off-site transport and disposal without treatment is the least-preferred alternative.

- Permanent solutions and alternative treatment technologies or resource recovery technologies should be assessed and used to the maximum extent practicable.

5.1.1. Effectiveness

The effectiveness criterion has been divided into four components. These components are as follows:

- Protection of public health and environment
- Reduction of toxicity/mobility/volume of contaminants
- Consistency with final remedial action
- Compliance with ARARs

5.1.1.1. Public Health and Environment

The components of effectiveness are evaluated by the alternatives' ability to ensure the protection of, and to minimize the impacts to, public health and environment. The evaluation addresses two aspects of public health: the general public and the workers involved in the removal action. In addition, the evaluation addresses the protection provided during implementation of the removal action and for the time period until any final remedial action takes place. The potential for failure of the alternative and any resultant public health threats is also evaluated. Any environmental impact resulting from the release of the residues is evaluated.

5.1.1.2. Reduction in Toxicity/Mobility/Volume

This component normally focuses on the treatment of the COC. This evaluation focuses on the alternative's ability to either reduce the mobility of the plutonium and tritium by providing leak-tight barriers, reduce the volume of contaminants readily available for release to the environment, or reduce the concentration of contaminants contributing to the exposure risk.

5.1.1.3. Consistency with Final Remedial Action

The NCP requires that a removal action be consistent with the anticipated final action for the OU and not unduly delay the final action. RI/FS activities for Mound Plant and affected surrounding areas are currently underway to determine the full nature and extent of contamination and to establish preferred alternatives for final remedial action. The preferred action for mitigation of the threat from canal contamination shall retain flexibility for action specified for final remediation.

5.1.1.4. Compliance with ARARs

The performance of each alternative with regard to the ARARs is assessed by means of listing of ARARs potentially applicable to Mound Plant that have been prepared as a part of the OU9 RI/FS activity. This listing of ARARs applies in part to the proposed removal action for OU4. Those indicating particular applicability have been summarized in Appendix A and were used to develop the effectiveness assessment for the alternatives developed.

5.1.2. Implementability

The implementability of an alternative is typically defined by its technical feasibility, including the availability of applicable technologies and its administrative feasibility. For purposes of this removal action, a third evaluation component, timeliness, is added due to the strong preference for removal actions that can be designed and implemented in a minimum amount of time.

5.1.3. Cost

The final factor considered is the total cost of an alternative. This factor includes direct capital costs, indirect capital costs, and any post-removal site control costs. The cost estimates are intended to provide an accuracy between +50 percent and -30 percent. A present-worth analysis is conducted to provide a common basis for comparison.

EPA guidance allows the use of Order of Magnitude estimation for the purposes of assessing the relative expense of a given alternative as compared to any other option or to a base option. At this stage, it is not expected that detailed costs such as those which come from a completed design would be available. In addition the guidance views costs as they relate to implementation of removal actions at Superfund sites which are not federal facilities. Requirements for implementation of projects at their facilities carry additional costs to comply with Departmental Policy and Procedures. An example would be DOE order 4700.1 which provides requirements for planning and implementing projects at DOE sites. These costs have not been included in the cost estimates developed for this EE/CA because they would not effect the results of the comparative evaluation.

The cost criterion is applied differently than the effectiveness and implementability criteria. The objective of the cost evaluation is to eliminate removal action alternatives for which the present worth cost greatly exceeds that of other alternatives while providing only a marginal increase in the degree to which the removal action objectives are satisfied.

5.2. ALTERNATIVE 1 - NO ACTION

This alternative consists of performing no removal action and maintaining the monitoring programs, current land use, and public access conditions at the site.

5.2.1. Effectiveness

The No Action alternative is included as a basis for evaluation of other alternatives to study and to assess the merits of continuing on the course of action. The No Action alternative does not pose an additional risk to the community, workers, or the environment; however, this alternative may not be effective under future land-use scenarios in protecting human health and the environment in that it does not reduce the toxicity, mobility, or volume of contaminants. Potential exposure pathways of direct contact, ingestion and inhalation of contaminated soils remain unchanged. Exposure to contaminants and the size of the affected area could increase over time as a result of disturbances by humans and natural processes and the subsequent movement of contaminants by erosion and surface water transport. The short- and long-term effectiveness of this alternative does not differ from the current status since all of the contaminated materials would remain in place and the possibility of the exposure of residents to radionuclides would remain the same. Although evaluations of the current risk to the public and environment (performed on the basis of present land use) indicate the threat to be small, the No Action scenario does not address the RAOs presented in Section 3. It would be consistent, however, with any final action developed since no site conditions would be changed.

5.2.2. Implementability

This alternative is easily implemented since it does not depend on the availability of funding, treatment and disposal services, construction materials or labor. Since this alternative does not involve materials handling operations or construction activities, no additional injury risks would be associated with this

alternative. This alternative also does not hinder the future undertaking of other remedial actions or monitoring.

5.2.3. Cost

No additional capital costs are required to implement the No Action alternative. The operation and maintenance (O&M) costs include the costs associated with the current monitoring program. The O&M costs to maintain monitoring are approximately $25,000 per year. The costing tables for this alternative are presented in Appendix B, Tables B-1 through B-5.

5.3. ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

This alternative includes actions taken to limit access to the site, thereby reducing the potential exposure of the public to contaminants at the site. The component actions include the installation of new fencing and posting of restrictive access signs. Monitoring the contaminant levels and environmental condition of the site (e.g., periodic site inspection and environmental monitoring) would be continued.

5.3.1. Effectiveness

This alternative would be slightly effective in reducing public potential exposure to contaminants present at the site and would continue to supply information regarding the environmental condition of the site. This alternative would also slightly reduce the mobility of contamination resulting from potential disturbance of the contaminated areas. However, the Institutional Controls alternative would not reduce the toxicity or volume of contaminants. The risk to workers associated with the installation of institutional controls is lower than risks associated with other removal alternatives due to the minimal soil disturbance required for this alternative. This alternative also does not involve the transport of contaminated materials, which reduces the potential for accidents and exposure of the general public. However, the implementation of institutional controls would involve some material handling and construction activities, which represent a potential risk of injury. The estimated time to complete this alternative is less than one month.

In the long term, this alternative does not represent an effective means of reducing the risk associated with the residual contamination at the site. This alternative would also not prevent the movement of contamination due to erosion. In order to maintain a reduced risk of exposure, the institutional controls

installed at the site must be inspected annually and periodic repairs must be performed in order to ensure that a breach of site security does not occur. The impacts to the environment from implementing the action are minor as only small amounts of material will be excavated to place posts and other items required to support fencing and signs.

5.3.2. Implementability

This alternative could be implemented relatively quickly and easily. There are no complex technologies or special actions required to effect the desired changes. The equipment, supplies, and experienced workers employed in these construction activities are typically readily available. Implementing this alternative would include installing new fencing, posting restrictive access warning signs at the site, and installing supplemental environmental monitoring capability to provide greater precision and consistency to surveillance activities required after the removal action is complete.

5.3.3. Cost

The cost of this alternative includes capital costs for supplies associated with the construction of fencing, posting of signs, installation of monitoring equipment, as well as labor costs. The capital costs associated with this alternative are estimated to be $234,000. The O&M costs to maintain institutional controls and conduct monitoring are $30,000 per year. The costing tables for this alternative are presented in Appendix B, Tables B-6 through B-12.

5.4. ALTERNATIVE 3 - CONTAINMENT

This alternative includes variations on the implementation of its overall objective. The options for implementation necessarily require more detail in discussion of their differences, especially in the areas of effectiveness and implementability.

The proposed Alternative 3 would involve two options: Limited Use and Beneficial Use. Both of these options involve leaving the contaminated soil in place and constructing a capping system in order to contain the contamination. As Figures 5.1. and 5.2. indicate, contamination may be present in soils high on the canal walls, a position that would not be covered by the proposed cap. This soil would be moved into the canal basin so that all of the contaminated soil would be under the cap. No institutional controls would be included to restrict the access to contaminated areas in either option.

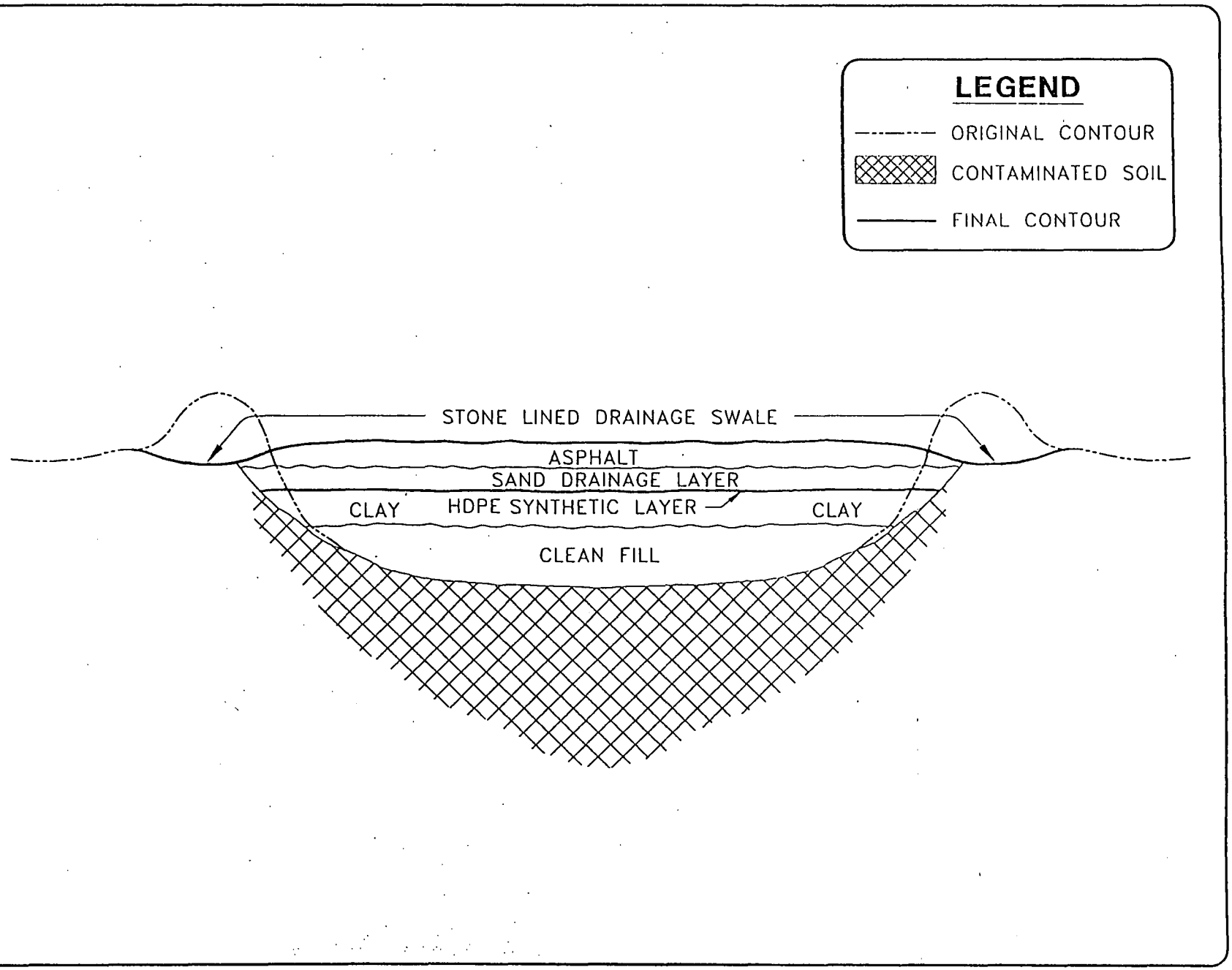

Figure 5.1. Alternative 3, Canal Cap For Beneficial Use

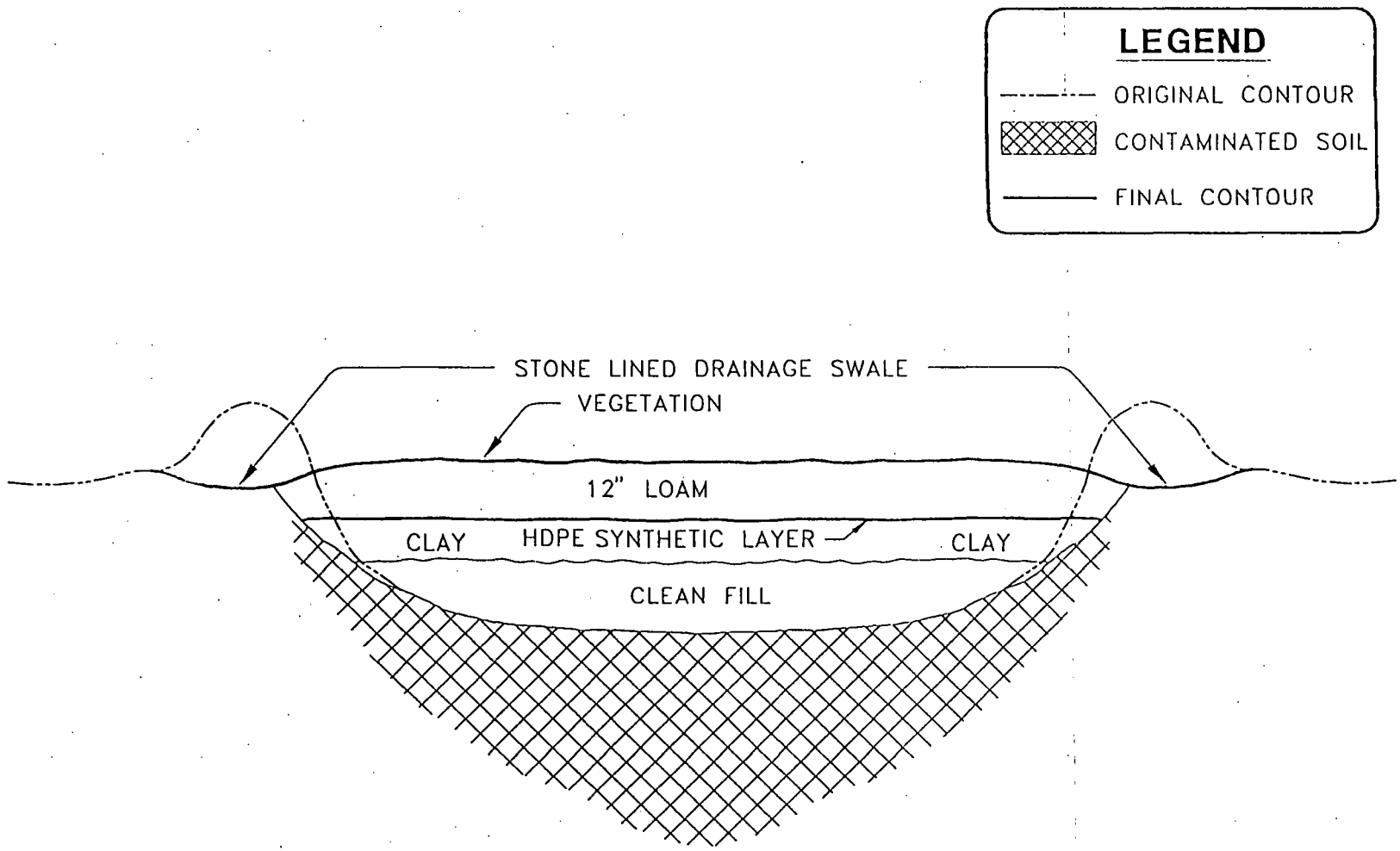

Figure 5.2. Alternative 3, Canal Cap For Limited Use

5.4.1 Limited Use

The Limited Use option would involve the installation of a synthetic/clay cap system in order to contain the contaminated material and prevent exposure to radionuclides. This option would involve capping the radionuclide-contaminated soils and sediments with a 40-mil thickness of a high density polyethylene (HDPE)/synthetic/clay cap system. The area would be restored to grade with a 12-inch thickness of loam and seeded with a vegetative cover such as grass.

5.4.1.1. Effectiveness

Strict dust control measures would be implemented during the excavation of contaminated soil encountered along the wall of the canal, and during handling and replacement of the contaminated soils into the base. Water sprays with surfactants would be employed at emission sources. Air-monitoring equipment would be positioned around the perimeter of the excavation site to measure airborne particles and their level of radioactivity. Erosion control measures would be taken to prevent the erosion of soil from the removal area. Additionally, the effect of recontamination of areas where soil has been removed along the canal wall can be minimized by excavating the upgradient portions first. During inclement weather, excavation activities would cease and the removal areas would be covered. The removal activities would not impact groundwater quality because all activities would be conducted above the water table. Mound site drainage would need to be rerouted from the canal area. The underground sanitary sewer would not be impacted by the construction of a Limited Use cap, except that the cap would have to be carefully constructed around the existing manhole risers. Access to the manholes would be maintained after the cap completion.

This alternative would be moderately protective of human health and the environment. Covering the contaminated areas would reduce the long-term risk to human health by minimizing exposure pathways of direct contact, ingestion or inhalation of contaminated particles. With respect to short-term effectiveness, the fugitive dust production would temporarily increase during construction activities, but most contaminated soils would remain undisturbed. Short-term excavation-associated risks to site workers could increase due to exposure via inhalation, dermal contact and incidental ingestion. The risks would be controlled through worker training, use of protective clothing/breathing equipment, and dust abatement actions such as damp sprays. The estimated time to complete this alternative is four months. Long term residual risk associated with implementation of this containment alternative is due to the contaminated materials that would remain beneath the cap at the site. Containment would be effective in reducing the

risk of exposure by eliminating the exposure pathways. In the long-term, natural forces such as wind and rain could eventually erode the multimedia cap and expose the contaminated soil. For this reason, long-term maintenance and possible future replacement would be required in order to ensure the integrity of the cap system. This alternative would maintain a moderate degree of long-term effectiveness and permanence if upkeep is performed.

Impacts to the workers, the public and the environment during material removal and replacement would also be minimized by the use of a vehicle decontamination facility. A sedimentation basin would be used to control excess water in the excavated material.

The non-radiological hazards associated with implementation of this alternative would be similar to those encountered in any earth-moving project. Existing activities could potentially result in accidents causing injuries to workers. An estimation of the risk associated with these activities would be based on the number of labor-hours required for construction activities, including site preparation, and movement of contaminated soils within the Miami-Erie Canal.

5.4.1.2. Implementability

Implementation of this alternative would require the clearing and grubbing of the Miami-Erie Canal (north and south), excavation of contaminated materials along the canal walls and incorporation of the material into the base, hauling of clean fill to restore the grade of the canal, installation of swales along the perimeter of the canal to accommodate surface runoff originating from the capping action, preparation of the areas to be capped, installation of the asphalt/synthetic cap/clay cap system, and installation of an alternate drainage route for Mound site runoff to reach the Great Miami River. The presence of the sanitary sewer manhole risers in the north canal would be a minor constraint in that the soil grading and cap installation efforts will have to be performed in a manner to avoid interfering with the sewer operation. The design phase of this system would require a moderate degree of effort. This option could affect the potential final remediation of OU4, in that it may be necessary to remove the cap structure to facilitate future remediation of the contaminated soils and/or ground water.

5.4.1.3. Cost

The direct capital costs for the containment alternative incorporate expenses for site preparation and construction of the cap (including labor, equipment, and testing.) Indirect capital costs (assumed to be

50 percent of capital costs) include engineering design, project management, and insurance. The total direct capital cost for installation of the cap for the limited use option is $1.4 million. The O&M costs for the cap include site inspections, erosion control and drainage way and cap maintenance. The estimated yearly maintenance cost for the cap is approximately $75,000. The costing tables, which include a sensitivity analysis, are presented in Appendix B, Tables B-13 through B-19.

The cost estimate for this alternative does not include costs for design, installation, and maintenance of a new Mound Plant drainage pathway from the drainage ditch to the overflow creek.

5.4.1.4 Other Criteria

The Limited Use Option is moderately effective in meeting the SARA Section 121 guidelines in that it is a relatively permanant solution and it does not require off-site transport. However, it does not significantly reduce the toxicity, mobility, or volume of the contaminated soil.

5.4.2. Beneficial Use

This option employs an asphalt/synthetic liner/clay cap system to contain the contaminated material and mitigate exposure. The cap would be designed such that it could be used for recreational purposes, such as a walking trail or a bike path.

5.4.2.1. Effectiveness

To ensure minimal impacts to the environment during implementation of this alternative, mitigating measures as described for the Limited Use option will also be implemented for this option (i.e., dust control, erosion control, air monitoring, etc). Similarly, the Beneficial Use option would not adversely impact the existing sanitary sewer lines. This alternative will be moderately protective of human health and the environment. The path must be constructed in a manner that would minimize the potential for exposure to individuals using the area. The capping of the contaminated areas would reduce the risk to human health by further minimizing exposure pathways of direct contact, ingestion or inhalation of contaminated particles. However, the increased public use of the constructed path would result in a greater potential exposure than in the Limited Use scenario. With respect to short-term effectiveness, the fugitive dust production would temporarily increase during construction activities. The estimated time to complete

this alternative is four months. Long-term residual risk associated with this containment alternative would be reduced by eliminating the exposure pathways. The outer asphalt surface of the cap system would eliminate the potential of a breach in the cap due to erosion; however, the asphalt cap would require periodic inspection and repair to ensure that no cracks develop during active use of the path. For this reason, long-term maintenance would be required (as is also the case for the Limited Use option). This alternative would maintain a moderate degree of long-term effectiveness and permanence if upkeep is performed.

The non-radiological hazards associated with implementation of this alternative would be similar to those encountered in any earth-moving project. An estimation of the risk associated with these activities would be based on the number of labor-hours required for construction activities, including site-preparation, and the movement of contaminated materials within the Miami-Erie Canal.

5.4.2.2. Implementability

The administrative feasibility of this alternative is moderate, primarily due to uncertainties about the degree of permanence this option provides with respect to consistency with any final remedial action identified. Public and regulatory acceptance will also be required to implement this alternative.

Implementation of this alternative would require the clearing and grubbing of the Miami-Erie Canal (north and south), excavation of contaminated materials along the canal walls and incorporation of the material into the base, hauling of clean fill to restore the grade of the canal, installation of swales along the perimeter of the canal to accommodate surface runoff created from the capping action, preparation of the areas to be capped, installation of the asphalt/synthetic cap/clay cap system and rerouting of Mound site runoff through an alternate drainage pathway to the Great Miami River. This option can be implemented relatively easily despite the presence of the sanitary sewer line. The design phase of this system would require a moderate degree of effort. This option could cause a small impact on the potential final remediation of OU4, in that it may be necessary to remove the cap structure to facilitate any future remediation of the contaminated soils and/or ground water.

5.4.2.3. Cost

The direct capital costs for the Beneficial Use alternative incorporate expenses for site preparation and construction of the cap (including labor, equipment, and testing). Indirect capital costs (assumed to be 50 percent of capital costs) include engineering design, project management, and insurance. The total direct capital cost for installation of the cap for the Beneficial Use option is $1.6 million. The O&M costs for the cap include site inspections, erosion control, drainage and cap maintenance and monitoring. The estimated yearly maintenance cost for the cap is approximately $75,000. The costing tables, which includes a sensitivity analysis, are presented in Appendix B, Tables B-13 through B-19.

The cost estimate for this alternative does not include costs for design, installation, and maintenance of a new Mound Plant drainage pathway from the drainage ditch to the overflow creek.

5.4.2.4. Other Criteria

(See discussion for Limited Use Option, Section 5.4.1.4.)

5.5. ALTERNATIVE 4 - EXCAVATION AND DISPOSAL

Under Alternative 4, all plutonium-contaminated soils and sediments exceeding the Mound site cleanup guideline (Appendix A) would be removed from the Miami-Erie Canal. Prior to implementation, a decontamination facility consisting of a vehicle wheel-wash system and water collection system would be constructed at the entrance of the site. The excavated soil and sediments would be removed via conventional earth-moving equipment such as backhoes and dump trucks, and would be transported using trailers.

To remove water from the soils and sediments, an earthen berm with silt fencing would be constructed adjacent to the work area for dewatering piles of excavated soil. Downstream of the work area, haybale check dams with silt fencing would be placed to intercept any soil particles that may become suspended in the water and transported down-stream during the excavation activities. Excavation of contaminated soils could affect the sanitary sewer depending on the soil depth required to achieve the cleanup standard. Water generated during excavation and treatment that is tritium-contaminated will be disposed. Prior to start of excavation, the exact location of the sewer line in the region of contaminated soil will be

determined. If excavation is required in the canal down to the elevation of the sewer line, measures can be taken to assure the integrity of the pipelines and risers during the removal action.

Prior to backfilling the excavated area, soil samples composited over the area of concern would be analyzed for plutonium and tritium content. Laboratory results would be analyzed to ensure compliance with the cleanup standards (see Section 3). As part of site restoration activities, clean backfill would be placed and compacted to existing contours. A drainage channel would be excavated into the backfill and stabilized with stone one-foot deep. In appropriate wetland areas, wetland vegetation engineering modules would be placed along the stream bank to prevent erosion and re-introduce indigenous vegetation to the drainage channel. The remaining portion of the disturbed areas would be restored with one foot of topsoil and hydroseeded.

It is necessary to determine the volume of contaminated canal soil and sediment in order to evaluate the feasibility and costs of the excavation alternatives. Based on the DOE cleanup guideline (100 pCi/g) for plutonium-238 (Appendix A), the volume of contaminated soil in the canal was estimated by determining the cross-section contamination profile of each sampling locations in the canal (Rogers 1975) and integrating this area over the length of the canal. (The cross-section contamination profile was assumed to be constant from each sample location up to the midway point between the selected location and the adjacent - upstream and downstream - locations.) Using this technique, the volume of contaminated soil above the cleanup standard in the canal and drainage ditch is estimated to be approximately 17,000 yd^3. (Per Rogers, 1975, no plutonium-238 concentrations above 100 pCi/g were found in the overflow creek.)

As a measure of the sensitivity of the evaluation to the volume of contaminated soil, the calculation was repeated for a lower cleanup standard (25 pCi/g, plutonium-238). The resulting volume of contaminated soil increased by 33%, or a total of approximately 23,000 yd^3, including part of the soils in the overflow creek.

5.5.1. Effectiveness

Work in the north canal will be conducted during the summer months when the canal is dry to mitigate the effect of canal surface runoff. Other measures to re-direct Mound site drainage away from the south canal will be implemented to improve working conditions. These measures which are not included in the scope of this removal action alternative will have to be implemented prior to commencing this removal

action. Any wet contaminated materials encountered will be placed in a dewatering sedimentation basin. Wet materials will be transported in leak-proof container trucks if necessary. The COCs are expected to adhere to the soil particles; therefore, water generated during remedial action should not be contaminated as long as silt fences and filtering techniques to remove suspended particulates from runoff or collected water are used. (Treatability studies may be required to verify that tritium contamination also behaves in this manner.) Strict dust control and erosion control measures would be instituted to mitigate these risks.

This alternative increases the potential public and environmental exposure in the short term, primarily from exposure via inhalation, dermal contact and incidental ingestion. The estimated time to complete the construction phase of this alternative is one to two years. The associated risk would be controlled through worker training, protective clothing and equipment. Resuspended contamination and potential groundwater contamination are the primary sources of the potential for increased short term environmental exposure. To control this and prevent the contamination from spreading to residential areas, all equipment would be monitored for radiation and decontaminated as necessary prior to leaving the site. All construction personnel would pass through access control points, and be radiologically scanned to assure that radioactive materials are not leaving the site.

This alternative has a high degree of long-term effectiveness because contaminated soils would be removed from the area, thereby eliminating any potential impacts to human health or the environment and eliminating the potential for migration. Removal of contaminated soils results in eliminating the need for long-term site management controls.

Excavation and disposal would reduce mobility of the contaminants by securing them in a disposal facility free of mobilization agents, such as water, air, and future construction activities. Toxicity of the waste would not be reduced; however, exposure risks to human and environmental receptors would substantially decrease.

The off-site disposal option would be effective to protect the public health and the environment because it would remove the source term from the Miami-Erie Canal. Once contaminants are placed at the selected disposal facility, the management of the contaminated soils is not expected to pose significant difficulties or impact reliability of environmental controls. Environmental controls at the facility would include monitoring the effectiveness, reliability, and integrity of the waste containment structure.

5.5.2. Implementability

This alternative is readily implementable from a technical standpoint. The chief technical difficulty would be associated with the excavation activities themselves. Excavation equipment and construction equipment are commercially available, as are borrow sites for backfill and soil cover material. Measures to protect underground pipelines can be easily implemented, if necessary.

The NTS facility is a constructed and operating disposal facility that is available for the acceptance of Mound waste on short notice (less than one month). Documentation to dispose of contaminated materials is required. Waste acceptance and capacity restrictions imposed by the off-site disposal facility is not presently a limiting factor. Appropriate transportation permits for truck would be filed with the U.S. Department of Transportation (DOT).

The off-site disposal options would not impact any potential final remediation of OU4 since the contaminated soils and sediments would have been removed and there would be no barriers to other OU4 media remediation (e.g., groundwater or the BVA).

5.5.3. Cost

The estimated cost for this alternative includes labor, equipment and materials for excavation, transportation and disposal fees as well as site restoration costs. Indirect capital costs are assumed to be 50 percent of direct capital costs and include engineering design, project management, and insurance. Direct capital costs for site preparation, excavation, and site restoration are $1.8 million.

The truck transportation cost for the off-site disposal option is $3.2 million. However, the transport to NTS requires containers which increases the cost by $3.5 million. The disposal cost for NTS is $8.0 million. O&M costs are not included for this alternative. Table V.1 summarizes the costs for Alternatives 4 and 5. Refer to Appendix B, Tables B-20 through B-26 for a breakdown of quantities and unit prices for all materials for Alternative 4.

The cost estimate for this alternative does not include costs for design, installation, and maintenance of a new Mound Plant drainage pathway from the drainage ditch to the overflow creek. The cost estimate also excludes additional costs required to excavate soil in close proximity to any buried pipelines.

Table V.1. Summary of Costs for Alternatives 4 and 5: ($ x1000)

Cost Component	Alternative 4 Excavation and Disposal*	Alternative 5 Excavation, Treatment and Disposal**
Direct Capital Costs:		
Site Preparation	$100	$100
Site Remediation	$820	$10,640
Site Restoration	$850	$715
Transportation	$6,660	$4,320
Disposal	$7,960	$5,180
Total Direct Capital Costs	$16,390	$20,900
Indirect Capital Costs:		
Engineering & Design	$4,100	$5,230
Contingency	$4,100	$5,230
Total Indirect Capital Costs	$8,200	$10,470
Total Capital Costs	$24,580	$31,400
Annual O&M Costs	$0	$800
Total Present Worth (5%)	$24,000	$32,230

* Refer to Table B-20

** Refer to Tables B-27 and B-30

5.5.4. Other Criteria

Alternative 4 (Excavation and Off-Site Disposal) is low to moderately effective in meeting the SARA Section 121 guidelines in that it significantly reduces the mobility of the contaminated soils and is a permanent solution. However, it is not effective to the degree that it does not treat the contamination and requires off-site disposal.

5.6. ALTERNATIVE 5 - EXCAVATION, TREATMENT, AND DISPOSAL

This alternative is similar to Alternative 4 with respect to excavation, site restoration, and disposal activities. However, following excavation activities, all excavated soils and sediments would be processed through a treatment system, prior to disposal.

The objective of this treatment process option is to separate the radioactive contaminants from the excavated soil to the extent possible, thereby reducing the volume of soil for disposal. The decontaminated (clean stream) soil will be suitable for backfill, while the residual (contaminated) soil, with the concentrated radioactive contaminants, will be managed in an appropriate disposal facility. Identification of the disposal option before beginning treatment is an important step since the disposal facility may impose limitations on treated waste characteristics.

The soil-washing treatment technology is the preferred technology and appears to best achieve the above goal assuming that the radioactive contaminants are preferentially consolidated in soils with smaller particle sizes (EPA 1987).

A conceptual model of the soil decontamination technique is shown in Figure 5.3. The washing technique removes the smaller-particle-size fractions of the soil where the radioactive contamination is anticipated to be present. Following confirmatory radioactive sampling, the soil containing the larger-grain-size particles will be replaced on the Mound property as clean backfill. The radioactive contaminants, concentrated in the smaller-soil process stream, will be managed as radioactive waste. The extraction process ideally operates in a closed cycle mode with the wash water recycled in the process, so that little side-stream liquid waste is generated. Bench scale and pilot plant operations have been conducted for this technology at various sites.

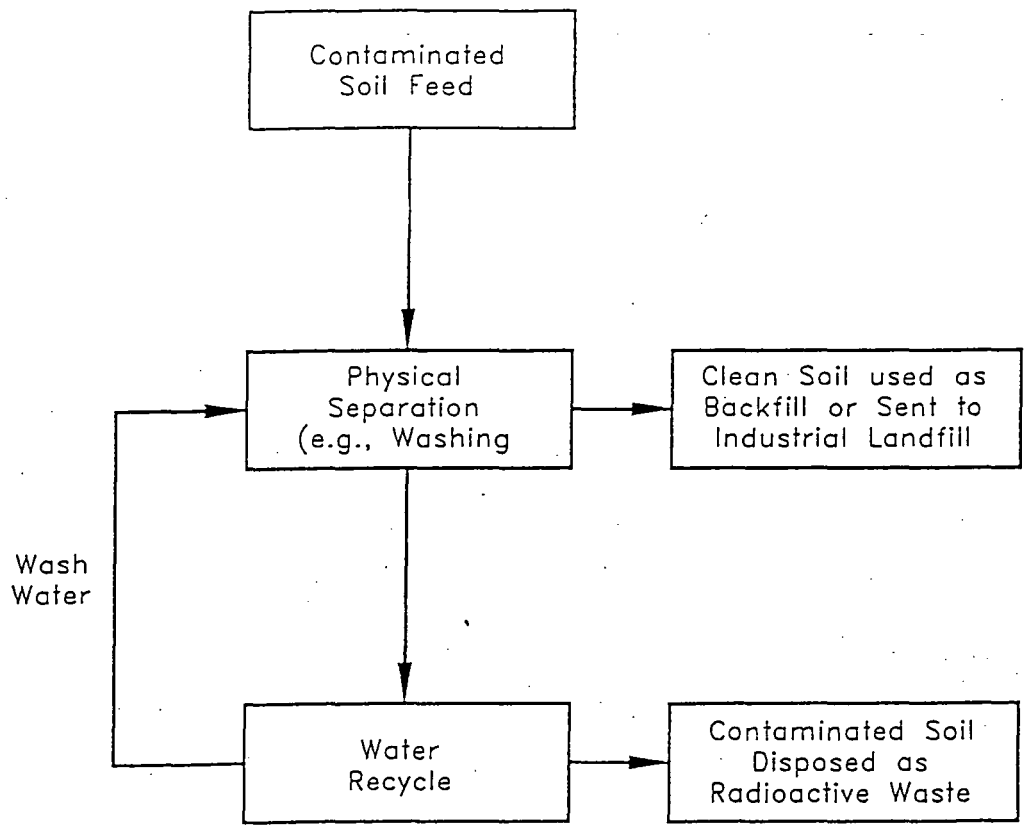

Figure 5.3. A Conceptual Model of the Soil Decontamination

Based upon bench scale and pilot plant operations, radionuclide contaminants tend to adhere to fine-grained particles (e.g., silts and clays). Review of particle size distribution curves at a soil depth of 5 feet below the surface for the Miami-Erie Canal soils indicates that the soils are composed of 65 percent silts and clays (Figure 5.4.). Therefore, at best, a volume reduction of 35 percent will be realized if the distribution curves reflect the soil composition for all Miami-Erie Canal radiologically contaminated soils.

Commercial treatment facilities are available for this technology, to be built either at the Mound Plant or at the Miami-Erie Canal or provided by commercial suppliers. The specific design, throughput, and operational capability for the process must be defined and addressed in the detailed final remediation design plans. The on-site treatment facility could be constructed and operated through contract with one of the commercial suppliers of the technology.

Developing physical treatment capabilities on-site would begin by establishing a specific location at the site to install the process. Utilities that must be provided for operation of the soil washing equipment include electricity and water. There must also be some mechanism to provide make-up water to the system to replace the amount lost to uptake by soil and to evaporation. Treatability testing indicates the wastewater from typical soil washing processes would not require additional treatment prior to discharge. However, water generated during excavation and treatment that is tritium-contaminated will be disposed.

The treatment facility itself can be a portable system, mounted on trailers, and need not be a permanent installation. Commercial suppliers and operators of treatment equipment are available. Pilot-scale operations with similar equipment have been conducted with a throughput of approximately 2 tons/h (1 to 1.5 yd^3/h). It is anticipated, based on size, that the throughput for a transportable system could be increased to approximately 20 tons/h. Some commercial soil washing operations have been reported to operate at 350 tons/h. Based on a contaminated soil volume of 17,000 yd^3, the time required to completely treat the soils excavated from the canal is 50 to 850 hours.

The physical process of a soil washing system is depicted in the simplified process flow model shown in Figure 5.5. Soils must be transported from the area of excavation to the treatment site. Methods for accomplishing this are determined by the throughput of the treatment system (i.e., quantity of soil that can be treated per unit time), the distance from the excavation site to the treatment facility, and the safety precautions necessary to move the soils (e.g., movement across unrestricted access areas such as public roads would require greater precautions than movement within a single area of contamination).

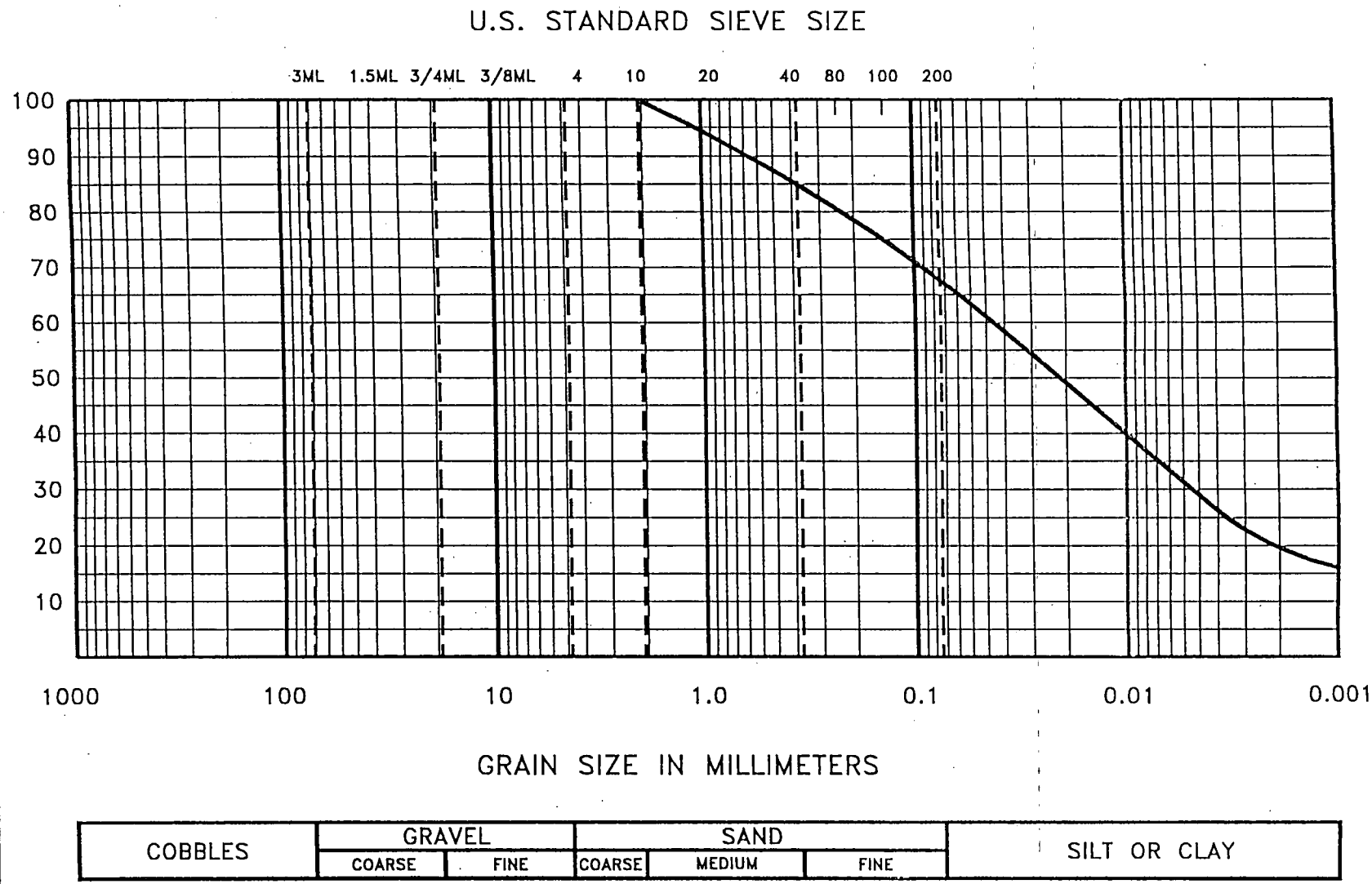

Figure 5.4. Particle Size Distribution, Miami-Erie Canal Soils, at Five-Foot Depth

REFERENCE: (ROGERS 1975)

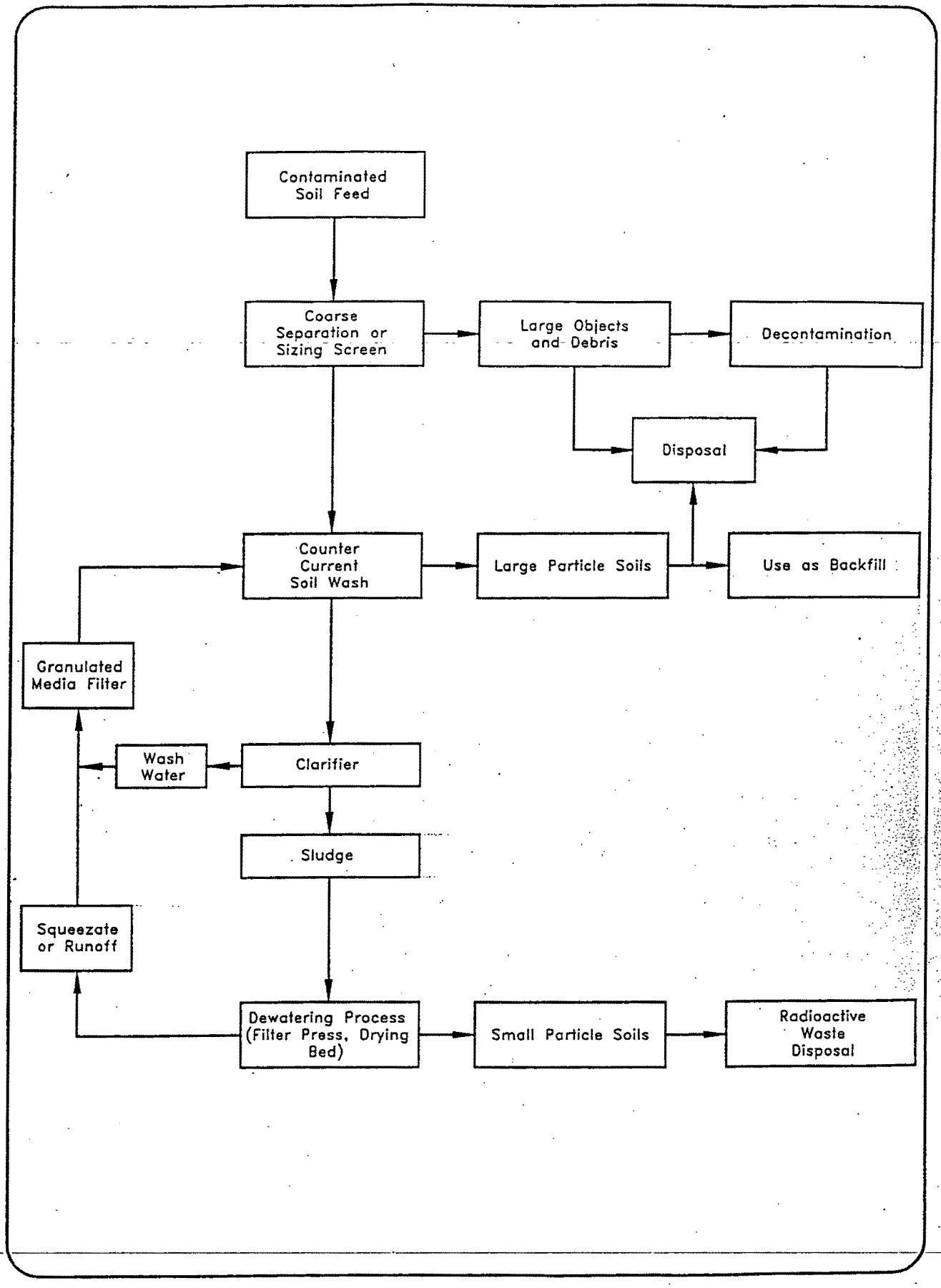

Figure 5.5. Simplified Process Flow of Soil-Washing Facility

At the end of the project, when all the soils intended for treatment have been processed by the facility, the equipment can be removed from the site. Before transporting the soil washing equipment, the accessible surfaces of the trailer and equipment must be decontaminated to levels consistent with NRC Regulatory Guide 1.86 (NRC 1974), DOE Order 5400.5 (DOE 1990), and DOT regulations 49 CFR 173.

5.6.1. Effectiveness

Short-term risks to remediation workers and the general public from this alternative would be similar to those for Alternative 4. The additional hauling required for treatment and subsequent potential exposure to more concentrated materials would increase the risk slightly. Conversely, the inherent wetness and smaller volume characteristics of the contaminated soils would tend to decrease risk.

Impacts would be mitigated through the proper use of safety procedures, personal protective equipment and clothing, and restrictions on access to contaminated areas. The reduced volume of contaminated soil would decrease handling associated with transportation and disposal.

Potential adverse environmental impacts similar to those described for Alternative 4 could result from remedial activities. Impacts would be mitigated by the use of proper drainage controls, silt fences, and site restoration. Construction of a temporary on-site treatment facility would temporarily increase emissions of fugitive dust. Particulate emissions would be controlled using appropriate dust control methods.

The overall effectiveness of the treatment operation at the OU4 site is unknown at this time. Overall effectiveness of the treatment process will depend on the following information:

- Reduction in volume of radionuclide-contaminated material requiring disposal;

- Composition of the Miami-Erie Canal soils (percent of coarse-grained soils versus fine-grained soils);

- Residual plutonium and tritium concentration in coarse grained soils to be used as clean backfill or disposed of at a commercial landfill.

The long-term effectiveness of Alternative 5 would be the same as Alternative 4, because the source term would be removed from the Miami-Erie Canal.

5.6.2. Implementability

This alternative is considered to be implementable if certain treatment performance criteria are met. Soil washing technology is currently commercially available, although some refining for site-specific conditions would be required to assure its reliability. A pilot plant operation would be necessary using the range of Miami-Erie Canal soils encountered in order to select the appropriate washing agent as well as determining the required number of washing and rinsing cycles to strip the soil particles of radionuclides. Therefore, results of treatability testing will determine the effectiveness of the treatment process. The waste acceptance and capacity restrictions imposed by an off-site disposal facility are not expected to impact implementability.

5.6.3. Cost

This alternative includes the complete excavation of all contaminated Miami-Erie Canal soils, site restoration, on-site treatment, and disposal. The construction costs for excavation and site restoration activities are identical to those developed for Alternative 4. On-site treatment capital costs are estimated to be $10.6 million as referenced on Table B-27 in Appendix B. The O&M costs to maintain and service the on-site treatment facility are $800,000 per year. Direct capital costs for the disposal operations are reduced by the amount of volume reduction realized. Based upon a volume reduction of 35 percent, the transportation and disposal costs as well as the various present worth values are summarized in Table V.1. (corresponding costs for Alternative 4 are included for comparison). The costing tables for excavation, treatment and off-site disposal are presented in Appendix B, Tables B-27 through B-33.

The cost estimate for this alternative does not include costs for design, installation, and maintenance of a new Mound Plant drainage pathway from the drainage ditch to the overflow creek. The cost estimate also excludes additional costs required to excavate soil in close proximity to any buried pipelines.

5.6.4. Other Criteria

The Excavation, Treatment and Disposal Alternative is moderately effective in meeting the SARA Section 121 guidelines in that it significantly reduces the volume and mobility of the contaminated soils, includes

treatment, and is a permanant solution. However, it is not effective to the degree that it requires off-site disposal (away from the canal site.)

6. COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

6.1. BASIS FOR COMPARISON

The purpose of the comparative analysis is to identify the advantages and disadvantages of the alternatives when compared with each other based on the detailed analysis described in Section 5. A discussion on the evaluation criteria (effectiveness, implementability, cost and the SARA Section 121 selection criteria) is also presented in Section 5 to provide the reader with an understanding of how the various alternatives are assessed. The comparative analysis allows for identification of items that can be evaluated by the decision-making party during the final selection of a preferred alternative. The results of this analysis are summarized in Table VI.1. and in the paragraphs which follow.

To recognize the preference for actions which tend to result in maximizing long term effectiveness, a weighted scoring system was developed and presented with the information in the tables for ease of reference. Although the assessments and comparisons were performed on a qualitative basis, the numerical translation provides a means of visualizing the relative merits or weaknesses of a given alternative. The weighted values of 50%, 30% and 20% of the total possible points for the alternatives under consideration were assigned respectively to the effectiveness, implementability and cost criteria. The weighting was further subdivided among the various components of the criteria so that a weighted score could be developed for each alternative.

Alternative 1 (No Action) provides a baseline for comparing other alternatives relative to their ability to provide a remedy more capable of meeting the RAOs listed in Section 3. As the reference alternative, Alternative 1 offers the greatest short-term effectiveness (but the least long-term effectiveness) because no action produces no change in the impacts from currently existing conditions. Similarly, the technical feasibility, availability and administrative feasibility aspects of implementability are highest for this alternative because no action produces no requirements in these areas. Costs are minimized in this alternative as well due to financial resources being used only for an ongoing environmental monitoring program.

TABLE VI.1. COMPARATIVE EVALUATION OF SITE-WIDE ALTERNATIVES 1-5
Page 1 of 2

CRITERIA	ALTERNATIVE 1 NO ACTION		ALTERNATIVE 2 INSTITUTIONAL CONTROLS/ ENVIRONMENTAL MONITORING		ALTERNATIVE 3 CONTAINMENT			
					(3a) Limited Use		(3b) Beneficial Use	
· Effectiveness								
Short-Term (15) Health Impacts	5	No additional impact if no action taken.	5	Negligible impacts associated with site security and monitoring.	5	Unlikely risk due to undisturbed contamination.	5	Unlikely risk due to undisturbed contamination.
Environmental Impacts	5	No additional impacts if no action taken.	5	Negligible impacts associated with site security and monitoring.	4	Environmental controls during construction.	4	Environmental controls during construction.
Long Term (35) Contamination Levels/Compliance with ARARs/Meets RAOs/Reduces Toxicity, Mobility, Volume	1	Contaminants remain.	3	Site restrictions provide some risk reduction to public	3	Public access unlimited. Contaminants remain.	3	Public access unlimited. Contaminants remain.
Environmental Impacts	1	Contaminants remain. Site management controls remain.	1	Monitoring provides assessment capability but contaminants remain.	3	Contaminants remain. Maintenance required.	3	Contaminants remain. Maintenance required.
Criterion Weighted Subtotal	2.2		2.9		3.4		3.4	
· Implementability								
Technical Feasibility (10)	5	No Action	5	Standard techniques and processes.	5	Standard technologies.	5	Standard technologies.
Availability (10)	5	No Action	5	Services & materials readily available.	5	Services & materials readily available.	5	Services & materials readily available.
Administrative Feasibility (10) Permits, Waivers and Access/State Acceptance/Community Acceptance	2	Public/regulators may demand reduction of contamination.	2	Public/regulators may demand reduction of contamination.	3	Public/regulators may demand reduction of contamination.	3	Public/regulators may demand reduction of contamination.
Criterion Weighted Subtotal	1.2		1.2		1.3		1.3	
· Cost (20)	5	<$1M	5	<$1M	4	$<4M	4	$<4M
Criterion Weighted Subtotal	1.0		1.0		0.8		0.8	
Summary Score	4.4		5.1		5.5		5.5	

( ) - Weighted Value, %
5 - High
4 - Moderate High
3 - Moderate
2 - Low-Moderate
1 - Low

TABLE VI.1. COMPARATIVE EVALUATION OF SITE-WIDE ALTERNATIVES 1-5
Page 2 of 2

CRITERIA	ALTERNATIVE 4 - EXCAVATION AND DISPOSAL		ALTERNATIVE 5- EXCAVATION, TREATMENT AND DISPOSAL	
· Effectiveness				
Short-Term (15) Health Impacts	3	Public risk unlikely in construction. Worker exposure to fugitive dust.	3	Handling requirements increase worker exposure.
Environmental Impacts	4	Environmental controls for dust and runoff applicable.	3	Increased requirements for monitoring higher concentrations.
Long Term (35) Contamination Levels/Compliance with ARARs/Meets RAOs/Reduces Toxicity, Mobility, Volume	5	Waste removal from site of canal reduces public exposure.	5	Waste removal from site of canal reduces public exposure.
Environmental Impacts	5	Storage facility provides isolation. Contamination removed.	5	Facility maintenance assures protection.
Criterion Weighted Subtotal	4.6		4.4	
· Implementability				
Technical Feasibility (10)	3	Facility already exists. Shipping logistics add complexity.	2	Treatment requirements must be developed site specific.
Availability (10)	5	Capacity available to accept waste.	4	Generic technology available for soil washing.
Administrative Feasibility (10) Permits, Waivers and Access/State Acceptance/Community Acceptance	3	Permits needed for transport and disposal.	3	Permits required for transport and disposal.
Criterion Weighted Subtotal	1.1		0.9	
· Cost (20)	2	<25M	1	<33M
Criterion Weighted Subtotal	0.4		0.2	
Summary Score	6.1		5.5	

( ) - Weighted Value, %
5 - High
4 - Moderate High
3 - Moderate
2 - Low-Moderate
1 - Low

6.2. EFFECTIVENESS

6.2.1. Short-Term

The short-term health and environmental impacts of all alternatives [other than Alternative 1 (No Action)] are acceptable as long as protective measures are followed to mitigate risks to workers and the environment during removal action execution. Alternative 2 (Institutional Controls) has high short-term effectiveness because the activities involved in the response will not expose the public or site workers to subsurface contaminants in the canal. Public risk and environmental impacts resulting from the implementation of monitoring and site access restrictions are considered negligible. The short-term effectiveness of Alternative 3 (Containment) is slightly lower than Alternative 2 in both the Limited Use and Beneficial Use options, and public risk under Alternative 3 is considered moderately high in comparison to Alternative 1 due mainly to the fact that some increased risk to worker health and safety is incurred during construction activities for capping the contaminated portion of the canal. No additional risk to the public or environment will occur provided adequate controls are implemented during construction to minimize dust emissions and sediment runoff.

Alternative 4 (Excavation and Disposal) and Alternative 5 (Excavation, Treatment, and Disposal) both provide moderate effectiveness for the short term because of increased potential for public and worker exposure during complete removal of contaminated soils. Some minor, but easily addressable, additional risk may also be associated with the handling of concentrated contaminants resulting from the treatment process; however, this risk would be countered by the fact that a smaller volume of contaminated soil is involved. Compared to the other alternatives, Alternative 5 is considered to have the lowest overall short-term effectiveness.

6.2.2. Long-Term

The most effective actions for reducing long-term impacts to the health and the environment are represented by Alternatives 4 and 5 (see Table VI.1., page 2 of 2). Alternative 5 is considered most effective because it provides a decrease in the volume of waste to be managed while at the same time minimizing the mobility of contaminants through removal of the source from the site. Alternative 4 is only slightly less effective than Alternative 5 due to the larger volume of wastes requiring disposal.

Both Alternatives 4 and 5 are considered equivalent in the effectiveness of their strategy/disposal options, in their ability to be consistent with final remedial action and in the satisfaction of ARARs because the contaminants will be housed in secure and monitorable facilities.

Long-term effectiveness of Alternative 3, though not as high as that of Alternatives 4 and 5, is still considered quite acceptable with an overall moderate ranking. Alternative 2 is lower in long-term effectiveness than Alternative 3 primarily because the environmental impacts would be minimal. Alternative 1 is lowest in long-term effectiveness because it provides no reduction in toxicity, mobility or volume of the contaminants, and does not fully comply with ARARs and RAGS.

6.3. IMPLEMENTABILITY

6.3.1. Technical Feasibility

Alternatives 1, 2 and 3 are considered to be equivalent in terms of technical feasibility. Technologies and methodologies required to implement these actions are readily available and frequently used. No technical difficulties are expected to arise during execution of these alternatives. Alternative 4 is expected to present moderate technical difficulty due to the added complexity of the logistics of shipping and disposal at NTS. Alternative 5 is considered to have the greatest degree of technical difficulty, although still feasible, due to the need to conduct further site characterization and treatability studies and the requirement to design and implement a waste treatment process for washing contaminated soils. Final disposition of "clean" soils would also need to be further addressed.

6.3.2. Availability

Services, supplies, materials and systems required for implementing all five alternatives are available on a timely basis. Alternative 5 is judged to have a disadvantage relative to other alternatives because of the need to establish site-specific criteria for procurement of soil washing equipment and services. This constraint may affect the availability of qualified vendors, the schedule for executing the removal action, and the ultimate cost of the soil washing system, depending on what soil conditions are established during treatability studies.

6.3.3. Administrative Feasibility

The implementation of Alternatives 4 or 5 (excavation and disposal) may greatly reduce the requirements of the remediation phase of OU4 (RI/FS, Record of Decision (ROD), remedial design and implementation). Conversely, the future requirement to remediate OU4 may adversely impact the administrative feasibility of Alternatives 1, 2, and 3.

The administrative feasibility of Alternative 2 is considered to be slightly lower than Alternative 1 because of the need to obtain permits and/or deed restrictions. The administrative feasibility of Alternative 3 is moderate, primarily due to uncertainties about the degree of permanence this solution offers with respect to consistency with any final remedial action identified, and the requirement for public and regulatory acceptance. A capping scenario such as that presented by Alternative 3 might receive resistance from the public and/or regulatory agencies should it be perceived that it biases or adversely impacts decisions for remedial action in the ROD. Alternatives 4 and 5 are considered moderately feasible to administer, because off-site disposal at NTS may be impacted by potential delays or difficulties in obtaining permits required for transport and disposal.

6.4. COST

The cost for Alternative 2 is low based on the requirement for only minimal materials and equipment (fencing and monitoring equipment). The cost for Alternative 3, is moderate, based on the placement of a cap over the contaminated portion of the canal. The costs for excavation, and disposal to an off-site facility (Alternative 4) are high due to packaging, transportation costs and disposal fees. The addition of a treatment process for Alternative 5 causes its cost to be higher than Alternative 4, despite the reduction in volume requiring off-site disposal.

6.5. SARA SECTION 121 SELECTION CRITERIA

Application of the SARA Section 121 guidelines does not produce a clear preference among the candidate alternatives. Alternatives 4 and 5 are moderately effective in reducing the mobility and volume of the contaminated soils, whereas Alternative 3 only reduces mobility, and Alternatives 1 and 2 are not effective in this regard. (None of the Alternatives is effective in reducing the toxicity of the contaminated soils.)

Only Alternative 5 includes practical treatment technologies. Alternatives 4 and 5, however, also require off-site transport of the contaminated soil. The other alternatives do not include treatment or disposal options. Therefore, Alternative 5 is slightly more preferable on this basis.

Alternatives 4 and 5 include permanent solutions to the RAOs. Alternative 3 may be considered permanent if it proves to be consistent with the long-term remediation strategy for OU4, and if the site is regularly inspected and maintained. Alternatives 1 and 2 do not address this guideline.

6.6. CONCLUSION

Based on a comparison of the alternatives, the preferred alternative is excavation and offsite disposal at NTS (Alternative 4). This alternative essentially eliminates the exposure pathways from the contaminated soil to the public and the environment, while reducing its mobility by placing it into a permanent (offsite) disposal facility. This alternative is judged to be equally or more effective in the long term than the other alternatives, while being moderately feasible to implement. However, the cost to implement this alternative is among the highest evaluated.

- Ship contaminated soil in containers from Mound site packaging facility to NTS via truck.

- Restore packaging facility location to original condition. (This step depends on whether the facility is located on or off the Mound site.)

- Provide alternative services for underground utilities, if required per site assessment report.

- Commence excavation of clean soils to design elevations to access contaminated soils.

- Excavate contaminated soils and load into 20 yd^3 dump trailers (approximately 850 truck trips) for transport to the temporary packaging facility. Trucks will consist of water tight containers with covers and will travel to the packaging facility on existing or specially-constructed haul roads. The road will be wetted to minimize fugitive emissions.

- Unload the 20 yd^3 dump trailers at the packaging facility, ensuring that the soils are in a damp state to minimize fugitive emissions.

- Remove saturated contaminated soils located in canal surface waters and exposed groundwater table with a "clamshell" crane. A dewatering area should be constructed consisting of earthen berms and silt fencing to dewater saturated soils prior to transportation. Haybale check dams will be placed in surface waters to prevent particle transport of contaminated sediments.

- Continue excavation until sampling and analysis confirm that remaining soils in canal are below Mound-site cleanup guidelines.

- Following excavation, sampling, and analysis, clean material will be hauled to fill in excavated areas (includes utilizing the stockpiled sod) in the canal. Remove temporary utility services and restore underground utilities, if required. Once the excavation void is filled and compacted to appropriate grades, a one-foot thick layer of topsoil will be placed over all disturbed areas and then hydroseeded.

- Drainage swales will be constructed within backfill areas utilizing one-foot thick layer of stone. Wetland engineering modules will be placed to stabilize the banks of the drainage swale. Wetland restoration using indigenous wetland vegetation will be planted as appropriate, to replace any delineated wetland areas disturbed during the excavation task.

effective and implementable, and higher in cost than Alternative 4. Alternative 3 is less effective, but more easily implementable, and less costly than Alternative 4.

7.2. RECOMMENDED ALTERNATIVE

The recommended removal action, Alternative 4, involves the consolidation of contaminated waste which currently exceeds Mound-site guidelines for plutonium contamination, by excavation and shipping off-site for permanent disposal at NTS.

The proposed removal action alternative would include the following activities:

- Prepare a conceptual and detailed design.

- Identify NTS waste acceptance criteria to support excavation and packaging plans.

- Prepare a detailed site assessment report, health and safety plans, and detailed plans and specifications for the excavation and packaging of radioactive contaminated soils from the Miami-Erie Canal.

- Survey the canal to determine the location of buried utilities.

- Prepare the Miami-Erie Canal for site remediation activities by installing a silt fence around the periphery of the designated work zone, constructing a decontamination facility, and clearing and grubbing all trees, shrubbery and vegetation including sod. Construct a temporary drainage pathway for Mound drainage ditch effluent to be routed to the overflow creek while working in the South Canal. Collect and analyze samples of plant roots and surrounding soil to determine radiological status. Chip all trees and shrubbery and stockpile on-site along with all sod and clean soil.

- Construct a temporary packaging facility to place excavated soil into suitable shipping containers. Facility may be located either in the vicinity of the canal, or on Mound site.

7. RECOMMENDED REMOVAL ACTION ALTERNATIVE

The alternatives developed in Section 5, and compared in Section 6, were evaluated in order to determine the preferred option. After assessing the results of the effectiveness comparison, the alternatives were compared to determine ease of implementation. Finally, the alternatives were further compared on the basis of least cost (present worth), if all other factors were equal.

7.1. BASIS FOR SELECTION

The primary basis for selection of the proposed alternative is the overall effectiveness of the alternative: effectiveness over the long term is judged to be more important than over the short term (EPA 1988). On the basis of long-term effectiveness, Alternatives 4 (Excavation and Disposal) and 5 (Excavation, Treatment, and Disposal) offer the highest degree of protection for public health and the environment (since the source of contamination is removed from the canal) and allow the most flexibility for accommodating alternatives for final remediation that may be developed in the ROD. In the short term, Alternative 5 is less effective than Alternative 4, due to the added impact from treatment operations. On the basis of the SARA Selection 121 guidelines Alternative 5 is preferable to any of the other Alternatives, since it includes treatment. However, on the basis of overall effectiveness, Alternative 4 is the preferred choice.

In terms of implementability, Alternative 4 is slightly easier to implement than Alternative 5. The treatment operations associated with Alternative 5 require additional site characterization and treatability studies prior to implementation.

In terms of cost, Alternative 4 is less expensive than Alternative 5, primarily due to the treatment prior to disposal.

Therefore, based on the comparison of alternatives (Section 6), the preferred removal action alternative is Excavation and Disposal (Alternative 4).

A review of the alternatives analyzed in this report shows that Alternative 5 (Excavation, Treatment and Disposal) and Alternative 3 (Containment) are the second most preferred alternatives. Alternative 5 is less

8. REFERENCES

ATSDR.1993. "Health Consultation, DOE Mound Plant," Miami-Erie Canal and Miamisburg Community Park, Miamisburg, Ohio. Division of Health Assessment and Consultation, Agency for Toxic Substances and Disease Registry, September 29, 1993.

BNI. 1989. "Conceptual Design Report for a Permanent Disposal Site for FUSRAP Wastes, "Bechtel National, Inc., April 1989.

Dames and Moore. 1976a. "Evaluation of the Buried Valley Aquifer Adjacent to Mound Laboratory". Prepared for Monsanto Research Corporation, Miamisburg, Ohio, December 1976.

Dames and Moore. 1976b. "Potable Water Standards Project, Mound Laboratory," Report MD-0151 prepared for Monsanto Research Corporation, Miamisburg, Ohio, August 1976.

DOE. 1986. "Comprehensive Evaluation Assessment Responsibility Program Phase 1 Report", U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico, 1986.

DOE. 1988. "Memorandum of Understanding Between the City of Miamisburg and the Department of Energy", Letter from J.K. Weithofer (City Manager) to J.A. Morley (DOE-DAO). April 21, 1988.

DOE. 1990. "Radiation Protection of the Public and the Environment", DOE Order 5400.5, U.S. Department of Energy, Office of Environment, Safety and Health, Washington, D.C., June 5, 1990.

DOE. 1992. "Remedial Investigation/Feasibility Study, Operable Unit 9, Site Wide Work Plan", Draft Final (Revision 4), U.S. Department of Energy, February, 1992.

DOE. 1993a. "Removal Site Evaluation, Operable Unit 4, Miami-Erie Canal" Draft Final (Revision 3), U.S. Department of Energy, May, 1993.

DOE. 1993b. "Focused Risk Assessment, Mound Plant, Miami-Erie Canal, Operable Unit 4", U.S. Department of Energy, Albuquerque Operations Office, Albuquerque, New Mexico, 1993.

EG&G. 1992. "Mound Site Environmental Report for Calendar Year 1991", EG&G Mound Applied Technologies Report No. MLM-3740. Prepared for the U.S. Department of Energy, Miamisburg, Ohio, June, 1992.

EPA. 1987. "Guidelines for Residual Radioactive Material at FUSRAP", Rev. 2, BNI/PDCC/E-03195, March 1987.

EPA. 1988. "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA [INTERIM FINAL]." Document No. EPA/540/G-89/004, OSWER Directive 9355.3-01. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C., October 1988.

EPA. 1989. "Guidance On The Definition and Identification of Commercial Mixed Low-Level Radioactive and Hazardous Waste and Answers to Anticipated Questions." U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, (530/SW-90-016), October 1989.

EPA. 1991. "Treatment Technologies" Second Edition, U.S. Environmental Protection Agency, Office of Solid Waste, Government Institutes, Inc., August 1991.

EPA. 1993. "Guidance On Conducting Non-Time-Critical Removal Action Under CERCLA", OSWER 9360.0.32, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, August 1993.

Farmer and Carfagno. 1978. "Stability of Plutonium Contaminated Sediments in the Maimi-Erie Canal," Monsanto Research Corporation Report Number MLM-2583. Prepared for the U.S. Department of Energy, Miamisburg, Ohio, March 1978.

Farmer and Carfagno. 1979. "Environmental Monitoring During Construction of the Miamisburg Solar and Fishing Ponds", Monsanto Research Corporation Report Number MLM-2621. Prepared for the U.S. Department of Energy, Miamisburg, Ohio, June 1979.

Federal Radiation Council. 1959. "Radiation Protection and Guidance for Federal Agencies, Memorandum for the President", Federal Register, 1960.

Halford. 1990. "Results of South Pond Sampling", Letter to Dwain Farley, Technical Support Office, ER Program. Los Alamos National Laboratory, Los Alamos, New Mexico, June 1990.

Kershner and Rhinehammer. 1978. "Mound Laboratory Tritium Environmental Study: 1976-1977", Monsanto Research Corporation Report Number MLM-2495. Prepared for the U.S. Department of Energy, April 1978.

NRC. 1974. "Termination of Operation Licenses For Nuclear Reactors", U.S. Nuclear Regulatory Commission, Regulatory Guide No. 1-86, June 1974.

Robinson, Rogers, Westendorf, and Black. 1974. "Mound Laboratory Plutonium-238 Study' Off-site Analytical Data, May-December, 1974", MLM-MU-74-72-001, Monsanto Research Corporation, 1974.

Rogers. 1975. "Mound Laboratory Environmental Plutonium Study 1974", Monsanto Research Corporation Report Number MLM-2249. Prepared for the U.S. Energy Research and Development Administration. Miamisburg, Ohio, September 1975.

SAIC. 1993a. "Operable Unit 4 Special Canal Sampling Report Miami-Erie Canal [FINAL]," Environmental Restoration Program. Prepared for EG&G Mound Applied Technologies and U.S. Department of Energy. Mound Plant, Miamisburg, Ohio, April 1993.

SAIC. 1993b. "Reconnaissance Sampling Report, Soil Gas Survey and Geophysical Investigation, Mound Plant, Main Hill and SM/PP Hill, "Final, Science Applications International Corporation, February, 1993.

Styron and Meyer. 1981. "Potable Water Standards Project: Final Report", Monsanto Research Corporation Report Number MLM-2819. Prepared for the U.S. Department of Energy, Miamisburg, Ohio, April 1981.

APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This appendix identifies potential ARARs for contaminated soils, sediments, air, surface water, and groundwater at Mound Plant. As the RI/FS at Mound Plant progresses, ARARs will be identified on a site-specific basis. Draft ARAR determinations will be prepared by the DOE. The USEPA and the Ohio EPA will review these determinations and make modifications as necessary. Potential ARARs will be reviewed and revised throughout the RI/FS process until a ROD is issued.

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that address problems or situations sufficiently similar to those encountered at the CERCLA site. While not "applicable" statutorily to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, the use of relevant and appropriate requirements is often well suited to a particular site.

CERCLA was passed in 1980, requiring that the NCP be prepared to include "methods and criteria for determining the appropriate extent of removal, remedy and other measures." The NCP requires that remedial actions "attain or exceed applicable or relevant and appropriate federal public health and environmental requirements." The current NCP, revised in accordance with reauthorized CERCLA in 1986, was published March 8, 1990.

Guidance on conducting remedial investigations and feasibility studies under CERCLA, issued in 1985, addressed public health and environmental requirements that should be considered. However, much uncertainty remained concerning the applicability of certain requirements in Superfund response situations and the precedence of regulation when a similar (or identical) substance was addressed by several authorities. Section 121 (d) of CERCLA, as amended by SARA, codified and expanded the ARARs.

Current and proposed USEPA guidance further clarifies the process by which requirements are determined to be either applicable, or relevant and appropriate (EPA 1988). These requirements and definitions apply to federal facilities as referenced in section 120 of SARA. "ARAR" is CERCLA-defined term applicable to the federal Superfund program. However, under the Superfund program, state requirements are ARARs and must be considered during CERCLA investigations.

TYPES OF ARARS

There are, in general, three different types of ARARs, although some requirements do not fit neatly into these categories:

- chemical-specific
- location-specific
- activity-specific

Chemical-specific (or ambient) ARARs are usually health- or risk-based numerical values or methodologies that establish concentrations or discharge limits for particular chemicals. Only a limited number have been promulgated.

The results of a risk assessment are used in establishing cleanup goals that are health-based. The total carcinogenic risk or hazard index for all chemicals of concern in a medium is calculated in this risk assessment. As a starting point for setting cleanup goals, the risk calculations are developed using chemical-specific requirements. If there are no chemical-specific ARARs, then specified federal or state TBC values are used in the calculations. Examples of this type of ARAR are RCRA maximum concentration limits, SDWA MCL goals, and water quality criteria developed under the Clean Water Act (CWA). Other non-promulgated values, such as reference doses, may be used in setting protective cleanup goals.

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of a site. RCRA location requirements, flood plain management restrictions, and wetlands discharge restrictions are examples of this type of ARAR.

Activity-specific, performance-specific, and design-specific ARARs are usually technology- or activity-based requirements or limitations on actions. Examples of this type of ARAR are the RCRA Subtitle C requirements for hazardous waste management.

STATE REQUIREMENTS AS POTENTIAL ARARS

CERCLA Section 121 provides that in order for a state requirement to be eligible to be an ARAR it must be 1) promulgated, and 2) more stringent than federal requirements. A state requirement is promulgated if it is legally enforceable. (i.e., it is enforceable through a general authority, or the enabling legislation contains specific enforcement provisions) and if it is generally applicable. The evaluation of stringency considers two types of regulation: 1) those for which there is a federal counterpart (or program), and 2) those for which there is no federal counterpart (or program).

For most federally authorized state programs (e.g., RCRA, CWA, SDWA), state requirements are "at least as stringent" as federal requirements. Therefore, state requirements under these programs do not require a comparison of stringency. For example, the state of Ohio has a federally authorized RCRA program, which qualifies it as an ARAR. Regulations promulgated under state programs that do no have a federal counterpart or a baseline of federal regulations, but that address specific conditions within that state, are more stringent than federal law because they add new or specific requirements to the body of federal environmental regulations. State and local ordinances, advisories, and other requirements that are not ARARs may, however, be used in determining the appropriate extent and manner of cleanup. These requirements can be TBC requirements. Generally, TBC requirements are used when no federal or state requirements exist for a particular situation.

State requirements must also be substantive by not imposing only administrative or procedural requirements or requirements that can be substituted effectively with established CERCLA administrative procedures. Furthermore, the USEPA will consider state requirements to be ARARs only if they are "of general applicability," that is, state requirements that apply to only a few selected Superfund sites are not considered ARARs. For a state requirement to be a potential ARAR, it must be applicable to all remedial situations described in the requirement, not just to Superfund sites. Also, the requirement must be consistently applied to all sites. Local laws are generally not promulgated state requirements and, therefore, may or may not be ARARs. If the local requirement is developed under explicit state authority or compliance is a requirement of a promulgated state statute, the local requirement may be an ARAR.

TO BE CONSIDERED

Requirements that are TBC are used to supplement ARARs.

Where no ARAR of the above type exists, or where ARARs are not sufficiently protective of human health and the environment, chemical-specific TBC values are used to establish cleanup targets. Examples of TBCs include health advisories, reference doses, proposed rules, guidance materials, and policy documents. In general, TBCs are not formally promulgated criteria or standards, and are developed, using best professional judgement, on the basis of the latest available information.

For Mound Plant, TBCs include DOE orders, USEPA Risk Assessment Guidelines, USEPA draft guidance (EPA 1977), NRC proposal policies, and Mound Plant Cleanup policies.

PLUTONIUM CLEANUP STANDARD

The following is a compilation of TBC - type standards that address the issue of a plutonium cleanup standard for contaminated soil.

No specific standards have been established regarding acceptable concentrations of plutonium-238 in soil. The EPA has proposed a screening level for soil contamination by transuranium[1] elements of 0.2 $\mu Ci/m^2$ for samples collected at the surface to a depth of 1 cm (EPA 1977). This screening level is set at a level to limit the dose to the critical population to 1 mrad/year to the lungs and 3 mrad/year to the bone. Assuming a soil density of 2 g/cm^3, this concentration is equivalent to a concentration of 25 pCi/g, for a committed dose equivalent of 25 mrem/yr.

Related standards promulgated by the USEPA include: the Environmental Standards for the Uranium Fuel cycle (40 CFR 190); Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and TRU Wastes (40 CFR 191); and Standards for Remedial Actions at Inactive Uranium Processing Sites (40 CFR 192). All three regulations limit the maximum public dose equivalent to 25 mrem/year to the whole body, 75 mrem/year to the thyroid, and 25 mrem/year to any other organ.

The International Commission on Radiological Protection (ICRP 1977) and the National Council on Radiation Protection and Measurements (NCRP 1987) have also recommended that the committed dose

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[1] "transuranium" refers to all elements with atomic numbers greater than uranium (92). Plutonium is atomic number 94.

equivalent to the public should be limited to 100 mrem/year for continuous exposures with a 500 mrem/year limit for any one year. The NRC has adopted this value as a reference level in 10 CFR 20. However, the overriding goal is that all exposures should be kept as low as reasonably achievable below these limits. At one time, the NRC issued a policy statement that radiation exposures below 10 mrem/year should be considered below regulatory concern (NRC 1988). However, the NRC currently has no plans to finalize this policy.

The primary DOE dose limits for members of the public exposed to radiation sources as a consequence of routine DOE activities and remedial actions shall not exceed 100 mrem/year committed effective dose equivalent or 5,000 mrem/year committed dose equivalent to any organ (DOE 1988). These limits, presented in DOE Order 5400.5, supersede the limits of 500 mrem/year to the whole body, gonads, or bone marrow, and 1,500 mrem/year to other organs previously specified in DOE Order 5480.1A.

Plutonium concentration guidelines can be derived from the EPA RAGS to achieve target lifetime risks of 10^{-4} to 10^{-6} for air, drinking water, and soil. This approach is similar to that used for the Focused Risk Assessment (FRA) for the Miami-Erie Canal (DOE 1993), except that the selection of exposure parameters in the FRA is not as conservative. The Superfund guidance allows for the substitution of site-specific exposure parameter values in place of the more conservative default values whenever available data permit (EPA 1991).

In the FRA for plutonium-238 contamination in the Miami-Erie Canal, the committed effective dose equivalent to the maximally exposed individual was estimated at 0.2 mrem/year based on current site conditions and feasible current land use scenarios. The incremental lifetime cancer risk to the maximally exposed individual was estimated to be 1.0×10^{-6}. This risk level complies with the target risk range of 10^{-4} to 10^{-8} recommended by the EPA RAGS. The derived cleanup level from this analysis to achieve a risk level of 10^{-6} is approximately 1200 pCi/g.

Healy recommended a plutonium-contaminated soil concentration limit of 100 pCi/g for the surface 5-cm depth averaged over an area of $100m^2$ (Healy 1977). This guideline is based on limiting the committed dose equivalent to bone (i.e., the critical organ) to 500 mrem/year.

DOE has established radiological guidelines for application to the Formerly Utilized Sites Remedial Action Program (FUSRAP). These guidelines are based upon pathways analysis for an assumed

residential/agricultural scenario in which a family establishes a residence and family farm at the site. The specified soil concentration guideline for plutonium-238 is 100 pCi/g for plutonium-238 in surface soils and 1,400 pCi/g in subsurface (below 1.5 m) soils (DOE 1983). These generic DOE soil concentration guidelines were derived based on residential land use (100% occupancy) at a model site with a homogeneous contaminated layer of surface soil extending 1.5 meters in depth and 2 hectares (20,000 m^2) in area. These values are based on limiting committed dose equivalent to 500 mrem/year to the whole body, gonads, or bone marrow, and 1,500 mrem/year to other organs for the maximally exposed individual (i.e., compliance with DOE Order 5480.1A).

The Allowable Residual Contamination Level (ARCL) method was developed by Pacific Northwest Laboratory to assist in evaluating decommissioning alternatives at the Hanford site. The ARCL method is based on an exposure pathway analysis for several potentially limiting land use scenarios including a residential/home-garden scenario, an agricultural scenario, and resource/recycle scenario for potential onsite exposures. A dose conversion factor (DCF) for plutonium-238 was estimated to be 0.23 mrem/year per pCi/g of contaminated soil (Napier et al. 1986), with inhalation of resuspended soil being the apparent dominant pathway. To achieve a committed dose equivalent limit of 25 mrem/year, this value yields a soil concentration limit of approximately 100 pCi/g.

Gilbert et al (Gilbert al 1989) developed a similar method (RESRAD) for implementing residual radioactivity guidelines for DOE FUSRAP and Remote Surplus Facilities Management Program (SFMP) sites. This method also is based upon a pathways analysis for a residential/agricultural scenario in which a family establishes a residence in the contaminated area and produces half of its vegetables and all of its meat and milk on the site. Inhalation of resuspended dust and ingestion of contaminated drinking water from an onsite well are also considered, but direct soil ingestion is not. This method produces a derived soil concentration guideline for a generic site of approximately 50 pCi/g for plutonium-238 to limit committed effective dose equivalent to 25 mrem/year.

Till and Moore (Til Moore 1988) developed another method for determining acceptable levels of radionuclide contamination in soils. Exposure pathways considered include direct radiation from contaminated ground surface, inhalation of resuspended radionuclides, and ingestion of contaminated food and drinking water by a resident/farmer. This method was used to estimate soil concentration guidelines for various radionuclides in soil, for conditions typical of a site in the southeastern United States. The derived soil

concentration guideline for plutonium-238 to limit committed effective dose equivalent to 100 mrem/year was approximately 400 pCi/g with nearly all of the total dose contributed by the inhalation pathway.

Zimmerman et al (Zimmerman et al 1991) used the RESRAD computer code (Gilbert et al 1989) to derive guidelines for plutonium-238 in soil at Mound Plant. Both resident and resident farm exposure scenarios were considered, in each case assuming establishment of a residence within the current Mound Plant boundary at the WD hilltop. Soil guidelines derived in this analysis to limit committed effective dose equivalent to 25 mrem/year were 131-295 pCi/g depending upon the specific exposure scenario assumptions. Inhalation was determined to be the dominant exposure pathway in this analysis.

Soil concentration guidelines derived by various investigators, normalized to limit effective dose equivalent to 25 mrem/year, are summarized in Table A.1. As noted in the previous discussion, each of these studies used a similar pathways analysis approach. However, assumed parameter values and model formulations differed in each case.

The Mound Plant Decontamination and Decommissioning (D&D) Program has established internal guidelines for onsite cleanup of soil contaminated with radioactivity greater than 100 pCi/g, and where cost-effective, to remove soils with radioactivity greater than 25 pCi/g. The use of the 100 pCi/g standard is estimated to result in a maximum dose commitment of 12 mrem/yr. (Stought et al. 1988).

Although the soil concentration guidelines developed by various investigators for plutonium-238 are similar, the relative contributions of exposure pathways and exposure scenario assumptions are quite different. For arid site conditions, inhalation tends to be a dominant pathway. However, inhalation contributes little to the total dose from the Miami-Erie Canal sediments because the moist soil, site topography, and heavy vegetation limit the resuspension of the sediments. These conditions are typical of the area and are not expected to change in the foreseeable future. Consequently, ingestion appears to represent the critical exposure pathway for this site.

From these results, it appears that a removal action soil concentration guideline of approximately 100 pCi/g for plutonium-238 in soil would provide reasonable assurance that no individual is likely to exceed a committed effective dose equivalent in excess of 25 mrem/yr as a result of exposure to plutonium-238 at this site. This is consistent with the existing Mound D&D guidelines. Thus 100 pCi/g is technically

Table A.1
Derived Concentration Guidelines for Plutonium-238 in Soil
(Based on limiting committed effective dose equivalent to 25 mrem/year except as noted)

Reference	Soil Concentration Guideline (pCi/g)	Soil Concentration Normalized to 25 mrem/yr (pCi/g)	Dominant Pathway
EPA 1991	150[a]	25	Soil Ingestion
Healy 1977	100[b]	5	Inhalation
DOE 1983	100[b]	5	Inhalation
Napier, Piepel, and Kennedy 1986	110	110	Inhalation
Gilbert et al. 1989	50	50	Inhalation
Till and Moore 1988	400[c]	100	Inhalation
Stought, Edling and Draper, 1988	100[d]	200	NA
Zimmerman et al 1991	131-295	131-295	Inhalation

[a] Based on 30 year cancer risk of 1×10^{-5}.
[b] Based on committed effective dose equivalent to the public of 500 mrem/yr.
[c] Based on committed effective dose equivalent to the public of 100 mrem/yr.
[d] Based on committed effective dose equivalent to onsite workers of 12 mrem/yr.
NA Not Applicable.

feasible. To address the uncertainty in the plutonium-238 soil cleanup standard, the EE/CA alternatives have been evaluated over soil concentrations ranging from 25 to 100 pCi/g. The final cleanup guideline for this removal action will be determined by DOE as the lead agency with imput from/discussion with the Mound Stakeholders (see Section 2.4). The DOE will issue an Action Memorandum as the primary decision document supporting the selection and authorization for this removal action, including the final cleanup guideline for the OU4 Miami-Erie canal.

TRITIUM CLEANUP STANDARD

Like plutonium, there are currently no concentration standards for tritium in soil. Since the dominant exposure pathways for tritium are air and water, most standards are applicable to these media only.

The USEPA drinking water standard for tritium is 20,000 pCi/L, equivalent to a total body dose of 4 mrem/yr. (40 CFR 141).

DOE (DOE 1983) estimated that a tritium soil moisture concentration of 5200 pCi/mL (5.2×10^{-3} uCi/mL) would result in a dose of 500 mrem/yr. The analysis was based on a resident homeowner scenario using a tritium dose methodology developed by the NCRP (NCRP 1979). The scenario assumed that an individual constructed a home in an area containing radioactively contaminated soil, and the excess soil excavated from the foundation was spread around the grounds of the home. It is further assumed that the soil is used for gardening and is available for wind resuspension. The dilution effect of mixing the contaminated and uncontaminated soils is included in the model.

NRC's requirements for land disposal of low-level radioactive waste provides concentration limits for various waste classes (10 CFR 61). The least hazardous waste, class A, has a minimum concentration limit of 40 Ci/m^3 for tritium (10 CFR 61.55), which is equivalent to 20,000 uCi/Kg assuming a soil density of 2 g/cm^3. Presumably, the NRC standards are based on the EPA's standards of 10 mrem/yr. emissions of radionuclides from DOE facilities (40 CFR 61).

DOE Order 5400.5 (DOE 1988) prescribes limits for tritium in air and water. The DOE limit for tritium in non-drinking water is 2×10^{-3} uCi/mL, which is 100 times EPA's drinking water standard. NRC's standard for tritium in water is 3×10^{-3} uCi/mL (10 CFR 20).

Due to the lack of tritium soil guidelines, and based on the following conditions, no tritium soil cleanup standard will be established for the EE/CA:

1) Due to the short decay half-life of tritium (12.5 years) and the gradual transfer of the bound-to-exchangable tritium to the BVA, the tritium concentration in the canal is now less than 1% of the 1974 level.

2) Current tritium concentrations in the canal do not cause drinking water supplies in the aquifer to exceed SDWA standards.

The following list includes ARARs and TBCs for Mound Plant:

Contaminant-Specific ARARs

1) 40 CFR 61 Subpart H - National Emission Standards for Emissions of Radionuclides Other Than Radon from DOE Facilities.

- Any member of the public will not receive in any year an effective dose equivalent of more than 10 mrem.

2) Ohio Administrative Code (OAC) 3745-81-15 A,B

- MCLs for Radium 226, 228, and Gross Alpha Emitters

3) OAC 3745-81-16 A,B

- MCLs for Beta Particle and Photon Radioactivity

4) 10 CFR 20 - Standards for Protection Against Radiation

- On-site worker receives a maximum effective dose of 5 rem/yr.
- Occupational dose of a minor is 10% of on-site adult worker.
- Maximum total effective dose equivalent to the public is 100 mrem/yr.
- Radiation exposures shall be maintained as low as reasonabley achievalbe (ALARA).
- Tritium and Plutonium-238 concentration limits:

	Water (uCi/mL)	Air (uCi/mL)
Pu-238	3×10^{-5}	1×10^{-12}
H-3	3×10^{-3}	2×10^{-7}

5) 40 CFR 141 - National Primary Drinking Water Regulations

- Gross alpha particle activity of 15 pCi/liter
- Average annual concentration of beta and photon activity from manmade radiation in drinking water shall not exceed dose of 4 mrem/year
  (This corresponds to 20,000 pCi/L for tritium)

6) 10 CFR 61 - Licensing Requirements for Land Disposal of Radioactive Waste

- Dose to any member of the public may not exceed 25 mrem to the whole body, 75 mrem to the thyroid, or 25 mrem to any other organ.
- Releases of radionuclides in effluents shall be maintained ALARA.

7) 40 CFR 191 - EPA Radiation Protection Standards for Managing and Disposing of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste

- The dose to any member of the public, resulting from discharges of radioactive material, not to exceed 25 mrem to the whole body and 75 mrem to any critical organ.

Location-Specific ARARs

1) RCRA

- Regulations regarding fault zones
- Regulations regarding flood plains

2) 33 CFR 320 to 329

- Regulations of activities affecting the waters of the U.S.

3) OAC 3745-27-07

- Specific locations in which solid waste landfills are not to be sited. Includes floodplains, sand or gravel pits, limestone or sandstone quarries, areas above sole source aquifers, wetlands, etc.

4) OAC 3745-1-21

- Establishes water use designations for stream segments within the Great Miami River Basin

Action-Specific ARARs

1) CERCLA 40 CFR 300

- Superfund off-plant policy: wastes may only be taken to facilities in compliance with their RCRA permit.
- Technological approaches to the cleanup of radiologically contaminated CERCLA sites.

2) Clean Water Act

- Requirements include effluent guidelines and standards, pretreatment standards, and discharge of treatment system effluent.

3) Occupational Safety and Health Administration (OSHA) 29 CFR 1910

- Requirements include general standards for worker protection.

4) OAC 3745-27-01 through 3745-33-10

- Requirements include authorized solid waste disposal methods, operational requirements for solid waste disposal facilities, and closure requirements.

5) OAC 3745-15-01 through 3745-15-09 and 3745-49-01 through 3745-49-04

- Requirements include measurement of emissions of air contaminants, scheduled maintenance, reporting, and malfunction of equipment.

6) OAC 3745-17-01 through 3745-17-11

- Measurement of ambient air quality and allowable emission standards

7) OAC 3745-32

- Establishes criteria for the discharge of dredged or fill material to surface waters.

8) Ohio Revised Code (ORC) 6111

- Prohibits pollution of waters within the state

9) ORC 3767

- Prohibits noxious exhalation or smells, obstruction or pollution of water courses, or other nuisances.

To Be Considered

1) DOE Order 5400.5 - Radiation Protection of the Public and the Environment

- Exposure of members of the public shall be limited to 100 mrem per year from the sum of external and internal exposures.
- All exposures shall be maintained ALARA.
- Effective dose equivalent to whole body via drinking water shall be limited to 4 mrem/yr.
- Tritium and Plutonium-238 concentration limits (based on 100 mrem/yr exposure):

	Ingested Water (uCi/ml)	**Inhaled Air (uCi/ml)**
H-3 (water)	2×10^{-3}	1×10^{-7}
H-3 (elemental)	_____	2×10^{-2}
Pu-238	4×10^{-8}	3×10^{-14}
Th-230	3×10^{-7}	4×10^{-14}

- Exposure to residual concentrations of radionuclides in soil shall be limited to 100 mrem/yr, above background, for members of the public.
- Thorium residual soil concentrations shall not exceed 5 pCi/g, averaged over the first 15 cm of soil below the surface, and 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.

2) EPA RAGS

- Provides pathway model to correlate risk as well as concentration of plutonium-238 and tritium. Specific derived concentration guidelines depend on scenario assumptions.

3) EPA draft guidance for cleanup of accidental releases of transurancies to the environment (EPA 1977).

- 0.2 uCi/m^2 in surface 1-cm soil

4) NRC proposed policy (NRC 1988)

- Proposed Below-Regulatory-Concern (BRC) dose of 10 mrem/yr.

5) Mound Onsite Cleanup Policy (June, 1986)

- Plutonium-238 concentration in soil less than 100 pCi/g

APPENDIX A REFERENCES

Code of Federal Regulations, 10 CFR 20, "Standards for Protection Against Radiation," 25 FR 10914, November 17, 1960; and "Standards for Protection Against Radiation; Proposed Rule," 51 FR 1092, January 1986.

Ibid, 40 CFR 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," 42 FR 2858, January 13, 1977.

Ibid, 40 CFR 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," 50 FR 38066, September 19, 1985.

Ibid, 40 CFR 192, "Health and Environmental Standards for Remedial Actions in Inactive Uranium Processing Sites," 48 FR 590, January 5, 1983; and "Environmental Standards for Uranium and Thorium Mill Tailings at Licensed Commercial Processing Site," 48 FR 45926, October 7, 1983.

DOE. 1983. "Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program." U.S. Department of Energy. ORO-831. March 1983.

DOE 1988. "Radiation Protection of the Public and the Environment." U.S. Department of Energy. DOE Order 5400.5.

DOE 1993. "Focused Risk Assessment, Mound Plant, Miami-Erie Canal, Operable Unit 4, EG&G Mound Applied Technologies for the U.S. Department of Energy, 1993.

EPA. 1977. "Federal Radiation Protection Guidance on Dose Limits: Persons Exposed to Transuranium Elements in the Environment." Federal Register Vol. 42 pp. 60956-60959. U.S. Environmental Protection Agency. November 30, 1977.

EPA. 1988. Memorandum, "Outline of EE/CA Guidance," Timothy Fields, Jr., Director, Emergency Response Division, U.S. Environmental Protection Agency, March, 1988.

EPA. 1989. "Risk Assessment Guidance for Superfund: Human Health Evaluation Manual (Interim Final)," 9285.701A. July 1989.

EPA. 1991. "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors." OSWER Directive 9285.6-03. March 1991.

Gilbert, T.L., C. Yu, Y.C. Yuan, A.J. Zielen, M.J. Jusko, and A. Wallo. 1989. "A Manual for Implementing Residual Radioactivity Guidelines." ANL/ES-160, DOE/CH/8901. June 1989.

Healy, J.W. 1977. "An Examination of the Pathways from Soil to Man for Plutonium," LA-6741-MS.

ICRP. 1977. "Recommendations of the International Commission on Radiological Protection." International Commission on Radiological Protection Publication 26, Pergamon Press, New York, NY. January 1977.

Napier, B.A., G.F. Piepel, and W.E. Kennedy. 1986. "A Manual for Applying the Allowable Residual Contamination Level Method for Decommissioning Facilities in the 100 Areas of the Hanford Site." Draft PNL Report, 1986.

NCRP. 1979. Tritium in the Environment. National Council on Radiation Protection and Measurements Report No. 62. Washington, D.C., 1979

NCRP. 1987. "Recommendations on Limits of Exposure to Ionizing Radiation." National Council on Radiation Protection and Measurements Report No. 91, 1987.

NRC. 1988. "Advanced Notice of Proposed Policy Statement on Exemptions from Regulatory Control." 53 FR 49886, December 12, 1988.

Stought, R.L., D.A. Edling, and D.G. Draper, 1988. "The Mound Site Survey Project for the Characterization of Radioactive Materials in Site Soils." Monsanto Research Corporation, Mound Plant, Miamisburg, Ohio. Report MLM-3517 for the U.S. Department of Energy. May 16, 1988.

Till, J.E., and R.E. Moore. 1988. "A Pathway Analysis Approach for Determining Acceptable Levels of Contamination of Radionuclides in Soil." Health Physics, 55:3, pp. 541-548.

Zimmerman, J.P., R. Eckart, R. Janke, and T. Ijaz. 1991. "Pathways Analysis to Determine Residual Radioactivity Soil Guidelines for the Mound Plant in the WD Hilltop, Basin and Hillside Regions." University of Cincinnati. April 1991.

APPENDIX B

COST ANALYSIS INFORMATION

APPENDIX B
COST ANALYSIS INFORMATION

This appendix provides backup information for the cost analysis portion of this document. General cost assumptions and information is provided in Section B.1 through B.10. Direct capital and O&M cost estimates for each alternative are provided in Table B-1 through B-32. The 30-year present worth costs (using 0, 5 and 10%, which forms the basis of a sensitivity analysis) are also presented in these tables. A 30-year analysis was used based on the U.S. EPA's "Remedial Action Costing Procedures Manual" (EPA 1987) which states that remedial actions requiring perpetual care should not be costed beyond thirty years for the purpose of feasibility analysis. This is because at a discount rate of 10% the present worth of costs beyond 30 years have little impact on the total present worth of an analysis. The cost estimates are expected to provide an accuracy of +50% to -30% and were prepared using available data.

Costs for additional studies such as a detailed environmental impact assessment (EIA) for the selected alternative have not been included in these estimates. A modest allocation for legal costs, siting studies, and the inventory of environmental impacts has been included in indirect costs, however, the actual costs for these activities could increase significantly due to the present uncertainty in the respective scopes of services required. The cost estimates in this appendix are based on the remedial action construction activities alone and do not incorporate additional studies or delays. These cost estimates are appropriate only for this EE/CA, and should not be extended to other applications. In addition, the actual realized costs for remedial activities at some DOE facilities have been shown to be higher, in some cases, than the calculated cost estimates from available construction cost estimating guides such as Means Heavy Construction Cost Data (Means 1992 and 1993).

COST NARRATIVE

Remediation costs may increase if it is determined that a wetlands resource exists within the area of concern of the Miami-Erie Canal. As stated in the Work Plan for Operable Unit 9 RI/FS (DOE 1992a), wetlands will be classified and delineated following the procedures and criteria contained in the Federal Manual for Identifying and Delineating Wetlands (DOE 1992b).

GENERAL COST INFORMATION

Unit and activity prices have been derived from contractors, equipment suppliers, service providers, and from industry standard cost estimating guides. In the majority of instances, unit material, labor, and equipment prices including contractor's overhead and profit (O&P) have been derived from Means Heavy Construction Cost Data, for example (Means 1992 and 1993).

B.1 OFF SITE DRAINAGE CONTAINMENT

The costs associated with the elimination of the use of open ditches and the Miami-Erie Canal for drainage have not been included in these estimates. A project to perform this task has been designed and costed by Mound (EG&G 1992). The work needs to be completed prior to beginning work on the preferred alternative in the canal area. The project involves the installation of the new box culvert to divert surface water runoff and is estimated at a cost of $4 million dollars.

B.2 INSTITUTIONAL CONTROLS

The costs for institutional controls include the cost of fencing the contaminated area and posting warning signs. The total perimeter of the three contaminated zones (north canal, south canal, and the drainage ditch) was used to determine the length of fence required. The fence is assumed to be one continuous unit surrounding all three areas with two gates for access to the area. It was assumed that 100 signs would be posted along the length of the fence.

B.3 EXCAVATION AND BACKFILLING

Excavation and backfilling costs include, respectively, the costs of excavating and stockpiling contaminated soils and replacing excavated material with clean fill. Costs for restoring properties to their pre-remedial action condition are presented within the direct cost tables under the heading "Site Restoration." Costs are based on equipment and labor usage rates obtained from Means (Means 1992 and 1993) for the estimated volumes of contaminated soil. No O&M costs are associated with excavation and backfilling. One radiation technician is assumed to be used with each crew and one foreman is assumed to be on the project for the entire duration.

The following assumptions are made regarding excavation: (1) backhoes and front end loaders are used for excavating at the site, (2) spreading and compaction of backfill is at the same production rate as excavation, (3) dump trucks are to haul backfill soil from borrow areas at the same rate as that of the excavation activity, and (4) material cost estimates do not include equipment decontamination activities.

Additional assumptions are as follows:

- Percent to account for over excavation = 20.
- Percent swell of excavated soil = 30.
- Entire area of both canals and drainage ditch will require clearing and grubbing before excavation or construction activities can take place.
- Weight of soil = 120 lbs. per ft^3.
- Dump truck capacity - 12 yd^3 (on-site movements); 20 yd^3 (off-site movements).
- Additional costs associated with careful excavation activities (such as near buried utilities) are not included.
- Work schedule composed of 52 weeks/year, 5 days/week, 8 hours/day.
- Construction crew rates based on hourly rate with O&P.
- Equipment rates based on monthly rental rates plus hourly fuel and maintenance cost.
- Material cost based on bare costs plus O&P.
- Trailers used for office space and maintenance facility.
- Decontamination facility cost is $60,000 (estimated).
- Utilization factor for workers on clean soils will be 1.3.
- Utilization factor for workers on contaminated soils will be 2.00 to account for dress-out procedures and training.
- Two 10 horsepower pumps will be utilized to keep rainwater away from waste.
- Duration for construction activities based on critical path of equipment operating needs.
- Lc = canal length = 5,135 ft.
- Wc = canal width (nominal) = 40 ft.
- Ld = drainage ditch length = 400 ft.
- Wd = drainage ditch width (nominal) = 30 ft.
- Vd = drainage ditch volume = 26,000 ft^3.
- Fo = overexcavation factor = 1.2

- Fs = swelling factor = 1.3 ft.
- Df = clean fill depth = 2 ft.
- Wds = drainage swale width (each side of canal) = 5 ft.
- Vnc = canal volume (north) = 189,000 ft^3.
- Vsc = canal volume (south) = 232,000 ft^3.

Office space will be provided near the entrance to the facility for administrative personnel during the construction and closure of the site. A maintenance building will be required for: maintenance shop, laundry facility for protective clothing, shower/dressing room, health physics, lab and equipment storage. A covered equipment decontamination facility sized to accommodate equipment as large as dump trucks will be used to decontaminate equipment contaminated by operations. The site will require a gravel road around the disposal facility to provide maintenance, monitoring, and inspection access. Security lighting will be installed to illuminate the roadway.

B.4 REQUIRED QUANTITIES

The required clean fill volume for Alternative 3 was calculated as the amount needed to place a two foot thick layer of material over the entire area of the north and south canals and to replace the contaminated material removed from the drainage ditch. The volume of clean fill required for the north and south canals was, however, reduced by the amount of material removed from the drainage ditch since this material would be deposited evenly in the canals.

The cap in Alternative 3 will cover the entire area of the north and south canal and will consist of one foot of sand, one foot of clay, a 60 mil HPDE liner and one foot of topsoil. The entire area will then be covered with Hydroseed. It is assumed that a five foot wide rip-rap drainage swale will be placed along both sides of the capped north and south canals.

The volume of clean fill required for Alternative 4 is enough to replace all the contaminated material excavated except for the volume of a one foot layer of topsoil over the entire area of the canals and drainage ditch.

In Alternative 5, 35% of the contaminated soil is assumed to be recovered in the on-site treatment, therefore the amount of clean fill required is 65% of the volume of excavated material, less the volume required for a one foot layer of topsoil over the entire area.

Surface areas for the north canal, south canal, and drainage ditch were estimated by multiplying the length of the contaminated zone times the estimated width. Areas determined using this procedure and required for costing calculations were estimated to be:

- North Canal = 106,000 ft^2
- South Canal = 100,000 ft^2
- Drainage Ditch = 12,000 ft^2

The volumes of contaminated soil were estimated by plotting contaminant concentration versus depth and canal width to obtain a cross-sectional area profile for the contamination. The areas with contamination greater than 100 pCi/g were then integrated to determine the contaminated volume requiring excavation. The volume of contaminated soil was estimated to be:

- North Canal = 189,000 ft^3
- South Canal = 232,000 ft^3
- Overflow Creek = 0 ft^3
- Drainage Ditch = 26,000 ft^3

For Alternative 3 only the drainage ditch required excavation. For Alternatives 4 and 5 all the contaminated soil required excavation.

B.5 ONSITE TREATMENT

Treatment costs include the mobilization, operation, and maintenance of the treatment units(s) at the Mound Canal site. Costs for the treatment unit are based on recent soil washing cost data provided by vendors and FUSRAP documentation (DOE 1992c). Treatment costs for soil washing volume reduction range from \$5/ft^3 to \$15/ft^3; \$15/ft^3 is used for cost estimation purposes. The duration of treatment is based on a throughput of 10 tons (6.2 yd^3) per hour and a 20% downtime. The treatment operation is

assumed to run concurrently with construction activities. An estimated volume reduction percentage of 35% is used and is based on soil gradation tests.

B.6 OFF-SITE DISPOSAL

The off-site disposal costs are based on the assumption that NTS will receive the contaminated material from the removal action. NTS is a Federal facility located approximately 65 miles northwest of Las Vegas, NV. It is subject to strict waste certification and acceptance criteria. The site is currently licensed to receive radioactive wastes but does not currently handle mixed wastes. A RCRA Part B permit for a mixed waste disposal cell at NTS is currently pending approval.

NTS is currently accepting waste from various sources, although a majority is from DOE defense testing. The facility is accessible by truck; rail access is not available. Bulk waste shipments are accepted in approved containers which can be entombed with the waste.

The estimated cost for disposal of low-level radioactive waste is \$10 per ft^3 (July, 1992). For this EE/CA the disposal cost has been estimated at \$300 per yd^3.

B.7 TRANSPORTATION

The costs for disposal of contaminated material assume that waste will be containerized and trucked to NTS for disposal.

It is assumed that two people (one equipment operator and one laborer) are needed for loading contaminated soils into B-25 boxes for transport to NTS. This activity is assumed to run concurrently with the excavation/backfill activities; therefore, in certain alternatives loading crews may be doubled or tripled to keep pace.

The estimated cost for the containers is \$208 per yd^3. The estimated cost for truck transportation is \$43 per yd^3.

B.8 ENVIRONMENTAL MONITORING

Costs for environmental monitoring are based on continuation of the present program, if applicable, or on establishing a program. The quarterly monitoring program would include air, groundwater, surface water, sediment and biota sampling at designated locations. Environmental monitoring is included in the cost analysis for Alternatives 1, 2 and 3, but is assumed to be $0 for Alternatives 4 and 5 because the contaminated soils will be excavated and disposed of off-site.

B.9 INDIRECT CAPITAL COSTS

Indirect capital costs consist of engineering, financial, supervision and other services necessary to carry out a remedial action. They are not incurred as part of actual remedial actions but are ancillary to direct or construction costs. Indirect capital costs include costs for design, engineering, and contingency allowance.

Engineering and design costs are estimated at 25% of direct capital costs. These costs include both costs associated with conventional engineering and an additional allotment for project development services such as legal services, siting studies, basic permitting and environmental impact evaluation. Conventional engineering services can range up to a maximum of 15% of capital costs, while additional indirect costs range between 5% to 25% of direct capital costs. For costing purposes, conventional engineering costs were assumed to be 15% of the total capital costs while other indirect costs were assumed to be 10% of the total capital costs.

Contingency allowances are added to total capital costs to account for unforeseen circumstances which result in additional costs. Contingency may include adverse weather conditions, strikes by material suppliers, and inadequate site characterization (particularly subsurface). Contingency allowance are estimated at 25% of total capital costs.

Technical and administrative personnel were assumed to be 1 to 2% of the total capital costs to conduct site construction and operation and maintenance services. The duration of these services is assumed to coincide with the governing construction or operation activity.

B.10 O&M COSTS

O&M costs are those non-construction costs necessary to ensure the effectiveness of a remedial action and/or ensure the protectiveness of human health and the environment. O&M costs include:

- Environmental monitoring,
- Surveillance and maintenance, and
- Treatment costs during the removal action period.

Costs for environmental monitoring include those costs associated with the installation, monitoring and analysis of both wells that are presently part of the site-wide monitoring program and any new wells that are required to better monitor the performance of the respective alternative.

Surveillance and maintenance costs include mowing, cap inspection/repairs, monitoring equipment inspection/repairs, fence inspection/repairs, etc. It is anticipated that periodic surveillance and maintenance activities will occur once a year.

Treatment costs include costs for: (1) electricity to run equipment, pumps, lights, and controls; (2) start up and commissioning of remedial equipment; (3) on-line operational training of clients operators; (4) three full time operators to run equipment during remedial period; and (5) maintenance of treatment equipment, feed lines, discharge lines and buildings.

Table B-1 Alternative 1:
No Action
Capital Costs

Cost Component	Cost Estimate	Basis of Estimate	Year Incurred
DIRECT CAPITAL COSTS			
1. Construction costs			
Subtotal	$0		
2. Equipment costs			
3. Land and site development			
Subtotal	$0		
4.Buildings and services			
Subtotal	$0		
5.Relocation costs			
Subtotal	$0		
6. Disposal costs			
Subtotal	$0		
Total direct costs	$0		
INDIRECT CAPITAL COSTS			
1. Engineering and design			
a. Conventional Engineering	$0	15% of direct costs	0
b. License/permit costs	$0	10% of direct costs	0
2. Contingency allowance	$0	25% of direct costs	0
TOTAL INDIRECT COSTS	$0		0
TOTAL CAPITAL COSTS	$0		0

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Table B-2 Alternative 1:
No Action
Annual Operating Costs

Cost Component	Estimate ($)	Basis of Estimate	Frequency	Year/ Period
DIRECT O & M COSTS				
1. Operating Labor				
a. Sampling	$4,000	80 hr. x $50./hr.	Annually	0-30
b. Analytical Report	$3,000	40 hr. x $75./hr.	Annually	0-30
2. Maintenance: Materials and Labor	$0			
3. Auxiliary: Materials and Labor	$0			
a.				
b.				
4. Purchased Service				
a. Analysis of Samples	$7,500	50 samples x $150/sample		
b.				
TOTAL DIRECT COSTS	$14,500			
INDIRECT O & M COSTS				
1. Administration	$3,625	25% of direct costs	Annually	0-30
2. Insurance, Taxes Licenses				
a.	$3,625	25% of direct costs	Annually	0-30
b.				
3. Maintenance: Reserve and Contingency costs	$3,625	25% of direct costs	Annually	0-30
TOTAL INDIRECT COSTS	$10,875			
TOTAL O & M COSTS	$25,375			

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Table B-3 Alternative 1:
No Action
Cost Analysis Work Sheet
0% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38
3. Annual Expenditures, x (sum of lines 1 and 2)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5. Present Worth (product of lines 3 and 4)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	
3. Annual Expenditures, x (sum of lines 1 and 2)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
5. Present Worth (product of lines 3 and 4)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	$ 787

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Form E

Table B-3 Alternative 1:
No Action
Cost Analysis Work Sheet
5% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. O & M Costs	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38
3. Annual Expenditures, x (sum of lines 1 and 2)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
4. Discount Factor (annual discount rate = 5%)	1.0	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530	0.505	0.481
5. Present Worth (product of lines 3 and 4)	25.4	24.2	23.0	21.9	20.9	19.9	18.9	18.0	17.2	16.4	15.6	14.8	14.1	13.4	12.8	12.2

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	
3. Annual Expenditures, x (sum of lines 1 and 2)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 5%)	0.458	0.436	0.416	0.369	0.377	0.359	0.342	0.326	0.310	0.295	0.281	0.268	0.255	0.243	0.231	
5. Present Worth (product of lines 3 and 4)	11.6	11.1	10.6	9.4	9.6	9.1	8.7	8.3	7.9	7.5	7.1	6.8	6.5	6.2	5.9	$ 415

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Form F

Table B-3 Alternative 1:
No Action
Cost Analysis Work Sheet
10% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38
3. Annual Expenditures, x (sum of lines 1 and 2)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4
4. Discount Factor (annual discount rate = 10%)	1.0	0.909	0.826	0.751	0.683	0.621	0.564	0.513	0.467	0.424	0.386	0.350	0.319	0.290	0.263	0.239
5. Present Worth (product of lines 3 and 4)	25.4	23.1	21.0	19.1	17.3	15.8	14.3	13.0	11.9	10.8	9.8	8.9	8.1	7.4	6.7	6.1

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	25.38	
3. Annual Expenditures, x (sum of lines 1 and 2)	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 10%)	0.218	0.198	0.180	0.164	0.149	0.135	0.123	0.112	0.101	0.092	0.084	0.076	0.069	0.063	0.057	
5. Present Worth (product of lines 3 and 4)	5.5	5.0	4.6	4.2	3.8	3.4	3.1	2.8	2.6	2.3	2.1	1.9	1.8	1.6	1.5	$ 265

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Form G

Table B-4 Alternative 1:
No Action
Sensitivity Factors

Sensitivity Factor	Justification for Consideration	Range	Justification of Range
Present Worth	Changes in time value of money.	Annual Discount Rate: 0%, 5%,10%	Per EECA guidance.
O&M Costs	Changes in monitoring program.	-30%, + 50%	Decrease/increase in number of samples collected.

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Table B-5 Alternative 1:

No Action

Summary of Sensitivity Analysis

Cost Factor	Baseline 5% Discount Rate	Sensitivity Factor Examined/Resulted			
		0% Discount Rate	10% Discount Rate	-30% in Total O&M	+50% in Total O&M
Capital Costs ($) (x1000) year 0	0	0	0	0	0
Present Worth ($) Total O & M $ (x1000)	415	787	265	290	622
Total Present Worth $ (x1000)	415	787	265	290	622

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Table B-6 Alternative 2:
Institutional Controls and Environmental Monitoring
Capital Costs

Cost Component	Cost Estimate	Basis of Estimate	Year Incurred
DIRECT CAPITAL COSTS			
1. Construction costs	$151,335	Fencing	0
	$4,300	Warning Signs	0
	$474	Fence Gates	
Subtotal	$156,109		
2. Equipment costs			
3. Land and site development			
Subtotal	$0		
4.Buildings and services			
	$0		
5.Relocation costs			
Subtotal	$0		
6. Disposal costs			
Subtotal	$0		
Total direct costs	$156,109		
INDIRECT CAPITAL COSTS			
a. Conventional Engineering	$23,416	15% of direct costs	0
b. License/permit costs	$15,611	10% of direct costs	0
2. Contingency allowance	$39,027	25% of direct costs	0
TOTAL INDIRECT COSTS	$78,054		0
TOTAL CAPITAL COSTS	$234,163		0

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Table B-7 Alternative 2:
Institutional Controls and Environmental Monitoring
Basis of Direct Cost Estimate

Cost Item: Construction costs
Cost Component: Labor & Materials
Basis: Installation of Warning signs
Installation of Chain Link Fence

Description	Quantity	Unit Price	Total Costs
Warning Signs	100	$43.00 /ea	$4,300
Chain Link Fence	11,210 lf	$13.50 /lf	$151,335
Chain Link Fence Gates	2	$237.00 /ea	$474
TOTAL DIRECT COSTS			$156,109

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Table B-8 Alternative: 2
Institutional Controls and Environmental Monitoring
Basis of Capital Cost Estimate

Cost Item:	Direct - Construction Costs
Cost Component:	Labor and Materials
Basis:	Installation of Warning Signs
	Installation of Chain Link Fence
Calculation/Source:	R.S. Means Company, Inc., "Means Site Work & Landscape Data, 12th Edition", Construction Publisher and Consultants, Kingston, MA, 1993.

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Table B-9 Alternative 2:
Institutional Controls and Environmental Monitoring
Annual Operating Costs

Cost Component	Estimate ($)	Basis of Estimate	Frequency	Year/ Period
DIRECT O & M COSTS				
1. Operating Labor				
a. Sampling	$4,000	80 hr. x $50./hr.	Annually	0-30
b. Analytical Report	$3,000	40 hr. x $75./hr.	Annually	0-30
c. Site Inspection	$600	8 hr. x $75./hr.	Semi-Annually	0-30
d. Inspection Report	$1,200	16 hr. x $75./hr.	Semi-Annually	0-30
2. Maintenance: Materials and Labor	$1,000	10 hr x $50/hr (Labor) $500 (Materials)	Annually	0-30
3. Auxiliary: Materials and Labor	$0			
a.				
b.				
4. Purchased Service				
a. Analysis of Samples	$7,500	50 samples x $150/sample		
b.				
TOTAL DIRECT COSTS	$17,300			
INDIRECT O & M COSTS				
1. Administration	$4,325	25% of direct costs	Annually	0-30
2. Insurance, Taxes Licenses				
a.	$4,325	25% of direct costs	Annually	0-30
b.				
3. Maintenance: Reserve and Contingency costs	$4,325	25% of direct costs	Annually	0-30
TOTAL INDIRECT COSTS	$12,975			
TOTAL O & M COSTS	$30,275			

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Table B-10 Alternative 2:
Institutional Controls and Environmental Monitoring
Cost Analysis Work Sheet
0% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	234.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28
3. Annual Expenditures, x (sum of lines 1 and 2)	264.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5. Present Worth (product of lines 3 and 4)	264.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	
3. Annual Expenditures, x (sum of lines 1 and 2)	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
5. Present Worth (product of lines 3 and 4)	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	$ 1,173

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Form E

Table B-10 Alternative 2:
Institutional Controls and Environmental Monitoring
Cost Analysis Work Sheet
5% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	234	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. O & M Costs	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28
3. Annual Expenditures, x (sum of lines 1 and 2)	264.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3
4. Discount Factor (annual discount rate = 5%)	1.0	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530	0.505	0.481
5. Present Worth (product of lines 3 and 4)	264.3	28.8	27.5	26.2	24.9	23.7	22.6	21.5	20.5	19.5	18.6	17.7	16.9	16.0	15.3	14.6

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	
3. Annual Expenditures, x (sum of lines 1 and 2)	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 5%)	0.458	0.436	0.416	0.369	0.377	0.359	0.342	0.326	0.310	0.295	0.281	0.268	0.255	0.243	0.231	
5. Present Worth (product of lines 3 and 4)	13.9	13.2	12.6	11.2	11.4	10.9	10.4	9.9	9.4	8.9	8.5	8.1	7.7	7.4	7.0	$ 729

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Form F

Table B-10 Alternative 2:
Institutional Controls and Environmental Monitoring
Cost Analysis Work Sheet
10% Annual Discount Rate _____

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	234.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28
3. Annual Expenditures, x (sum of lines 1 and 2)	264.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3
4. Discount Factor (annual discount rate = 10%)	1.0	0.909	0.826	0.751	0.683	0.621	0.564	0.513	0.467	0.424	0.386	0.350	0.319	0.290	0.263	0.239
5. Present Worth (product of lines 3 and 4)	264.3	27.5	25.0	22.7	20.7	18.8	17.1	15.5	14.1	12.8	11.7	10.6	9.7	8.8	8.0	7.2

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	30.28	
3. Annual Expenditures, x (sum of lines 1 and 2)	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 10%)	0.218	0.198	0.180	0.164	0.149	0.135	0.123	0.112	0.101	0.092	0.084	0.076	0.069	0.063	0.057	
5. Present Worth (product of lines 3 and 4)	6.6	6.0	5.5	5.0	4.5	4.1	3.7	3.4	3.1	2.8	2.5	2.3	2.1	1.9	1.7	$ 550

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Form G

Table B-11 Alternative 2:
Institutional Controls and Environmental Monitoring
Sensitivity Factors

Sensitivity Factor	Justification for Consideration	Range	Justification of Range
Present Worth	Changes in time value of money.	Annual Discount Rate: 0%, 5%,10%	Per EECA guidance.
O&M Costs	Changes in monitoring program.	-30%, + 50%	Decrease/increase in number of samples collected.

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Table B-12 Alternative 2:

Institutional Controls and Environmental Monitoring

Summary of Sensitivity Analysis

Cost Factor	Baseline 5% Discount Rate	Sensitivity Factor Examined/Resulted			
		0% Discount Rate	10% Discount Rate	-30% in Total O&M	+50% in Total O&M
Capital Costs ($) (x1000) year 0	234	234	234	234	234
Present Worth ($) Total O & M $ (x1000)	495	939	316	346	742
Total Present Worth $ (x1000)	729	1,173	550	580	976

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Table B-13 Alternative 3:
Containment
(Limited Use)
Capital Costs

Cost Component	Cost Estimate	Basis of Estimate	Year Incurred
DIRECT CAPITAL COSTS			
1. Construction costs	$132,836	Site Preparation	0
	$893,825	Site Remediation	0
	$329,015	Site Restoration	0
Subtotal	$1,355,676		
2. Equipment costs			
3. Land and site development			
Subtotal	$0		
4.Buildings and services			
Subtotal	$0		
5.Relocation costs			
Subtotal	$0		
6. Disposal costs			
Subtotal	$0		
Total direct costs	$1,355,676		
INDIRECT CAPITAL COSTS			
1. Engineering and design			
a. Conventional Engineering	$203,351	15% of direct costs	0
b. License/permit costs	$135,568	10% of direct costs	0
2. Contingency allowance	$338,919	25% of direct costs	0
TOTAL INDIRECT COSTS	$677,838		0
TOTAL CAPITAL COSTS	$2,033,514		0

Note: Replace site remediation and restoration costs with costs from Table B-14A, Alternative 3A, to determine beneficial reuse total direct costs.

Form A
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Table B-14 Alternative 3:
Containment
(Limited Use)
Basis of Direct Cost Estimate

Cost Item: Direct Construction Costs
Basis: Institutional Controls; Construction of Storm Water Control; Construction of containment system

Cost Component: Equipment, Labor and Materials

Description	Quantity		Unit Price		Total Costs
1. SITE PREPARATION					
a. Decontamination Facility	1		$60,000	/ea	$60,000
b. Silt Fencing	11,210	lf	$1.20	/lf	$13,452
c. Clearing & Grubbing	5	ac	$5,150	/ac	$25,750
d. Excavating Contaminants	1,560	cy	$21.56	/cy	$33,634
Total Preparation					$132,836
2. SITE REMEDIATION					
a. Clean Fill	15,260	cy	$14.17	/cy	$216,234
b. Clay	7,630	cy	$29.03	/cy	$221,499
c. HDPE Synthetic Liner	206,000	sf	$1.00	/sf	$206,000
d. Topsoil	7,630	cy	$31.63	/cy	$241,337
e. Hydroseed	206	msf	$42.50	/msf	$8,755
Total Remediation					$893,825
3. SITE RESTORATION					
a. Drainage Swale	5,722	sy	$57.50	/sy	$329,015
Total Restoration					$329,015
Basis:					
1b. Fencing = 2(Lc+Wc+Ld+Wd) = 2(5135+40+400+30) = 11210 ft					
1c. Area = (LcxWc+LdxWd)/43560 sf/ac = (5135x40+400x30)/43560 = 5 acres					
1d. Volume = VdxPcxFs/27 cf/cy = 26,000x1.2x1.3/27 = 1560 cy					
2a. Volume = LcxWcxDf/27 cf/cy = 5135x40x2/27 = 15260 cy					
2b. Volume = "2a"/2 = 15260/2 = 7630 cy					
2c. Area = LcxWc = 5135x40 = 206000 sf					
2d. "2d" = "2b"					
2e. "2c"/1000 = 206 msf					
3a. Area = 2(LcxWds)/9 sf/sy = 2(5135x5)/9 = 5722 sy					
TOTAL DIRECT COSTS					$1,355,676

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Form B

Table B-14A Alternative 3A:
Containment
(Beneficial Reuse)
Basis of Direct Cost Estimate

Cost Item: Direct Construction Costs
Basis: Institutional Controls: Construction of Storm Water Control: Construction of containment system

Cost Component: Equipment, Labor and Materials

Description	Quantity		Unit Price		Total Costs
1. SITE PREPARATION					
a. Decontamination Facility	1		$60,000	/ea	$60,000
b. Silt Fencing	11,210	lf	$1.20	/lf	$13,452
c. Clearing & Grubbing	5	ac	$5,150	/ac	$25,750
d. Excavating Contaminants	1,560	cy	$21.56	/cy	$33,634
Total Preparation					$132,836
2. SITE REMEDIATION					
a. Clean Fill	15,260	cy	$14.17	/cy	$216,234
b. Clay	7,630	cy	$29.03	/cy	$221,499
c. HDPE Synthetic Liner	206,000	sf	$1	/sf	$206,000
d. Sand Drainage Layer	7,630	cy	$26.00	/cy	$198,380
Total Remediation					$842,113
3. SITE RESTORATION					
a. Asphalt	22,889		$12.70	/sy	$290,690
b. Drainage Swale	5,722	sy	$57.50	/sy	$329,015
Total Restoration					$619,705
Basis:					
1b. Fencing = 2(Lc+Wc+Ld+Wd) = 2(5135+40+400+30) = 11210 ft					
1c. Area = (LcxWc+LdxWd)/43560 sf/ac = (5135x40+400x30)/43560 = 5 acres					
1d. Volume = VdxFcxFs/27 cf/cy = 26,000x1.2x1.3/27 = 1560 cy					
2a. Volume = LcxWcxDf/27 cf/cy = 5135x40x2/27 = 15260 cy					
2b. Volume = "2a"/2 = 15260/2 = 7630 cy					
2c. Area = LcxWc = 5135x40 = 206000 sf					
2d. "2d" = "2b"					
3a. Area = "2c"/9 sf/sy = 206,000/9 = 22889 sy					
TOTAL DIRECT COSTS					$1,594,654

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Table B-15 Alternative: 3
Containment
Basis of Capital Cost Estimate

Cost Item:	Direct - Construction Costs
Cost Component:	Equipment, Labor & Material
Basis:	Institutional Controls; Construction of Storm Water Control; Construction of Containment System
Calculation/Source:	R.S. Means Company, Inc. "Means Site Work & Landscape Cost Data, 12th Edition", Construction Publishers and Consultants, Kingston, Ma, 1993. R.S. Means Company, Inc. "Means Heavy Construction Cost Data, 6th Edition", Construction Publishers and Consultants, Kingston, Ma, 1992. Engineering News Record, Vol. 227, No. 5

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Table B-16 Alternative 3:
Containment
Annual Operating Costs

Cost Component	Estimate ($)	Basis of Estimate	Frequency	Year/ Period
DIRECT O & M COSTS				
1. Operating Labor				
a. Sampling	$4,000	80 hr. x $50./hr.	Annually	0-30
b. Site Inspection	$4,875	65 hr. x $75./hr.	Quarterly	0-30
c. Analytical Report	$3,000	40 hr. x $75./hr.	Annually	
d. Inspection Report	$7,200	96 hr. x $75./hr.	Quarterly	
2. Maintenance: Materials Equipment and Labor	$16,000	160 hr x $100/hr	Annually	0-30
3. Auxiliary: Materials and Labor	$0			
a.				
b.				
4. Purchased Service				
a. Analysis of Samples	$7,500	50 samples x $150/sample		
b.				
TOTAL DIRECT COSTS	$42,575			
INDIRECT O & M COSTS				
1. Administration	$10,644	25% of direct costs	Annually	0-30
2. Insurance, Taxes Licenses				
a.	$10,644	25% of direct costs	Annually	0-30
b.				
3. Maintenance: Reserve and Contingency costs	$10,644	25% of direct costs	Annually	0-30
TOTAL INDIRECT COSTS	$31,932			
TOTAL O & M COSTS	$74,507			

Note: Annual operation costs are assumed to be the same for both sub-options.

Form D
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Table B-17 Alternative 3:
Containment (Limited Use)
Cost Analysis Work Sheet
0% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	2,033.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51
3. Annual Expenditures, x (sum of lines 1 and 2)	2,108.0	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5. Present Worth (product of lines 3 and 4)	2,108.0	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	
3. Annual Expenditures, x (sum of lines 1 and 2)	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
5. Present Worth (product of lines 3 and 4)	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	$ 4,343

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Form E

Table B-17 Alternative 3: Containment (Limited Use) Cost Analysis Work Sheet 5% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	2,033.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. O & M Costs	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51
3. Annual Expenditures, x (sum of lines 1 and 2)	2,108.0	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5
4. Discount Factor (annual discount rate = 5%)	1.0	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530	0.505	0.481
5. Present Worth (product of lines 3 and 4)	2,108.0	70.9	67.6	64.4	61.3	58.4	55.6	53.0	50.4	48.1	45.7	43.6	41.5	39.5	37.6	35.8

		17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	
3. Annual Expenditures, x (sum of lines 1 and 2)	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 5%)	0.458	0.436	0.416	0.369	0.377	0.359	0.342	0.326	0.310	0.295	0.281	0.268	0.255	0.243	0.231	
5. Present Worth (product of lines 3 and 4)	34.1	32.5	31.0	27.5	28.1	26.7	25.5	24.3	23.1	22.0	20.9	20.0	19.0	18.1	17.2	$ 3,251

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Form F

Table B-17 Alternative 3: Containment (Limited Use) Cost Analysis Work Sheet 10% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	2,033.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51
3. Annual Expenditures, x (sum of lines 1 and 2)	2,108.0	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5
4. Discount Factor (annual discount rate = 10%)	1.0	0.909	0.826	0.751	0.683	0.621	0.564	0.513	0.467	0.424	0.386	0.350	0.319	0.290	0.263	0.239
5. Present Worth (product of lines 3 and 4)	2,108.0	67.7	61.5	56.0	50.9	46.3	42.0	38.2	34.8	31.6	28.8	26.1	23.8	21.6	19.6	17.8

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	74.51	
3. Annual Expenditures, x (sum of lines 1 and 2)	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	74.5	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 10%)	0.218	0.198	0.180	0.164	0.149	0.135	0.123	0.112	0.101	0.092	0.084	0.076	0.069	0.063	0.057	
5. Present Worth (product of lines 3 and 4)	16.2	14.8	13.4	12.2	11.1	10.1	9.2	8.3	7.5	6.9	6.3	5.7	5.1	4.7	4.2	$ 2,810

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Form G

Table B-18 Alternative 3:
Containment
Sensitivity Factors

Sensitivity Factor	Justification for Consideration	Range	Justification of Range
Present Worth	Changes in time value of money.	Annual Discount Rate: 0%, 5%,10%	Per EECA guidance.
O&M Costs	Changes in monitoring program.	-30%, + 50%	Decrease/increase in number of samples collected

Note: Sensitivity factors can be applied to both sub-options.

Form H
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Table B-19 Alternative 3:

Containment
(Limited Use)
Summary of Sensitivity Analysis

Cost Factor	Baseline 5% Discount Rate	Sensitivity Factor Examined/Resulted			
		0% Discount Rate	10% Discount Rate	-30% in Total O&M	+50% in Total O&M
Capital Costs ($) (x1000) year 0	2,034	2,034	2,034	2,034	2,034
Present Worth ($) Total O & M $ (x1000)	1,217	2,309	776	852	1,826
Total Present Worth $ (x1000)	3,251	4,343	2,810	2,886	3,860

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Table B-20 Alternative 4:
Complete Excavation and Off-Site Disposal
Capital costs

Cost Component	Cost Estimate	Basis of Estimate	Year Incurred
DIRECT CAPITAL COSTS			
1. Construction costs	$99,202	Site Preparation	1-2
	$824,772	Site Remediation	1-2
	$846,778	Site Restoration	1-2
Subtotal	$1,770,752		
2. Equipment costs			
3. Land and site development			
Subtotal	$0		
4.Buildings and services			
a. Equipment			
b. Labor			
c. Materials			
Subtotal	$0		
5.Relocation costs			
Subtotal	$0		
6. Disposal costs	$14,612,520	Off-site disposal	1-2
Subtotal	$14,612,520		
Total direct costs	$16,383,272		
INDIRECT CAPITAL COSTS			
1. Engineering and design			
a. Conventional Engineering	$2,457,491	15% of direct costs	1-2
b. License/permit costs	$1,638,327	10% of direct costs	1-2
2. Contingency allowance	$4,095,818	25% of direct costs	1-2
TOTAL INDIRECT COSTS	$8,191,636		1-2
TOTAL CAPITAL COSTS	$24,574,908		1-2

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Table B-21 Alternative 4:
Complete Excavation and Off-Site Disposal
Basis of Direct Cost Estimate

Cost Item: Direct Construction Costs
Basis: Excavation of Contaminated Soils and Sediments, Off-Site Disposal

Cost Component: Equipment, Labor and Materials

Description	Quantity	Unit Price	Total Costs
1. SITE PREPARATION			
a. Decontamination Facility	1	$60,000 /ea	$60,000
b. Silt Fencing	11,210 lf	$1.20 /lf	$13,452
c. Clearing & Grubbing	5 ac	$5,150 /ac	$25,750
Total Preparation			$99,202
2. SITE REMEDIATION			
a. Excavate Soils + Sediments	26,520 cy	$31.10 /cy	$824,772
Total Site Remediation			$824,772
3. SITE RESTORATION			
a. Clean Fill	18,890 cy	$14.17 /cy	$267,671
b. Loam	7,630 cy	$31.63 /cy	$241,337
c. Hydroseed	206 msf	$42.50 /msf	$8,755
d. Drainage Swale	5,722 sy	$57.50 /sy	$329,015
Total Restoration			$846,778
4. DISPOSAL			
a. Off-Site Facility	26,520 cy	$551.00 /cy	$14,612,520
Total Disposal			$14,612,520
Basis:			
1b. Fencing = 2(Lc+Wc+Ld+Wd) = 2(5135+40+400+30) = 11210 ft			
1c. Area = (LcxWc+LdxWd)/43560 sf/ac = (5135x40+400x30)/43560 = 5 acres			
2a. Volume = (FoxFs)(Vwc+Vsc+Vd)/27 cf/cy = (1.2x1.3)(189000+232000+26000)/27 = 26520 cy			
3a. Clean Fill Volume = "2a" - "3b" = 26,520-7,630 = 18,890 cy			
3b. Loam Volume = ""2a"/2 = 18,890/2 = 9,445 cy			
3c. Hydroseed Volume = (LcxWc)/1000 = (5,135x40)/1000 = 206 msf			
3d. Area = 2(LcxWds)/9 sf/sy = 2(5,135x5)/9 = 5,722 sy			
4a. Disposal Volume = "2a" = 15,260 cy			
TOTAL DIRECT COSTS			$16,383,272

4/1/94 Form B

Table B-22 Alternative: 4
Complete Excavation and Off-Site Disposal
Basis of Capital Cost Estimate

Cost Item:	Direct - Construction Costs
Cost Component:	Equipment, Labor & Material
Basis:	Excavation of Contaminated Soils and Sediments Off-Site Disposal or Off-Site Disposal
Calculation/Source:	R.S. Means Company, Inc. "Means Site Work and Landscape Data Cost Data, 11th Edition", Construction Publishers and Consultants, Kingston, MA, 1992. R.S. Means Company, Inc. "Means Heavy Construction Cost Data, 6th Edition", Construction Publishers and Consultants, Kingston, MA, 1993. R.S. Means Company, Inc. "Means Site Work and Landscape Data Cost Data, 12th Edition", Construction Publishers and Consultants, Kingston, MA, 1993. SAIC. 1992. "Feasibility Study Environmental Impact Statement for the Radioactive Contaminants at the Maywood Site," Prepared for the U.S. Department of Energy, Maywood, New Jersey, February 1992.

4/1/94 Form C

Table B-23 Alternative 4:
Complete Excavation and Off-Site Disposal
Annual Operating Costs

Cost Component	Estimate ($)	Basis of Estimate	Frequency	Year/ Period
DIRECT O & M COSTS				
1. Operating Labor				
a. Site Inspection	$0			0-30
b. Inspection Reports	$0			0-30
2. Maintenance: Materials and Labor	$0			0-30
3. Auxiliary: Materials and Labor	$0			
a.				
b.				
4. Purchased Service				
a.	$0			
b.				
TOTAL DIRECT COSTS	$0			
INDIRECT O & M COSTS				
1. Administration	$0	25% of direct costs	Annually	0-30
2. Insurance, Taxes Licenses				
a.	$0	25% of direct costs	Annually	0-30
b.				
3. Maintenance: Reserve and Contingency costs	$0	25% of direct costs	Annually	0-30
TOTAL INDIRECT COSTS	$0			
TOTAL O & M COSTS	$0			

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Table B-24 Alternative 4:
Complete Excavation and Off-Site Disposal
Cost Analysis Work Sheet
0% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	12,287	12,287	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Annual Expenditures, x (sum of lines 1 and 2)	12,287	12,287	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5. Present Worth (product of lines 3 and 4)	12,287	12,288	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3. Annual Expenditures, x (sum of lines 1 and 2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
5. Present Worth (product of lines 3 and 4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$ 24,575

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Form E

Table B-24 Alternative 4:
Complete Excavation and Off-Site Disposal
Cost Analysis Work Sheet
5% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	12287	12287	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Annual Expenditures, x (sum of lines 1 and 2)	12,287.0	12,287.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Discount Factor (annual discount rate = 5%)	1.0	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530	0.505	0.481
5. Present Worth (product of lines 3 and 4)	12,287.0	11,697.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

		17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3. Annual Expenditures, x (sum of lines 1 and 2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 5%)	0.458	0.436	0.416	0.369	0.377	0.359	0.342	0.326	0.310	0.295	0.281	0.268	0.255	0.243	0.231	
5. Present Worth (product of lines 3 and 4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$ 23,984

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Form F

Table B-24 Alternative 4:
Complete Excavation and Off-Site Disposal
Cost Analysis Work Sheet
10% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	12,287.5	12,287.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Annual Expenditures, x (sum of lines 1 and 2)	12,287.5	12,287.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Discount Factor (annual discount rate = 10%)	1.0	0.909	0.826	0.751	0.683	0.621	0.564	0.513	0.467	0.424	0.386	0.350	0.319	0.290	0.263	0.239
5. Present Worth (product of lines 3 and 4)	12,287.5	11,169.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3. Annual Expenditures, x (sum of lines 1 and 2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 10%)	0.218	0.198	0.180	0.164	0.149	0.135	0.123	0.112	0.101	0.092	0.084	0.076	0.069	0.063	0.057	
5. Present Worth (product of lines 3 and 4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$ 23,457

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Form G

Table B-25 Alternative 4:
Complete Excavation and Off-Site Disposal
Sensitivity Factors

Sensitivity Factor	Justification for Consideration	Range	Justification of Range
Present Worth	Changes in time value of money.	Annual Discount Rate: 0%,5%,10%	Per EECA guidance.
Increase in Contaminated Soil Volume	Lower Cleanup Guideline	+33%	Decrease from 100 pCi/g to 25 pCi/g

4/1/94 Form H

Table B-26 Alternative 4:

Complete Excavation and Off-Site Disposal

Summary of Sensitivity Analysis

Cost Factor	Baseline 5% Discount Rate	Sensitivity Factor Examined/Resulted		
		0% Discount Rate	10% Discount Rate	+33% Volume Increase @25 pCi/g
Capital Costs ($) (x1000) years 1-2	23,984	24,575	23,457	29,596
Present Worth ($) Total O & M $ (x1000)	0	0	0	0
Total Present Worth $ (x1000)	23,984	24,575	23,457	29,596

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Table B-27 Alternative 5:
Complete Excavation, Treatment and Off-Site Disposal
Capital costs

Cost Component	Cost Estimate	Basis of Estimate	Year Incurred
DIRECT CAPITAL COSTS			
1. Construction costs	$99,202	Site Preparation	1-2
	$10,637,172	Site Remediation	1-2
	$715,252	Site Restoration	1-2
Subtotal	$11,451,626		
2. Equipment costs			
3. Land and site development			
Subtotal	$0		
4.Buildings and services			
Subtotal	$0		
5.Relocation costs			
Subtotal	$0		
6. Disposal costs	$9,498,138	Off-site disposal	1-2
Subtotal	$9,498,138		
Total direct costs	$20,949,764		
INDIRECT CAPITAL COSTS			
1. Engineering and design			
a. Conventional Engineering	$3,142,465	15% of direct costs	1-2
b. License/permit costs	$2,094,976	10% of direct costs	1-2
2. Contingency allowance	$5,237,441	25% of direct costs	1-2
TOTAL INDIRECT COSTS	$10,474,882		1-2
TOTAL CAPITAL COSTS	$31,424,646		1-2

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Table B-28 Alternative 5:
Complete Excavation, Treatment and Off-Site Disposal
Basis of Direct Cost Estimate

Cost Item: Direct Construction Costs
Basis: Excavation and Treatment of Contaminated Soils & Sediments, Off-Site Disposal

Cost Component: Equipment, Labor and Materials

Description	Quantity		Unit Price		Total Costs
1. SITE PREPARATION					
a. Decontamination Facility	1		$60,000	/ea	$60,000
b. Silt Fencing	11,210	lf	$1.20	/lf	$13,452
c. Clearing & Grubbing	5	ac	$5,150	/ac	$25,750
Total Preparation					$99,202
2. SITE REMEDIATION					
a. Excavate Soils + Sediments	26,520	cy	$31.10	/cy	$824,772
b. Treatment of Soils & Sediments	26,520	cy	$370	/cy	$9,812,400
Total Remediation					$10,637,172
3. SITE RESTORATION					
a. Clean Fill	9,608	cy	$14.17	/cy	$136,145
b. Loam	7,630	cy	$31.63	/cy	$241,337
c. Hydroseed	206	msf	$42.50	/msf	$8,755
d. Drainage Swale	5,722	sy	$57.50	/sy	$329,015
Total Restoration					$715,252
4. DISPOSAL					
a. Off-Site facility	17,238	cy *	$551.00	/cy	$9,498,138
Total Disposal					$9,498,138
Basis:					
(See Table B-14)					
3a. Clean Fill Volume = ((0.65)("7b") - "3b") = 0.65(26520) - 7630 = 9610 cy					
TOTAL DIRECT COSTS					$20,949,764

* Based on 35% soil volume reduction with treatment by soil washing.

Form B
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Table B-29 Alternative: 5
Complete Excavation, Treatment and Off-Site Disposal
Basis of Capital Cost Estimate

Cost Item:	Direct - Construction Costs
Cost Component:	Equipment, Labor & Material
Basis:	Excavation of Contaminated Soils and Sediments,
	Treatment of Contaminated Soils & Sediments,
	with Off-Site Disposal
Calculation/Source:	"Means Site Work Cost Data" 1991, 10th Edition
	"Means Heavy Construction Cost Data," 1992, 6th Edition
	"Means Site Work Cost Data" 1992, 11th Edition
	Maywood Feasibility Study, 1992

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Table B-30 Alternative 5:
Complete Excavation, Treatment and Off-Site Disposal
Annual Operating Costs

Cost Component	Estimate ($)	Basis of Estimate	Frequency	Year/ Period
DIRECT O & M COSTS				
1. Operating Labor				
a. Operate equipment	$305,760	8736 x $35/hr.		1-2
2. Maintenance: Materials & Labor	$112,500	22,500 tons x 5$/ton (Maintenance of Equipment)	Annually	1-2
3. Auxiliary: Materials and Labor	$0			
a.				
b.				
4. Purchased Service				
a. Electricity	$46,600	582,400 kw-hr x .08 $/kw-hr		1-2
b.				
TOTAL DIRECT COSTS	$464,860			
INDIRECT O & M COSTS				
1. Administration	$116,215	25% of direct costs	Annually	1-2
2. Insurance, Taxes Licenses				
a.	$116,215	25% of direct costs	Annually	1-2
b.				
3. Maintenance: Reserve and Contingency costs	$116,215	25% of direct costs	Annually	1-2
TOTAL INDIRECT COSTS	$348,645			
TOTAL O & M COSTS	$813,505			

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Table B-31 Alternative 5:
Complete Excavation, Treatment and Off-Site Disposal
Cost Analysis Work Sheet
0% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	15,712.2	15,712.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	813.51	813.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Annual Expenditures, x (sum of lines 1 and 2)	16,525.8	16,525.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5. Present Worth (product of lines 3 and 4)	16,525.8	16,525.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3. Annual Expenditures, x (sum of lines 1 and 2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 0%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
5. Present Worth (product of lines 3 and 4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$ 33,052

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Form E

Table B-31 Alternative 5:
Complete Excavation, Treatment and Off-Site Disposal
Cost Analysis Work Sheet
5% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	15,712.3	15,712.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. O & M Costs	813.51	813.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Annual Expenditures, x (sum of lines 1 and 2)	16,525.8	16,525.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Discount Factor (annual discount rate = 5%)	1.0	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645	0.614	0.585	0.557	0.530	0.505	0.481
5. Present Worth (product of lines 3 and 4)	16,525.8	15,732.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3. Annual Expenditures, x (sum of lines 1 and 2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 5%)	0.458	0.436	0.416	0.369	0.377	0.359	0.342	0.326	0.310	0.295	0.281	0.268	0.255	0.243	0.231	
5. Present Worth (product of lines 3 and 4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$ 32,258

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Form F

Table B-31 Alternative 5:
Complete Excavation, Treatment and Off-Site Disposal
Cost Analysis Work Sheet
10% Annual Discount Rate

	Cost/Year Cost Occurs (thousands of dollars)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Capital Costs	15,712.2	15,712.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. O & M Costs	813.51	813.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Annual Expenditures, x (sum of lines 1 and 2)	16,525.8	16,525.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4. Discount Factor (annual discount rate = 10%)	1.0	0.909	0.826	0.751	0.683	0.621	0.564	0.513	0.467	0.424	0.386	0.350	0.319	0.290	0.263	0.239
5. Present Worth (product of lines 3 and 4)	16,525.8	15,022.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
1. Capital Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. O & M Costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
3. Annual Expenditures, x (sum of lines 1 and 2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Total Present Worth ($1000)
4. Discount Factor (annual discount rate = 10%)	0.218	0.198	0.180	0.164	0.149	0.135	0.123	0.112	0.101	0.092	0.084	0.076	0.069	0.063	0.057	
5. Present Worth (product of lines 3 and 4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	$ 31,548

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Form G

Table B-32 Alternative 5:
Complete Excavation, Treatment and Off-Site Disposal
Sensitivity Factors

Sensitivity Factor	Justification for Consideration	Range	Justification of Range
Present Worth	Changes in time value of money.	0%, 5%,10%	Per EECA guidance.
O&M Costs	Changes in monitoring program.	-30%, + 50%	Decrease/increase in number of samples collected.
Increase in Contaminated Soil Volume	Lower cleanup guideline	+33%	Decrease from 100 p Ci/g to 25 p Ci/g
Treatment Costs	Lower treatment costs from $15/cf to $5/cf	-67%	Per vendor data

Table B-33 Alternative 5:

Complete Excavation, Treatment and Off-Site Disposal

Summary of Sensitivity Analysis

Cost Factor	Baseline 5% Discount Rate	Sensitivity Factor Examined/Resulted					
		0% Discount Rate	10% Discount Rate	-30% in Total O&M	+50% in Total O&M	+33% Volume Increase @ 25 p Ci/g	-67% in Treatment $/cf
Capital Costs ($) (x1000) years 1-2	30,670	31,425	29,995	30,670	30,670	38,051	21,519
Present Worth ($) Total O & M $ (x1000)	1,588	1,627	1,553	1,112	2,382	1,253	1,588
Total Present Worth $ (x1000)	32,258	33,052	31,548	31,782	33,052	39,303	23,134

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Form I

APPENDIX B REFERENCES

BNI. 1989. "Conceptual Design Report for a Permanent Disposal Site for FUSRAP Wastes, Bechtel National, Inc., April 1989.

DOE. 1992a. "Remedial Investigation/Feasibility Study, Operable Unit 9, Site Wide Work Plan" Draft Final (Revision 4), U.S. Department of Energy, February 1992.

DOE. 1992b. "Federal Manual for Identifying and Delineating Wetlands," U.S. Department of Energy, 1992.

DOE 1992c. "Choices II: Exploring Remedial Action Alternatives Interchange," U.S. Department of Energy, Oak Ridge, TN. September 15-16, 1992.

EG&G. 1992. "Conceptual Design Report for the Off Site Drainage Containment," EG&G Mound Applied Technologies, Inc., Mound Plant, Miamisburg, Ohio, February 1992.

EPA. 1987. "Remedial Action Costing Procedures Manual," EPA/600/8-87/049, October 1987.

Means. 1992 and 1993. "Heavy Construction Cost Data," Means.