R-010-203.4

ENGINEERING EVALUATION/COST ANALYSIS WASTE PIT AREA STORMWATER RUNOFF CONTROL AUGUST 1990

DOCUMENT DATE 08-01-90

[redacted] 451

ENGINEERING EVALUATION/ COST ANALYSIS WASTE PIT AREA STORM WATER RUNOFF CONTROL

FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

August 1990

U. S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

457

Engineering Evaluation/Cost Analysis
Waste Pit Area
Storm Water Runoff Control

FEED MATERIALS PRODUCTION CENTER
Fernald, Ohio

Prepared for
U.S. Department of Energy
Oak Ridge Operations Office

Prepared by

Advanced Sciences, Inc.
International Technology Corporation

August 1990

FMPC-0002-5

TABLE OF CONTENTS

	PAGE
List of Tables	v
List of Figures	vi
List of Acronyms	vii
Distribution List	ix
Executive Summary	ES-1
1.0 Introduction	1-1
2.0 Site Characterization	2-1
2.1 Site Background	2-1
2.1.1 Waste Storage Area Description	2-3
2.1.2 Environmental Impacts of Waste Storage Area	2-7
2.1.3 FMPC Effluent	2-7
2.2 Site Setting	2-9
2.2.1 Climate	2-9
2.2.2 Surface Water Hydrology	2-9
2.2.3 Groundwater Hydrology	2-11
2.2.4 Soils	2-12
2.2.5 Vegetation and Wildlife	2-12
2.2.6 Land Use and Population	2-15
2.3 Analytical Data	2-16
2.3.1 Introduction	2-16
2.3.2 Analytical Results	2-24
2.3.3 Summary	2-29
2.4 Site Conditions That Justify A Removal Action	2-31
2.4.1 Release Mechanisms	2-32
2.4.2 Environmental Fate	2-32
2.4.3 Potential Risks	2-33
3.0 Removal Action Objectives	3-1
3.1 Response Authority	3-1
3.2 Scope and Purpose	3-1
3.3 Compliance With Applicable or Relevant and Appropriate Requirements and Other Criteria, Advisories, and Guidance to be Considered	3-2

TABLE OF CONTENTS (Continued)

		PAGE
4.0	Removal Action Alternatives	4-1
4.1	Development of Initial Alternatives	4-1
4.2	Description of Removal Action Alternatives	4-1
4.2.1	Alternative 1 - No Action	4-2
4.2.2	Alternative 2 - Surface Capping	4-2
4.2.3	Alternative 3 - Surface Capping with Lateral Drainage Sump Collection	4-5
4.2.4	Alternative 4 - Runoff Collection and Treatment	4-8
4.2.5	Alternative 5 - Source Removal	4-11
4.3	Screening of Alternatives	4-14
5.0	Evaluation of Alternatives	5-1
5.1	Evaluation Criteria	5-1
5.1.1	Effectiveness	5-1
5.1.2	Implementability	5-4
5.1.3	Cost	5-4
5.2	Alternative 1 - No Action	5-5
5.2.1	Effectiveness: Public Health	5-5
5.2.2	Effectiveness: Environmental	5-7
5.2.3	Effectiveness: Reduction in Toxicity/Mobility/Volume	5-8
5.2.4	Effectiveness: Consistency with Final Action	5-8
5.2.5	Effectiveness: Other Factors	5-8
5.2.6	Implementability: Technical Feasibility	5-8
5.2.7	Implementability: Administrative Feasibility	5-8
5.2.8	Implementability: Timeliness	5-8
5.2.9	Cost	5-8
5.3	Alternative 2 - Capping	5-9
5.3.1	Effectiveness: Public Health	5-9
5.3.2	Effectiveness: Environmental	5-9
5.3.3	Effectiveness: Reduction in Toxicity/Mobility/Volume	5-10
5.3.4	Effectiveness: Consistency with Final Action	5-10
5.3.5	Effectiveness: Other Factors	5-11
5.3.6	Implementability: Technical Feasibility	5-11
5.3.7	Implementability: Administrative Feasibility	5-11
5.3.8	Implementability: Timeliness	5-12
5.3.9	Cost	5-12

TABLE OF CONTENTS (Continued)

		PAGE
5.4	Alternative 4 - Runoff Collection and Treatment	5-12
5.4.1	Effectiveness: Public Health	5-12
5.4.2	Effectiveness: Environmental	5-13
5.4.3	Effectiveness: Reduction in Toxicity/Mobility/Volume	5-15
5.4.4	Effectiveness: Consistency with Final Action	5-15
5.4.5	Effectiveness: Other Factors	5-16
5.4.6	Implementability: Technical Feasibility	5-16
5.4.7	Implementability: Administrative Feasibility	5-17
5.4.8	Implementability: Timeliness	5-17
5.4.9	Cost	5-17
5.5	Requirements Potentially Applicable or Relevant and Appropriate to the Proposed Actions and Other Criteria, Advisories, and Guidance to be Considered	5-18
5.5.1	Contaminant-Specific ARARs	5-18
5.5.2	Location-Specific ARARs	5-18
5.5.3	Action-Specific ARARs	5-24
5.5.4	TBCs	5-25
6.0	Selection of Preferred Alternative	6-1
6.1	Elimination of Nonresponsive Alternatives	6-1
6.2	Comparative Evaluation	6-1
6.3	Preferred Alternative	6-5
References		
Appendix A - Operable Units 1 and 5 Alternatives Recommended for Detailed Analysis		A-1
Appendix B - Radionuclides Discharge at 001		B-1
Appendix C - Rick Assessment		C-1
Appendix D - Cost Estimate for Alternatives		D-1
Appendix E - Present Worth Calculation		E-1

LIST OF TABLES

Table		Page
ES-1	Summary of Evaluation of Alternatives After Initial Screening	ES-6
2-1	WMCO Data for Surface Water Runoff	2-17
2-2	Weston Data for Surface Water Runoff	2-19
2-3	ASI/IT Data for Surface Water Runoff	2-21
2-4	Dames & Moore Data for Surface Water Runoff	2-23
5-1	Uranium Concentrations: Filtered versus Unfiltered Samples	5-14
5-2	Applicable or Relevant and Appropriate Requirements and Other Criteria, Advisories, and Guidance to be Considered for the Waste Pit Area Storm Water Runoff Control	5-19
6-1	Summary of Evaluation of Alternatives After Initial Screening	6-2

457

LIST OF FIGURES

Figure		Page
2-1	FMPC Site and Vicinity	2-2
2-2	FMPC General Layout	2-4
2-3	Topography Map, Waste Storage Area	(end pocket)
2-4	Waste Storage Area	2-5
2-5	Wetlands Delineated in Waste Pit Area	2-14
2-6	Storm Water Runoff Sample Locations	(end pocket)
4-1	Alternative 2 - Surface Capping	4-3
4-2	Alternative 2 - Cover Profile	4-6
4-3	Alternative 3 - Capping with Subsurface Drainage Collection	4-7
4-4	Alternative 4 - Runoff Collection and Treatment	(end pocket)
4-5	Alternative 4 - Process Flow Diagram	(end pocket)
4-6	Block Flow Diagram - Existing Flow Configuration Through Demonstration Biodenitrification Facility	4-12
4-7	Block Flow Diagram, Alternative 4 - Proposed Flow Configuration Through Production Biodenitrification Facility	4-13

LIST OF ACRONYMS

AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ARAR	Applicable or Relevant and Appropriate Requirement
ASI	Advanced Sciences, Inc.
AWQC	Ambient Water Quality Criteria
AWWT	Advanced Wastewater Treatment
BAT	Best Available Technology
BDN	Biodenitrification
BMP	Best Management Practices
BSL	Biodenitrification Surge Lagoon
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COE	U.S. Corps of Engineers
CRP	Chlorosulfanated Reinforced Polyethylene
DCGs	Derived Concentration Guides
DOE	Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FEMA	U.S. Federal Emergency Management Agency
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
GPM	Gallons Per Minute
HI	Hazard Index
HSL	Hazardous Substance List
IT	International Technology Corp.
MCL	Maximum Contaminant Level
MCLGs	Maximum Contaminant Level Goals
NCP	National Contingency Plan
NEPA	National Environmental Policy Act of 1969
NLO	National Lead Company of Ohio
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
O&M	Operations and Maintenance

OAC	Ohio Administrative Code
OSHA	Occupational Safety and Health Administration
PFD	Process Flow Diagram
RFD	Reference Dose
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Concentration Level
SOWC	Southwest Ohio Water Company
TBC	To Be Considered
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TSS	Total Suspended Solids
USGS	U.S. Geological Survey
Weston	Roy F. Weston, Inc.
WMCO	Westinghouse Materials Company of Ohio

DISTRIBUTION LIST

Project Director - John Wood, Fernald
Project Technical Director - John Razor, Fernald
Technical Manager - Bob Galbraith, Fernald
Responsible Operable Unit/Task Managers - Dave Harmer, Knoxville
Robin Smith, Pittsburgh
Sam Wolinsky, Fernald
Dan Smith, Oak Ridge
Mike Higgins, Knoxville

Project QA Officer - Larry Sexton, Fernald
Technical QA Officer - Don Mack, Knoxville
Community Relations Coordinator - Sue Wolinsky, Fernald
NEPA Office - Fernald
Site Project Files - Fernald
IT-Monroeville Project Central Files
IT-Knoxville Project Central Files
ASI-Oak Ridge Project Files

DOE COR - Bobby Davis, Fernald
WMCO - Pat Hopper, Fernald
Lee Wan & Associates - Fred Haywood, Fernald

DOE-HQ - Randi Allen, Washington, DC
Carolyn Osborne
Lisa Feldt

EPA, Region 5 - Catherine McCord, Chicago
OEPA - Graham Mitchell, Dayton

FMPC-0002-5
August 10, 1990

EXECUTIVE SUMMARY

The U.S. Atomic Energy Commission (AEC), predecessor to the U.S. Department of Energy (DOE), established a production complex in the early 1950s for processing uranium and its compounds from natural uranium ore concentrates. This complex, known as the Feed Materials Production Center (FMPC), is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. The villages of Fernald, Ross, New Haven, and Shandon are all located within a few miles of the plant.

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by DOE and the U.S. Environmental Protection Agency (EPA). This agreement pertains to environmental impacts associated with the extended years of operation at the FMPC. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented. In April 1990, DOE and EPA signed a CERCLA Consent Agreement that supercedes the FFCA.

In response to the FFCA and consistent with the modifications agreed to in April 1990, a Remedial Investigation/Feasibility Study (RI/FS) is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The technical strategy adopted for the RI/FS is to issue distinct RI/FS reports for each of five identified operable units at the FMPC.

One of the operable units (Operable Unit 1) includes those facilities utilized for the storage/disposal of radiological and chemical wastes from FMPC operations. Related facilities that now contain similar waste types are also included. These facilities include Waste Pits 1, 2, 3, 4, 5, and 6; the burn pit; and the Clearwell. Analytical results indicate that elevated concentrations of uranium are present in the storm water runoff from the waste pit area and adjacent areas. Because of the associated potential threat to human health and the environment, DOE is pursuing a removal action to control the storm water runoff from these areas pending the outcome of the RI/FS and the implementation of a final remedial action for the waste storage units.

Removal actions, as described in the National Contingency Plan, (NCP) of April 1990 (55 Federal Register 8666), are primarily intended to abate, prevent, minimize, stabilize, mitigate, or eliminate a

release or a threat of release prior to a final action if there were a threat to public health or welfare or the environment. In this case, a planning period of at least six months exists before on-site removal action activities would be initiated; therefore, DOE conducted this engineering evaluation/cost analysis (EE/CA) to analyze removal action alternatives and to support the selection of a preferred alternative. This document represents the EE/CA for the waste pit area removal action at the FMPC and will be used by DOE as the basis for selection of the removal action.

The scope for this removal action can be broadly defined as management of radioactively contaminated storm water runoff from the waste pit area. The area includes six waste pits, a burn pit, four concrete silos, the Clearwell, and surrounding areas of approximately 20 acres. Storm water data collected to date from the site drainage ditches in this area indicate the presence of radionuclides and inorganic metals in the storm water runoff from the waste pits and perimeter areas. Most of the radionuclides are normally present at natural background concentrations. Several of the parameters exceed established concentration guidelines or limits, but most exceedances are sporadic and within the range of uncertainty in the data. Based on the data results, uranium has been designated as the contaminant of concern for the waste pit area removal action.

The fundamental objective of the removal action is to protect public health and the environment by controlling the release of storm water runoff with uranium concentrations exceeding the proposed DOE-derived concentration guides (DCGs) for surface water discharge. Related objectives, founded on other risk-based levels for various potential exposure scenarios, include the protection of biotic environments in Paddys Run and the mitigation of contaminants from surface water to the underlying aquifer.

Based on the study objective of controlling the release of contaminated storm water runoff from the waste pit area to Paddys Run, the following five alternatives were developed as the initial set of alternatives for the waste pit area removal action:

- Alternative 1 - No Action
- Alternative 2 - Surface Capping
- Alternative 3 - Surface Capping with Lateral Drainage Sump Collection
- Alternative 4 - Runoff Collection and Treatment
- Alternative 5 - Source Removal

Although not required, based on U.S. EPA draft Guidance dated March 1988, the no-action alternative has been included for comparison purposes. A brief description of each proposed removal action is provided in the following paragraphs.

Alternative 1 - No Action

Under the no-action alternative, no additional abatement, remediation, treatment, or security activities would occur at the waste pit area. Any reduction in contamination would be brought about by natural phenomena such as radioactive decay and removal of contaminated soil through erosion.

Alternative 2 - Surface Capping

This alternative consists of constructing a cap over surface areas to minimize the contact of rainwater with the contaminated soil. These areas include Waste Pits 1, 2, 3, 5, and 6; the burn pit; and surface areas southeast of the pits. The site would be graded to provide proper drainage. The majority of the water would be routed away from the waste pit area for direct discharge into Paddys Run. In order to maximize the effectiveness of this alternative, three subalternatives were considered: 1) a compacted clay cap, 2) a synthetic liner cap, and 3) a Resource Conservation and Recovery (RCRA) cap. Based on technical and cost decision factors, (see below) the synthetic liner cap was selected as the capping alternative of choice.

Cost and Technical Factors

Cap Type	Cost ($)	Completion	Infiltration Volume (ft^3)
Clay	874,300	24 in. thick compactor clay	37,843
Liner	1,660,800	20 mil. liner	16,117
RCRA	2,535,100	24 in. thick compacted clay and 20 mil. liner	513

Alternative 3 - Surface Capping with Lateral Drainage Sump Collection

The surface capping with lateral drainage incorporates the components of Alternative 2 with a lateral drainage collection sump. This alternative would intercept all subsurface lateral flow resulting from infiltration through the cap from rainfall. The flow would be collected in a six-inch trench downgradient from the cap. The trench would be sloped to a central collection sump. Lateral flow would be pumped out of the sump on a semiannual basis from a riser pipe to the Biodenitrification Surge Lagoon. Suspended solids would settle here prior to treatment through the biodenitrification towers and effluent water treatment system. The treated water then would be

discharged to the Great Miami River through Manhole 175. The use of the combined cap and collection sump would eliminate the potential release of contaminated infiltrated rainwater from reaching Paddys Run.

Alternative 4 - Runoff Collection and Treatment

This alternative incorporates planned separation of drainage areas within the waste pit storage area, thus isolating contaminated from noncontaminated storm water runoff. Contaminated water would be collected in the existing Clearwell and in a new collection sump and pumping station that would be located south of the Clearwell. Drainage flow control devices would be installed in upstream drainage channels located in the waste pit area to restrict peak flows to the new pumping station. The new system would pump the collected runoff to the Biodenitrification Surge Lagoon where suspended solids would be allowed to settle prior to treatment through the biodenitrification towers and effluent water treatment system and before discharge to the Great Miami River through Manhole 175. A pilot scale waste water treatment system also would be installed to demonstrate technologies applicable to the Advanced Waste Water Treatment System (AWWT) that would be installed in the future. The demonstration system would treat 10 gpm of wastewater discharged from the Biodenitrification Surge Lagoon.

Alternative 5 - Source Removal

This source removal alternative would consist of removing all disposed waste and contaminated berm and cover soils and regrading the site with clean fill. An estimated 444,500 cubic yards of waste and 58,900 cubic yards of contaminated soil would have to be excavated, packaged in waste disposal boxes, and disposed of at an approved facility. The removal of the source would eliminate the threat of contaminated runoff entering Paddys Run via the waste pit area.

Summary

These five alternatives for the storm water runoff removal action were subjected to a screening to ascertain if any could be eliminated from further consideration prior to the detailed evaluation phase. The capping alternative and the runoff collection and treatment alternative were judged to be effective and implementable as removal actions and to warrant further evaluation in this EE/CA. The no-action alternative was further evaluated as a baseline. The effectiveness introduced by the lateral drainage collection system in Alternative 3 was considered questionable due to a potential problem with infiltration moving vertically and not being collected. The effectiveness was considered insufficient to offset the increased cost and time required for its implementation. Also,

while fully effective in meeting the removal action objectives, Alternative 5, waste removal, far exceeds the scope of the other removal action alternatives. However, it remains as a candidate for long-term remediation of the waste storage area under the Operable Unit 1 RI/FS. Alternative 5 is carried as one of the recommended alternatives in the Operable Unit 1 Initial Screening of Alternatives RI/FS Report. Implementing of this alternative essentially would constitute final remediation of Operable Unit 1 that is now being evaluated in the FMPC RI/FS process under CERCLA guidelines.

Alternatives 1, 2, and 4 were then evaluated according to the following criteria:

- Effectiveness
- Implementability
- Cost

The components of the effectiveness criterion include public health protection; environmental protection; the degree to which the toxicity, mobility, or volume of the contaminants in the storm water runoff would be reduced; the consistency of the alternative with the final remedial action alternatives under consideration for the waste pit area; and other miscellaneous factors important to the overall effectiveness of the action.

Factors of implementability considered for the detailed evaluation include technical feasibility (including the availability of applicable technologies) and administrative feasibility. A third evaluation component, timeliness, was also considered due to the strong preference for removal actions that can be designed and implemented in a minimum amount of time to satisfy both the desires and commitments of the involved agencies.

The total cost of an alternative is the final factor considered. This factor includes direct capital costs, indirect capital costs, and any postremoval operation and maintenance costs. A summary of this evaluation is presented in Table ES-1.

As shown in Table ES-1, the no-action alternative is a deficient response action in relation to several factors. First and foremost is the continued release of storm water runoff with uranium concentrations exceeding DOE DCGs, resulting in noncompliance with the guidelines to be considered (TBC) that establish the concentration of uranium that provide protection for a hypothetical maximally exposed individual. Also, the no-action alternative would prolong any

TABLE ES-1

SUMMARY OF EVALUATION OF ALTERNATIVES AFTER INITIAL SCREENING

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Effectiveness: Public Health	Does not meet TBC for max. exposed individual; no imminent & substantial risk	All exposure pathways within acceptable risk limits ($< 10^{-5}$)	All exposure pathways within acceptable risk limits ($< 10^{-7}$)
Effectiveness: Environmental	No decrease in uranium loading to Paddys Run; continuation of any current impacts	Significant reduction in uranium loading to Paddys Run; overall improvement elsewhere; potential wetlands impact	Total reduction in uranium loading to Paddys Run; little improvement elsewhere; potential wetlands impacts
Effectiveness: Reduction In Toxicity, Mobility, Volume	No reduction in toxicity, mobility, or volume	Significant reduction in uranium concentration and loading in runoff	No reduction in volume of contaminanted runoff prior to treatment; "End of Pipe" treatment varies with time
Effectiveness: Consistency with final action	No effect on alternatives recommended for final action.	Not consistent with alternatives recommended for detailed analysis for Operable Units 1 and 5 unless capping is selected.	Consistent with all alternatives recommended for detailed analysis for Operable Units 1 and 5
Effectiveness: Other factors	None	Reduction in infiltration and leaching potential	No reliance on controlling the source of contaminants in runoff

16

457

TABLE ES-1 - CONTINUED

SUMMARY OF EVALUATION OF ALTERNATIVES AFTER INITIAL SCREENING

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Implementability: Technical Feasibility	Not Applicable	Straightforward, with readily available labor and materials; special conditions require consideration	Straightforward, with readily available labor and materials; special conditions require consideration
Implementability: Administrative Feasibility	Maintains conditions exceeding DOE limits; inconsistent with previous decision to collect runoff.	No permits required for on-site actions; however, requirements for wetlands must be met	No permits required for on-site actions; however, requirements for wetlands must be met
Implementability: Timeliness	No time element involved	Design required; construction period of approximately 12 months	Design complete; construction period of approximately 10 months
Cost (Present Worth) (I = 10%)	$0	$6,862,300	$4,228,400

environmental impacts associated with the release. The contribution of uranium to the regional aquifer via leakage from Paddys Run would also remain at its current level if no action is taken to reduce the uranium loading to Paddys Run. For these reasons, the no-action alternative is eliminated from further consideration.

In the detailed analysis, both Alternatives 2 and 4 are shown to satisfy the important public health protection criterion. Both alternatives also satisfy the objective of reducing the uranium loadings to Paddys Run for purposes of protecting the aquatic environment of the stream and the aquifer, with the collection and treatment option providing a higher level of protection since no residual loadings are associated with this alternative. However, overall environmental improvement would be better satisfied by the capping alternative since it also would protect (by eliminating runoff contact with the source of contamination) the local environments downstream from the waste pit area and upstream from Paddys Run. As a result, the precipitation and waste would not mix, resulting in migration of contaminated runoff to local environments. This would be accomplished since contaminated runoff would no longer flow through to Paddys Run and drainage ways downstream of the waste pit area. The capping alternative also has the advantage of preventing the generation of additional waste by precluding contact with the waste area, rather than providing for its treatment after the contamination occurs.

The collection and treatment alternative is expected to be consistent with the final remedial actions for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5). Although final actions have not been selected for these operable units, evaluation of the consistency of the removal action was performed considering the various proposed remedial actions. This CERCLA-based requirement, as well as the requirement to abate a release or threat of release, for a removal action is not, however, satisfied by the capping alternative. Implementation of the capping alternative would prejudice the final remediation of Operable Unit 1. By implementing a capping removal action the final Record of Decision for Operable Unit 1 would either have to include capping as the final action or deal with the additional wastes that would be created by capping activities. See Appendix A for listings of potential final remedial action alternatives for Operable Units 1 and 5.

Neither alternative would result in a significant public health or environmental concern due to temporary system failures or disruptions.

Conditions that would require special attention during both the engineering and construction activities are associated with both the capping and the collection and treatment alternatives. Again, however, none of these conditions are insurmountable constraints to the technical feasibility of the alternative and are not considered to represent a critical decision factor.

The collection and treatment alternative is also preferential from a timeliness standpoint. This option has been considered as part of the Best Management Practices (BMP) Plan at the site and design is already completed. In addition, the construction time is less than that estimated for the capping option.

The present worth cost of the capping alternative has been estimated to be approximately $6,862,300 while the cost of the collection and treatment alternative is estimated to be $4,228,400.

Based on the comparative evaluation of the capping and the collection and treatment alternatives, there are several factors that favor the collection and treatment alternative as the preferred removal action for the storm water runoff from the waste pit area. First, it is protective of human health and the environment. Second, the collection and treatment alternative is consistent with all final remedies being considered for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5), as listed in Appendix A. Any work that would be done on or around the waste pits would require implementation of runoff control actions. This is not only necessary for work in hazardous areas, but is also required for standard construction projects requiring earthwork. Third, the time for completion of the alternative is shorter than the capping alternative. Fourth, this alternative provides an effective solution for approximately one-half the cost of the capping alternative.

1.0 INTRODUCTION

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (U.S. EPA) for DOE's Feed Materials Production Center (FMPC) in Fernald, Ohio. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented. In April 1990, DOE and EPA signed a CERCLA Consent Agreement that supersedes the FFCA.

In response to the FFCA and consistent with the modifications agreed to in April 1990, a Remedial Investigation/Feasibility Study (RI/FS) is in progress pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The technical strategy adopted for the RI/FS is to issue distinct RI/FS reports for each of five identified operable units for the FMPC. By accommodating separate schedules for each operable unit, the remedial action decision process is proceeding to completion for the most problematic units while data collection and analysis continue for other operable units.

One of the operable units (Operable Unit 1) includes those facilities utilized for the storage/disposal of radiological and chemical wastes from FMPC operations. Related facilities that now contain similar waste types are also included. These facilities include Waste Pits 1, 2, 3, 4, 5, and 6; the burn pit; and the Clearwell. Analytical results indicate that elevated concentrations of uranium are present in the storm water runoff from the waste pit area and adjacent areas. Because of the associated potential threat to human health and the environment, DOE is pursuing a removal action to control the storm water runoff from these areas pending the outcome of the RI/FS and the implementation of a final remedial action for the waste storage units.

Removal actions, as described in the National Contingency Plan, (NCP) of April 1990 (55 Federal Register 8666), are primarily intended to abate, prevent, minimize, stabilize, mitigate, or eliminate a release or a threat of release prior to a final action if there is a threat to public health or welfare or the environment. A second reason for implementing a removal action is to mitigate contaminant migration pending final action if site conditions permit a straightforward mitigative action, and significant migration would occur in the interim if no action is taken. Additionally, removal actions are to be consistent with the anticipated long-term remedial action and to contribute to the efficient performance of the long-term remedy to the extent practicable.

In this case, a planning period of at least six months is available before on-site removal action activities will be initiated; therefore, DOE conducted this engineering evaluation/cost analysis (EE/CA) to analyze removal action alternatives and to support the selection of a preferred alternative. This document represents the EE/CA for the waste pit area removal action at the FMPC. The National Environmental Policy Act of 1969 and implementing regulations at 40 CFR 1500-1508 (NEPA) require that federal agencies include in their decision-making processes appropriate and careful consideration of all possible environmental and social effects of proposed actions, such as the alternative removal actions considered in this EE/CA. DOE Order 5400.4 directs the integration of environmental compliance process required by CERCLA and NEPA. Therefore, this EE/CA has been prepared to integrate the requirements of CERCLA/NEPA and will be used by DOE as the basis for selection of the removal actions.

2.0 SITE CHARACTERIZATION

2.1 SITE BACKGROUND

The U.S. Atomic Energy Commission (AEC), predecessor to the DOE, established the FMPC for processing uranium and its compounds from natural uranium ore concentrates for government needs. This integrated production complex began operations in the early 1950s. In 1951, National Lead Company of Ohio (now NLO, Inc.) entered into contract with the AEC as Operations and Maintenance (O&M) Contractor. This contractual relationship lasted until January 1, 1986. Westinghouse Materials Company of Ohio (WMCO), a wholly-owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities of the site operations and facilities for a minimum five-year period.

The FMPC site is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. The production area is limited to an approximate 136-acre tract near the center of the FMPC site. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant (Figure 2-1).

A variety of chemical and metallurgical processes are utilized at the FMPC for the manufacture of uranium products. High-quality uranium compounds are introduced into the manufacturing process at several points. Impure feed materials are dissolved in nitric acid and the uranium is purified through solvent extraction to yield a solution of uranyl nitrate. Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced with hydrogen to uranium dioxide (UO_2) and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined reduction vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot. Various uranium metal-working processes also exist.

Large quantities of liquid and solid wastes are generated by the various operations at the FMPC. Solid waste materials associated with uranium metals production are presently stored on site in steel drums awaiting further processing or off-site disposal at approved facilities. These wastes include off-specification UF_4 or thorium tetrafluoride (ThF_4), reject UO_3 oils, sludges, contaminated combustibles, and filter cake. The drums sit on various pads and/or in warehouses and are inspected on a weekly basis. Contents of deteriorated drums are repackaged. Other stored waste materials include spent degreasing solvents and PCB-contaminated material.

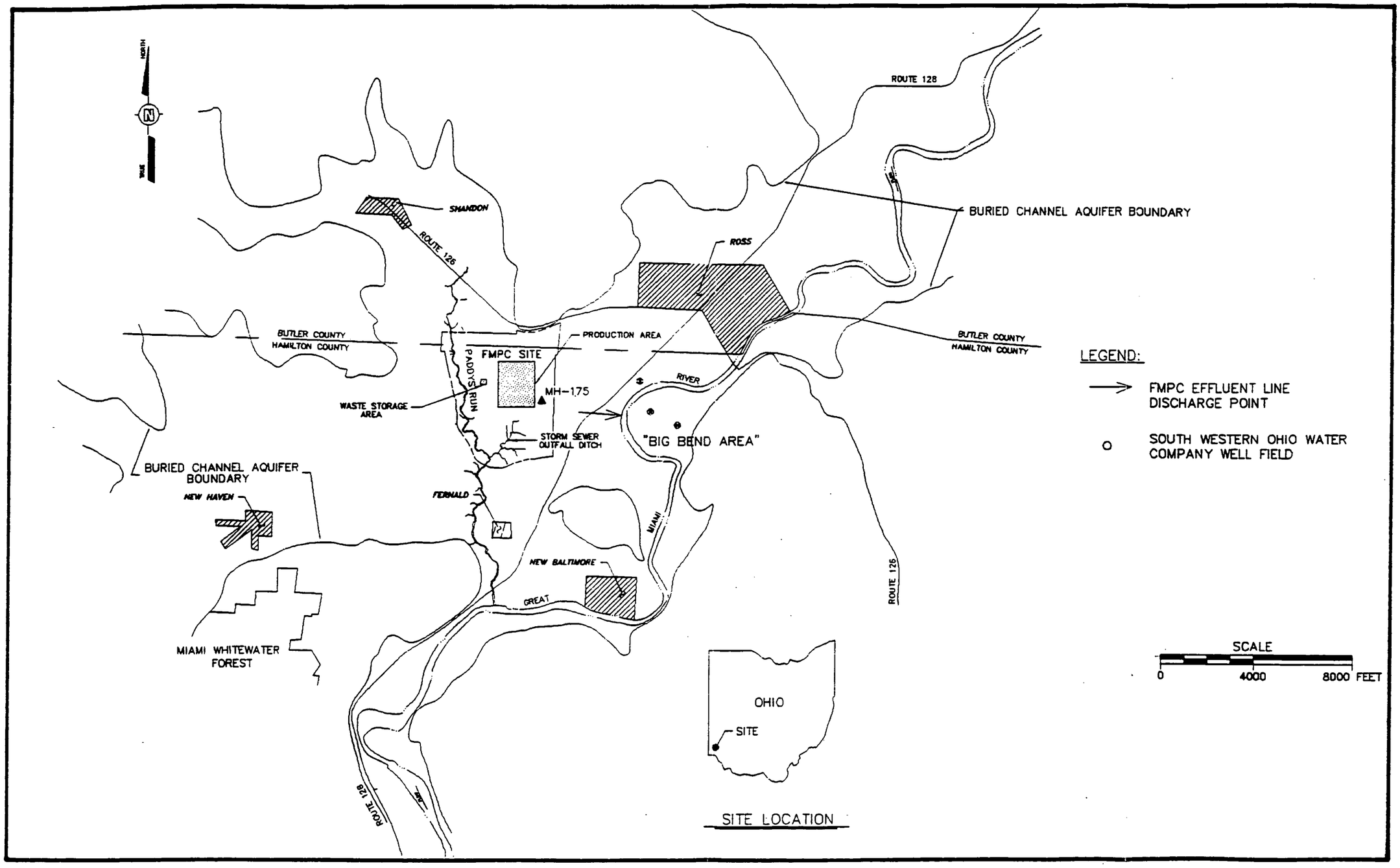


FIGURE 2-1. FMPC SITE AND VICINITY

2.1.1 Waste Storage Area Description

Prior to 1985, solid and slurried wastes from FMPC processes were disposed of in the on-site Waste Storage Area (Figure 2-2). This area, which is located west of the production facilities, includes six low-level radioactive waste storage pits, a burn pit, two earthen-bermed concrete silos containing K-65 residues (i.e., high specific activity and low-level radium-bearing residues resulting from the pitchblende refining process), a concrete silo containing metal oxides, two lime sludge ponds, and a sanitary landfill. A topographic map of the waste storage area is located in the end pocket (Figure 2-3).

The primary features of the Waste Storage Area are shown in Figure 2-4. Waste Pit 1 has been out of service since 1959 when it was backfilled, covered with clean soil, and graded to provide surface drainage away from the waste pit area. Pit 1 was constructed in 1952 into existing native clay and then lined with an additional four feet of clay. This clay was taken from an on-site borrow source and was not engineered to permanently contain waste materials. The maximum depth of the pit is 17 feet. It has an 80,000 square foot surface area with an estimated 40,000 cubic yards of buried waste. This pit contains neutralized waste filter cake, fly ash, scrap graphite, brick scraps, sump liquor/cake, depleted slag, and an estimated 115,000 pounds of uranium.

Waste Pit 2 has been out of service since 1964 when it was backfilled and covered with clean soil. It was not engineered to permanently contain waste material. Pit 2 was constructed in 1957 into native clay with a 17-foot maximum depth. It has a 48,215 square foot surface area with an estimated 13,000 cubic yards of buried waste. This pit contains neutralized waste filter cake, scrap graphite, brick scrap, concrete, construction rubble, sump cake, depleted slag, an estimated 2,700,000 pounds of uranium, and approximately 900 pounds of thorium.

Waste Pit 3 was constructed in 1959 and has been out of service since 1977 when it was backfilled and covered with clean soil. The pit was constructed into an existing clay layer and was lined with an additional foot of clay. This clay was taken from an on-site borrow source and was not engineered to permanently contain waste materials. The maximum depth of the pit is 27 feet. It has a 238,500 square foot surface area with an estimated 227,000 cubic yards of buried waste. This pit contains lime-neutralized raffinate (i.e., lime-neutralized liquid residue generated from the uranium refining process), raffinate concentrate, slag leach residues, filter cake, and fly ash, with an estimated 290,000 pounds of uranium and approximately 900 pounds of thorium.

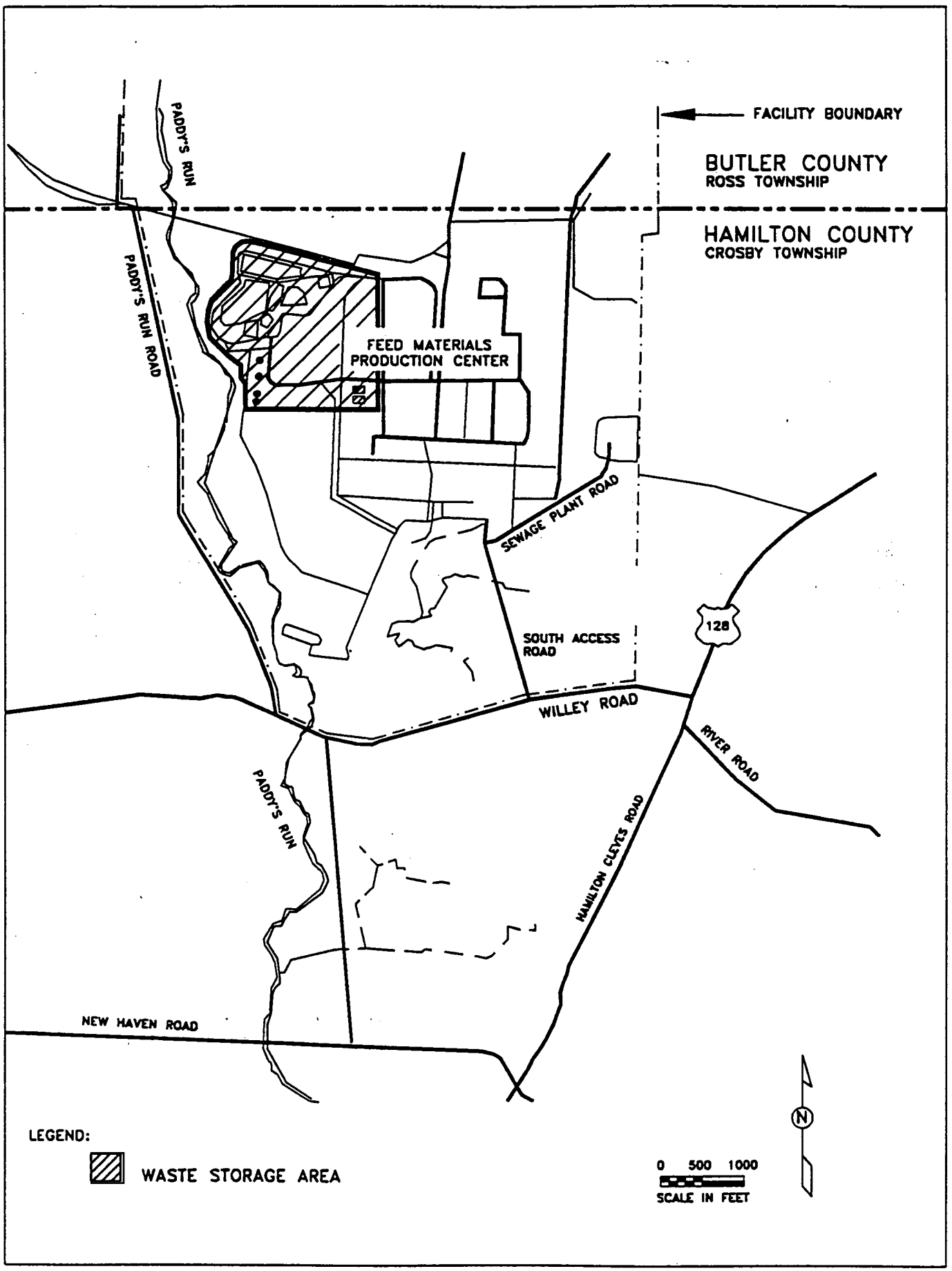


FIGURE 2-2. FMPC GENERAL LAYOUT

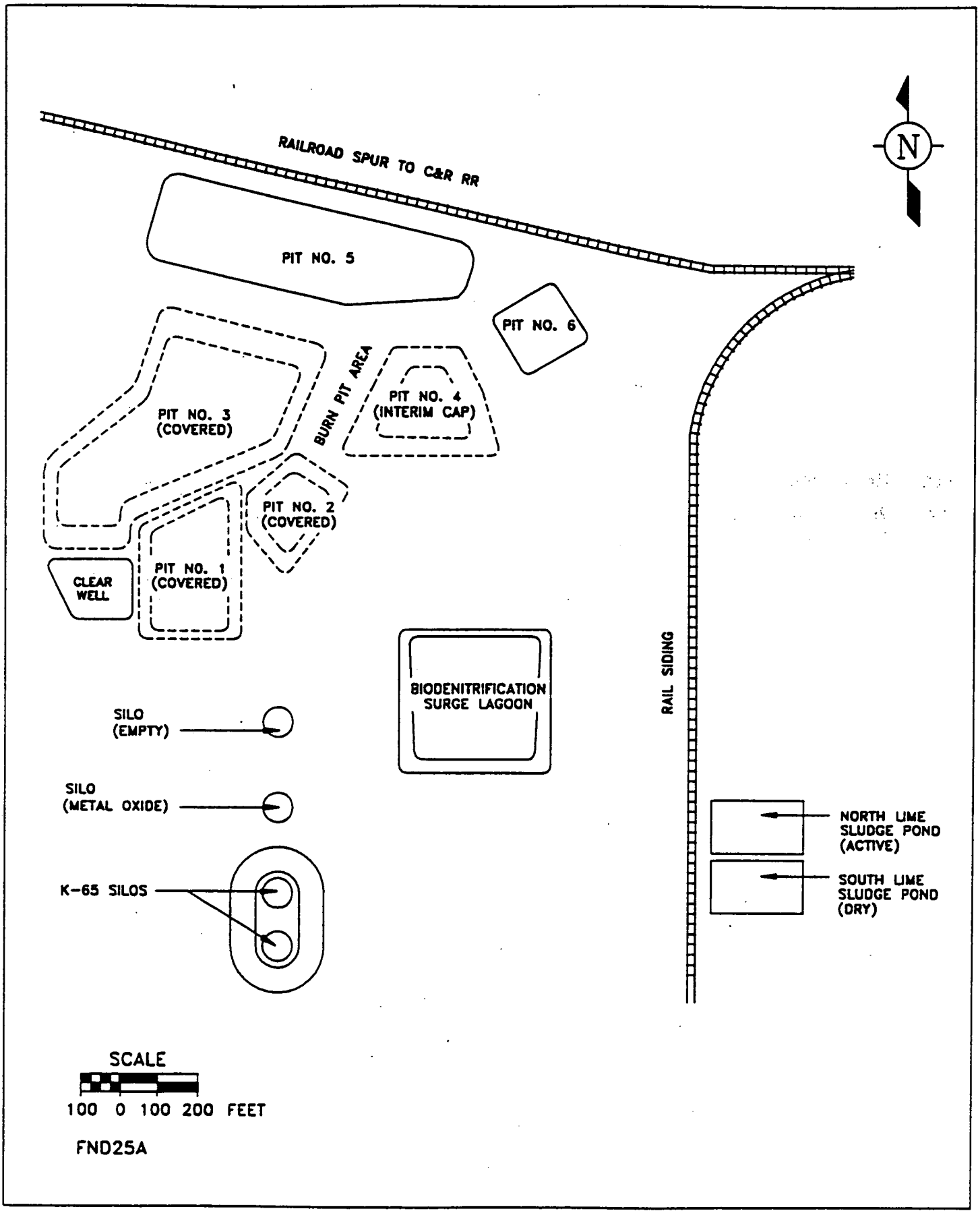


FIGURE 2-4. WASTE STORAGE AREA

Waste Pit 4 has been out of service since 1986 when it was backfilled and covered with clean soil. Recently, an interim cap providing an additional cover of compacted clay overlain by a 45-mil-thick Hypalon chlorosulfanated reinforced polyethylene (CRP) liner was installed to further ensure segregation of encapsulated materials from surface water during the interim period prior to implementation of a final remedial action under the Record of Decision (ROD). This is a clay-lined pit and was constructed in 1960 with a 24-foot maximum depth. It was not engineered to permanently contain waste material. It has an 85,685-square-foot-surface area with an estimated 53,000 cubic yards of buried waste. This pit contains process residues, raffinates, slurries, filter cake, lime sludge, 23,500 pounds of barium chloride, scrap graphite, noncombustible trash, asbestos, and construction rubble, with an estimated 1,400,000 pounds of uranium and 140,000 pounds of thorium.

Waste Pit 5 has been out of service since 1987 although it has not yet been dewatered and covered. It is a 183,737-square-foot, 30-foot-deep pond lined with a 60-mil-thick Royal-Seal ethylene rubber elastomeric membrane. The pit was constructed in 1968 and served as a settling pond for slurried waste from various production processes. It contains an estimated 102,500 cubic yards of settled waste material consisting of neutralized raffinate, slag leach slurry, sump slurry, lime sludge, and some construction debris, with an estimated 110,000 pounds of uranium and 38,000 pounds of thorium. Only rainfall currently enters Waste Pit 5, which flows by gravity from the pit and is released to the Clearwell. Therefore, no storm water runoff of concern to this removal action originates from Waste Pit 5.

Waste Pit 6 has been out of service since 1985 although it has not been covered. It is a 32,400-square-foot, 24-foot-deep pond lined with a 60-mil-thick Royal-Seal ethylene rubber elastomeric membrane. The pit was constructed in 1979 and contains an estimated 9000 cubic yards of waste material consisting of green salt, filter cake, depleted slag, and process residues, with an estimated 950,000 pounds of uranium. Standing water remains trapped within the berms of the pit. This waste is pumped to the Biodenitrification Surge Lagoon. As with Waste Pit 5, no storm water runoff originates from Waste Pit 6.

The Burn Pit was excavated in 1957 as a clay borrow pit for lining Waste Pits 1 and 2. The depth and size of the pit are not precisely known, but it is believed to be approximately 20 feet deep. The pit was subsequently used to dispose of and burn laboratory chemicals, including pyrophoric and reactive chemicals, waste oils, and other low-level contaminated materials such as wooden pallets. The residual waste quantities are not known.

The Clearwell served as a settling basin for process water and storm water runoff from the waste pits. Most recently, the Clearwell was used as a final settling basin for process water that passed through Waste Pit 5 prior to its discharge to the Great Miami River via Manhole 175, a National Pollutant Discharge Elimination System (NPDES) discharge point. This use was terminated in March 1987 when Pit 5 was removed from the process water treatment scheme. The Clearwell currently receives surface water runoff from the majority of the surfaces of Pits 1, 2, and 3 and from the entire surface of Pit 5. Water of varying depth remains in the Clearwell at all times depending on recent precipitation amounts. The sediments resulting from material deposition were removed on at least one occasion during the period of operation. The depth of sediment remaining in the Clearwell is unknown.

2.1.2 Environmental Impacts of Waste Storage Area

Surface water runoff from a portion of the waste pit area and other affected areas within the western portion of the FMPC enters Paddys Run, a tributary of the Great Miami River. Paddys Run originates just north of the FMPC and flows south-southeast along the western edge of the site and, for a part of the year, is a dry streamed with occasional rainfall-induced flows.

Leachate from these same areas can potentially migrate vertically to the regionally important Great Miami Aquifer which underlies the site. This aquifer serves as a principal source of domestic, municipal, and industrial water throughout the region. A portion of the flow in Paddys Run is also known to enter this aquifer downstream from the waste pit area as a result of leakage through the stream bottom.

2.1.3 FMPC Effluent

Liquid waste effluent generated from FMPC process operations is pumped to a central plant for treatment and analysis prior to release to the Great Miami River through the main effluent line discharge point (Figure 2-1). Storm water runoff from the production area is collected in storm water retention basins to allow solids to settle and is monitored during release through the same effluent line to the Great Miami River. During major storm events, if the storm water retention basins overflow, storm water may be discharged via NPDES outfall number 1I000004002 through a Storm Sewer Outfall Ditch into Paddys Run.

The main effluent line to the Great Miami River, which is a permitted discharge for wastewater from the FMPC and the storm water presently collected in the Clearwell, would also be the

discharge facility for waste pit area storm water runoff under one of the removal action alternatives presented in this EE/CA. The discharge is regulated by an NPDES permit and DOE orders, with compliance monitoring performed at Manhole 175 before the effluent leaves the site boundary. The effluent line is a 4200-foot-long, 16-inch-diameter cast-iron pipe constructed in 1952. Because the lower reaches of the effluent pipeline would be submerged under high water conditions in the Great Miami River, the pipeline was designed to accommodate pressure flow in these lower reaches. The flow capacity of the pipeline has been computed to be about 6.5 million gallons per day (mgd) or 10 cubic feet per second (ft^3/s). This greatly exceeds the value that would be realized under gravity flow only. In 1987, the average rate of discharge from the pipeline was 0.576 mgd or 0.89 ft^3/s (WMCO 1988), far below the design capacity.

One requirement of the NPDES permit for the FMPC specifies that the following effluent characteristics be monitored at Manhole 175: flow rate, Biological Oxygen Demand (BOD), pH, suspended solids, ammonia, oil and grease, residual chlorine, and nitrate. DOE Order 5400.5 also require daily sampling for radionuclides, with the daily samples composited on a weekly basis for laboratory analysis. Based on the analytical data from the weekly composites, the average concentration of total uranium in the FMPC effluent discharge in 1987 was found to be 660 picocuries per liter (pCi/l), which exceeds the DCG of 550 pCi/l. This was about the same as the average value of 661 pCi/l measured in 1985 and more than the average value of 450 pCi/l measured in 1986 (WMCO 1986, 1987). Summary tables of radionuclides (including uranium) for 1986, 1987, and 1988 are presented in Appendix B.

To ensure compliance with the NPDES limits for nitrate, a demonstration biodenitrification (BDN) facility was constructed and placed into operation in 1986. This treatment system includes a Biodenitrification Surge Lagoon (BSL) and biodenitrification towers. The BSL is used to equalize and settle process wastewater and storm water runoff flows before processing for nitrate removal in the downstream towers. The BDN is currently being upgraded to full production status.

Additionally, an Advanced Wastewater Treatment (AWWT) Facility is proposed to treat FMPC wastewater discharge to Manhole 175 for the removal of radioactivity. The AWWT facility is in the Title I Design (30 percent Design) phase. The current projected start-up date is October of 1993. DOE Order 5400.5 requires best available technology (BAT) as the required level of treatment for liquid wastes containing radioactive material in excess of the DCGs. The facility would be designed to comply with this order. The streams targeted for treatment are the general sump, biodenitrification facility (of which the waste pit area storm water flows would be part),

sewage treatment plant, and storm water retention basin. Preliminary designs target the use of ion exchange, reverse osmosis, or a combination of both, whichever provides BAT treatment. The final design would be based on treatability studies that are presently being conducted.

2.2 SITE SETTING

The following description of the physical setting of the FMPC and surrounding area was derived from various existing reports. Two documents were relied on substantially (IT 1988; DOE 1987) and are not specifically referenced in the text but are listed in the list of refernces at the end of this document. Other documents used to support individual statements are appropriately cited within the text.

2.2.1 Climate

Data from the Greater Cincinnati International Airport has been shown to satisfactorily characterize the climatic regime of the FMPC area. Wind-flow data from the Dayton Airport have been utilized as a secondary data source.

The regional climate is defined as continental, with temperatures ranging from a monthly average of 29°F in January to 75°F in July. The highest temperature recorded from 1950 through 1984 was 102°F in August 1962 and the lowest was -25°F in January 1977. The average number of days per year with a minimum temperature of 32°F or less is 110 days, and the average number of days with a maximum temperature of 90°F or above is 20 days per year. Frost depth ranges from 30 to 36 inches.

The average annual precipitation for the period 1955 through 1984 was 37.75 inches and ranged from 29.22 to 40.64 inches. The rainfall for 1 and 10 year 24-hour events is 2.5 inches and 4.1 inches, respectively. The highest precipitation occurs during the spring and early summer; precipitation is lowest in late summer and fall. The average annual snowfall for the same period was 24.0 inches, with heaviest snowfall in January.

2.2.2 Surface Water Hydrology

The FMPC is located within the Great Miami River Basin drainage but above the river's present-day floodplain. The waste pit area is outside of the 100 year flood plain as described on the U.S. Federal Emergency Management Agency (FEMA) Maps. The waste pit area is outside of this flood plain because of the diking placed west of Pit 3. It is believed that this engineered diking was installed to fulfill dual purposes. The primary purpose was to prevent elevated water

levels in Paddy's Run from eroding the west berm of Pit 3. The other purpose was to provide a secondary containment in the event of a catastrophic failure of one of the bermed waste pits (i.e. Pit 3 or Pit 5). The Great Miami River is the receiving stream for the FMPC effluent discharge and represents the main surface water feature in the vicinity of the FMPC. The river flows generally to the southwest and has a drainage area of approximately 3360 square miles at the Hamilton gage, which is located about 10 miles upstream from the FMPC discharge outfall. The average discharge of the Great Miami River at Hamilton, based on 55 years of records, is 3305 ft^3/s. Using drainage area scaling, the corresponding average flow at the FMPC point of discharge has been estimated to be 3460 ft^3/s. The minimum daily discharge of 155 ft^3/s was recorded on September 27, 1941. This value is approximately one-half of the 7-day, 10-year low-flow value (Q_{7-10}) of 267 ft^3/s, as computed by the U.S. Geological Survey (USGS) for the Hamilton gage. This translates to 280 ft^3/s at the site boundary.

Natural surface drainage from the FMPC is primarily to Paddys Run. Paddys Run originates north of the site, drains southward through the western portion of the FMPC, and eventually enters the Great Miami River approximately 1.5 miles south of the FMPC (Figure 2-1). This stream loses flow to the groundwater along much of its course due to its highly permeable channel bottom and limited elevation above the regional groundwater table. Paddys Run is an ungaged, intermittent stream that flows primarily between January and May, with an estimated discharge for this period ranging between 0.2 and 4.0 ft^3/s (Dames and Moore, July 1985). Its floodplain does not encompass any portion of the waste pit area.

A principal drainage feature of the FMPC is a tributary to Paddys Run known as the Storm Sewer Outfall Ditch. This drainage course originates south of the production area, flows southwest across the southern portion of the site, and enters Paddys Run downstream from the waste pit area near the southwest corner of the property. Much of the stream bottom of this drainage course, which also collects runoff from an area east of the plant, is composed of sand and gravel. Vertical seepage rates through the stream bottom may be high. This drainage course is generally dry throughout most of the year, with flows occurring during and immediately after precipitation.

The Storm Sewer Outfall Ditch historically conveyed surface water runoff from the production area directly to Paddys Run when the capacity of the storm sewer lift station, which diverts low flow to Manhole 175, was exceeded. Two storm water retention basins were recently constructed at the head of the Storm Sewer Outfall Ditch. Storm water runoff from the production area is now conveyed to these retention basins. The basins, designed to retain the runoff from a 10-year,

24-hour rainfall event, essentially eliminate the contribution of storm water from the production area to the outfall ditch and thus to Paddys Run. After at least a 24-hour retention period to allow for settling of suspended solids, the water is pumped out of the retention basins to the Great Miami River via the FMPC's main effluent line.

2.2.3 Groundwater Hydrology

The FMPC is located within a two- to three-mile-wide subterranean valley known as the New Haven Trough, a valley that formed as a result of Pleistocene glaciation and subsequent filling with glacial outwash materials and till. The FMPC lies on top of terrace remnants left after the establishment of the present-day Great Miami River channel. The lower portions of Paddys Run have cut through this till and lie directly on the sands and gravels of the buried channel.

Flat-lying, olive-gray Ordovician shale with thin, interbedded layers of limestone form the floor and valley walls of the New Haven Trough. The trough ranges from 60 to more than 200 feet deep in the vicinity of the FMPC and is filled with approximately 150 feet of Pleistocene glacial valley fill deposits, generally composed of sand and gravel outwash deposits. The buried valley is about one-half to over two miles wide and is U-shaped, having a broad, relatively flat bottom and steep valley walls. Interbedded glacial till deposits occur within the outwash deposits, but in most cases are of limited lateral extent. The till deposits are composed primarily of poorly sorted pebbles, cobbles, and boulders in a predominantly clay matrix.

Within some areas, including the waste pit area, till deposits overlie the bedrock uplands and portions of the outwash materials where they form the thick, unconsolidated sediment layers beneath the soil zone. This glacial till is composed of dense, silty clay that varies in composition vertically and laterally. The silty clay till contains lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt with layers of silty clay.

Large groundwater supplies of regional significance occur in the outwash deposits (buried channel aquifer) and are recharged by three principal sources: recharge from bedrock area, precipitation recharge, and recharge by stream infiltration. Under natural conditions, the gradient of groundwater flow is from the aquifer to the Great Miami River, except during dry periods when the gradient is reversed. Intermittent recharge to the aquifer also occurs along Paddys Run. The groundwater in the regional aquifer beneath the FMPC flows from the buried valleys west, north, and east towards the center of the FMPC study area and subsequently south-southeast through the branch of the buried channel aquifer west of New Baltimore. However, large pumping wells of the Southwest

Ohio Water Company (SOWC) in the "Big Bend" (Figure 2-1) meander of the Great Miami River east of the FMPC produce a pronounced cone of depression that, due to bedrock geometry, extends more in the east-west direction than in the north-south direction. This results in a groundwater divide and in an eastward groundwater flow component across portions of the FMPC, including the waste pit area. Consequently, infiltration into the regional aquifer beneath the waste pits would tend to move eastward, while storm water runoff from the same area could enter Paddys Run and subsequently be lost to the regional aquifer in an area with a southern flow component.

2.2.4 Soils

Soils at the FMPC site, including the waste storage area, are primarily categorized as Fincastle-Xenia silt loams. These soils are light colored, medium acid, and moderately high in productivity when properly managed. Moisture-supplying capacity is moderate, as is fertility and organic content. The soils have formed as 18 to 40 inches of wind-blown material (loess) over limy loam till of Wisconsin age. Fincastle soils are developed on glacial till of the upland till plain where the FMPC production area and waste pits are located. These soils are poorly drained, due in part to the nearly flat slopes on which they lie and the presence of a clay-rich subsoil beneath the topsoil. The soils are drained by open ditches, drain tile, or natural gullies. If artificial drainage is not used, the water content remains high for extended periods in winter and spring.

Soils along Paddys Run are categorized as Fox-Genesee loams. These soils are light colored, high in productivity, and moderate in fertility and organic matter. Fox soils are slightly to medium acid, moderate in moisture-supplying capacity, and well drained. They have formed as 24 to 40 inches of silty materials over sand and gravel on level areas of the first terrace above the stream's normal floodplain. Genesee soils occur on the stream's normal floodplain. They are well drained, high in moisture-supplying capacity, and are subject to flooding.

2.2.5 Vegetation and Wildlife

The FMPC is in a region containing beech and mixed deciduous forests. Generalized habitats on the FMPC have been described as grazed and ungrazed pastures, the reclaimed fly ash pile, pine plantations, and deciduous and riparian woodlands (Facemire et al. 1990). Grasses and herbs dominate the pasture areas and covered waste pit areas. Deciduous woodlands occur mainly north of the production area and contain a variety of species, including ash, elm, hickory, and sugar maple.

Wetlands on the FMPC are being delineated as part of the RI/FS. Preliminary results indicate that the impacted area is small (five to eight acres). Implementation of the chosen alternative would result in a short-term disturbance during construction; the area would be allowed to revegetate after construction and the long-term impacts would be minimal.

A description of preliminary results of the wetlands identified in the waste pit area include the riparian woodland along Paddys Run, the drainage ditches along the railway north of Waste Pit 5, and other drainage ditches in the waste pit area (Figure 2-5). The dominant tree species in the riparian woodland are eastern cottonwood, American elm, hackberry, and boxelder. Cattails and rushes grow in the drainage ditches in the waste pit area and in portions of Paddys Run. The most common fish in Paddys Run are bluntnose and stoneroller minnows, creek chubs, shiners, and darters (Facemire et al. 1990). Fifty-six benthic macroinvertebrate taxa have been identified in Paddys Run. The most common of these are nonbiting midges, riffle beetles, mayflies, and stoneflies. Ecological diversity in Paddys Run as a whole is considered typical for area streams (Facemire et al. 1990).

Common fish species in the Great Miami River include carp, gizzard shad, and sunfish (WMCO 1988). Fish populations in the Great Miami River remain healthy and have not changed appreciably since 1984 (WMCO 1988).

Mammals in the FMPC area predominantly include the whitetail deer, eastern cottontail, fox squirrel, eastern chipmunk, woodchuck, and raccoon. Birds requiring open pasture, wooded, and shrubby field habitats have been observed on the site. These include the red-winged blackbird, mourning dove, blue jay, tufted titmouse, song sparrow, and common yellowthroat.

The FMPC is within the geographic ranges of several species determined by the U.S. Fish and Wildlife Service to be endangered or threatened. These include the Indiana bat, bald eagle, peregrine falcon, and northern wild monkshood (50CFR17.11 and 17.12). The cave salamander is recognized as state endangered (ODNR 1974). There are no critical habitats in the vicinity of the FMPC. The bald eagle and peregrine falcon do not nest in the counties surrounding the FMPC site and would occur only as rare transients along the Great Miami River. The northern wild monkshood has not been observed in the FMPC area.

During RI/FS biological sampling, Indiana bats were not found on or adjacent to the FMPC, but were netted at a monitoring site three miles northeast of the FMPC boundary. Potential habitat for

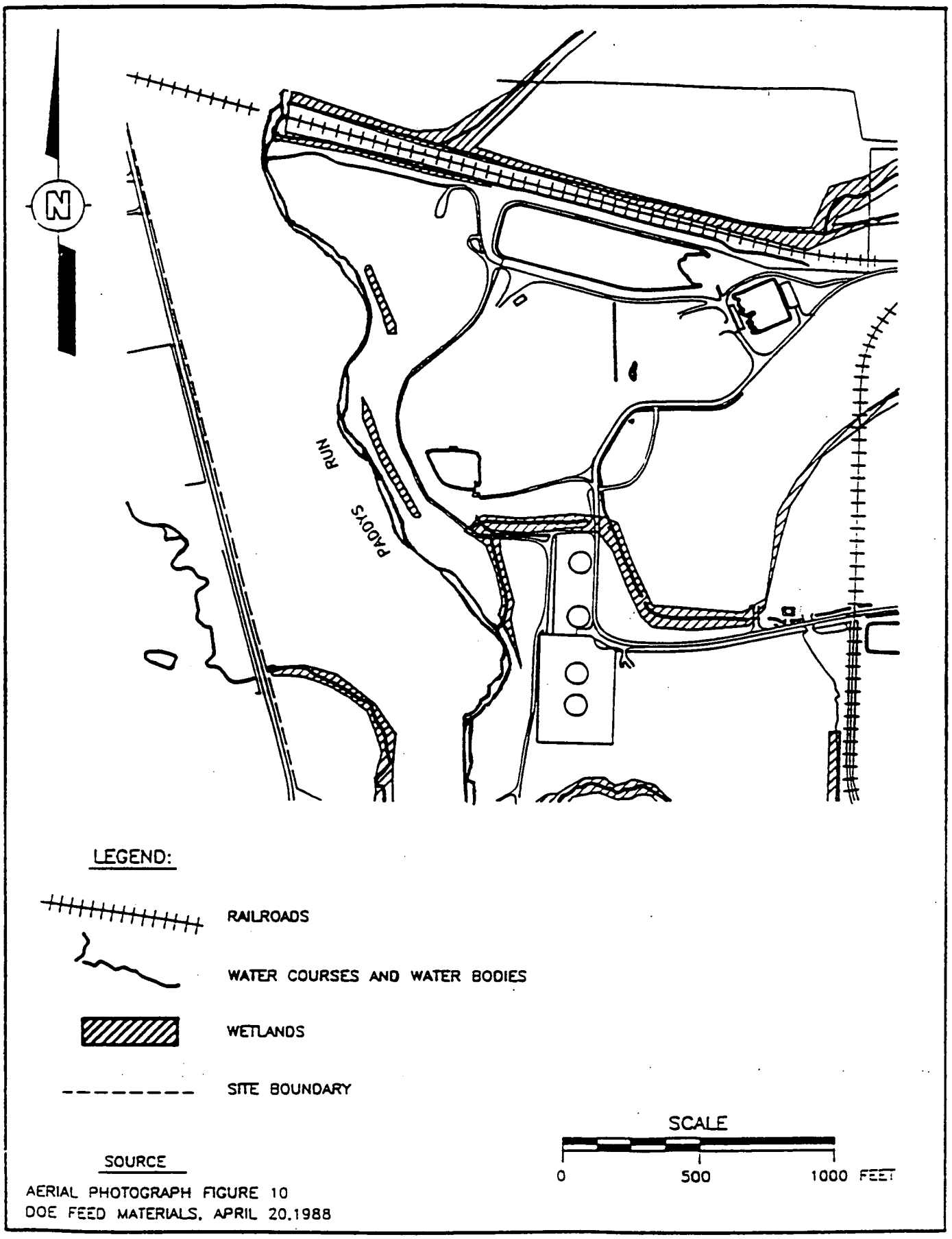


FIGURE 2-5

WETLANDS DELINEATED
IN WASTE PIT AREA

the Indiana bat along Paddys Run ranges in quality from poor to excellent, with over 50 percent fair. The cave salamander was not found within FMPC boundaries during RI/FS sampling. Marginal habitat for this species was identified along Paddys Run.

A study to assess the acute and chronic toxic effects of effluent from the FMPC on algae, invertebrates, and fathead minnows, following standard U.S. EPA methods (Peltier and Weber 1985 and Weber et al. 1989), is being conducted for the environmental media, Operable Unit 5. The toxicity of soils and sediments collected from the FMPC is also being evaluated. The effects of FMPC contaminants on the macroinvertebrate community structure in the Great Miami River and Paddys Run are also being examined as part of the RI/FS.

2.2.6 Land Use and Population

The area surrounding the FMPC is mainly agricultural, with dairy, beef, corn, and soybean production. Several industries, including Delta Steel, Albright and Wilson Chemical Company, Ruetgers-Nease Chemical Company, two commercial gravel operations, and a cement plant, are located south of the site. The Miami Whitewater Forest, a Hamilton County park, is located five miles to the southwest of the FMPC.

FMPC RI/FS Project population estimates use the standard approach of estimating the population from a source of emissions. For the purposes of this study, specific sources of emissions, such as the waste pits, were considered appropriate to use the center points for calculations. Because of the difficulty in preparing a separate population estimate for each of the specific sources, the center of the FMPC was chosen as the source and center point for calculations. Using this approach, the population within a 5-mile radius of the center of the FMPC is estimated to be over 24,000. This estimate includes onsite workers and residents.

The area surrounding the FMPC contains several sites of historical interest, but none are within the immediate waste pit study area. The National Register of Historic Places lists four prehistoric Indian sites within a three-mile radius. These include the Adena Circle, the Demoret Mound, the Colerain Work, and the Dunlap Work. The closest site, the Colerain Work, is situated approximately one mile east of the FMPC. The State Historical Preservation Officer reports that there are no known sites of archaeological significance on the FMPC site. There are also no known archaeological sites in the immediate vicinity of the waste pit area.

2.3 ANALYTICAL DATA

2.3.1 Introduction

DOE has conducted four storm water runoff samplings studies in the waste storage area. For clarity, data from the four studies is presented in this report under the name of the contractor commissioned to do the work: 1) WMCO; 2) Roy F. Weston, Inc. (Weston); 3) Advanced Sciences, Inc./International Technology (ASI/IT); and 4) Dames and Moore.

The sampling performed by WMCO and Weston was accomplished using standard techniques as described in "Sampling Plan for the Characterization of Storm Water Runoff at the Feed Materials Production Center," October 1987, and "Quality Assurance and Quality Control Plan for Preparation of Best Management Practices (BMP) Plan for the Feed Materials Production Center," October 30, 1987. The sampling performed by ASI/IT was accomplished using standard techniques as described in the "Surface Water and Sediment Sampling Plan" (Section 5.0 of the "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Volume I - Sampling Plan," Rev. 3) and the RI/FS "Quality Assurance Project Plan."

Sample locations are identified in Figure 2-6 (located in end pocket). The analytical results of the storm water runoff sampling data are summarized in Tables 2-1 through 2-4. Only the sample locations which relate to the waste pit area are tabulated; therefore, the results presented in the tables are actually subsets of each contractor's sampling data.

Table 2-1 is a tabulation of WMCO data indicating analytical results of total uranium in storm water runoff reported in total milligrams per liter (mg/l). The data was taken between April 23, 1987 and November 9, 1989; 19 sample locations are identified as being within the waste pit area. Table 2-2 is a tabulation of data, taken by Weston, indicating the analytical results for drainage ditch samples collected on July 20 and July 21, 1988. An asterisk (*) indicates the parameter was analyzed but not detected. The minimum detection limit, not the method detection limit for the sample, is reported preceding the asterisk. Minimum detection limits are the minimum concentration that is detectable in the presence of interfering substances (i.e., high concentrations of other substances may cause a high background signal in the area where the analyte signal occurs, thereby requiring a higher concentration) before detection occurs. Method detection limits are set from normal laboratory analysis without matrix interference. Seven drainage ditch sample locations are considered applicable for this removal action. For all samples collected by Weston, analyses included uranium and other chemical and radiological parameters as indicated in Table 2-2.

TABLE 2-1
WMCO DATA FOR SURFACE WATER RUNOFF

Sample Point Location	Total Uranium (mg/l) By Sampling Date (Unfiltered)									
	4/23/87	7/28/87	1/20/88	2/1/88	3/2/88	3/3/88	3/25/88	3/21/89	9/14/89	11/8/89
2	-	-	-	-	-	-	-	-	2.00	8.3
3	-	-	-	-	-	-	-	-	4.70	15.2
5	-	-	-	-	-	-	-	0.800	1.74	14.9
7	-	-	-	-	-	-	-	-	1.56	3.4
8	-	-	-	-	-	-	-	0.770	2.52	6.6
12	DRY	0.124	0.240	0.047	0.043	0.095	0.041	-	-	-
13	DRY	-	-	6.28	1.18	5.12	1.52	0.37	0.21	0.333
14	DRY	0.163	0.320	0.128	0.043	0.096	0.042	-	0.027	-
15	0.052	0.028	0.200	0.047	0.046	0.078	0.050	-	0.051	15N-0.265 15S-0.224
16	0.007	0.256	0.160	0.071	0.801	0.32	0.28	-	0.16	0.226
18	0.068	-	-	0.302	1.26	0.78	0.64	0.43	0.24	0.692
22	-	-	-	0.115	0.293	1.12	0.42	0.43	0.18	0.179
23	-	-	-	0.232	DRY	0.061	0.260	0.27	-	0.119

TABLE 2-1 (continued)
WMCO DATA FOR SURFACE WATER RUNOFF

Sample Point Location	Total Uranium (mg/l) By Sampling Date (Unfiltered)									
	4/23/87	7/28/87	1/20/88	2/1/88	3/2/88	3/3/88	3/25/88	3/21/89	9/14/89	11/8/89
24	-	-	-	0.698	0.68	1.50	0.34	0.12	0.12	0.223
25	-	-	-	0.793	2.38	1.64	0.70	0.440	0.28	0.249
26	-	-	-	1.013	2.24	1.54	0.72	0.340	0.32	0.449
27	-	-	-	0.454	11.30	2.70	6.44	-	-	-
28	-	-	-	2.23	DRY	5.86	1.12	0.60	0.38	0586

SOURCE: Site Environmental Monitoring Data

TABLE 2-2
WESTON DATA FOR SURFACE WATER RUNOFF

	Drainage Ditch Samples Collected July, 1988						
Analyte	DD-07	DD-09	DD-14	DD-23	DD-01	DD-12	DD-13
Aluminum, µg/L	456	964	14,400	11,700	869	345	200
Barium, µg/L	320	209	387	226	217	200*	200*
TOC, mg/L	118	7.6	16.6	9.4	14.4	10.1	5.0
TOX, µg/L	260	37	39	43	41	14	10*
TDS, mg/L	1190	414	358	155	692	237	169
TSS, mg/L	20.0	148	2150	385	266	10.0	23.0
Chloride, mg/L	28.1	39.3	227	2.5*	11.3	14.8	5.7
Fluoride, mg/L	1.2	1.3	0.68	0.32	0.24	1.5	0.69
Nitrate, mg/L	0.20*	2.6	1.8	0.20*	1.0*	6.3	3.1
Gross Alpha pCi/L	850±50	420±30	450±60	100±20	8±5	390±20	180±100
Gross Beta pCi/L	560±20	380±10	370±30	110±10	13±3	330±10	140±10
Thorium-228 pCi/L	NR	0.1±0.3	NR	NR	NR	NR	NR
Thorium-230 pCi/L	NR	1.4±0.5	NR	NR	NR	NR	NR
Thorium-232 pCi/L	NR	0.1±0.2	NR	NR	NR	NR	NR
Uranium-234 pCi/L	160±30	57±30	120±10	14±4	0.6±0.5	150±20	45±11

TABLE 2-2 (Continued)
WESTON DATA FOR SURFACE WATER RUNOFF

Analyte	Drainage Ditch Samples Collected July, 1988						
	DD-07	DD-09	DD-14	DD-23	DD-01	DD-12	DD-13
Uranium-235 pCi/L	5±10	1.0±8.6	21±5	2.0±1.3	0.3±0.2	8.7±4.4	6.1±3.7
Uranium-238 pCi/L	740±60	310±40	220±20	64±6	2.4±0.5	230±20	100±14
Radium-226 pCi/L	NR	NR	7.0±0.6	NR	NR	NR	NR
Radium-228 pCi/L	NR	NR	4.5±1.8	NR	NR	NR	NR
Chromium, µg/L	10.0*	10.0*	12.8	18.5	10.0*	10.0*	10.0*
Sulfate, mg/L	38.3	89.9	48.4	14.3	317	48.1	25.7

* The asterisk indicates the paramenter was analyzed for but not detected. The minimum detection limit for the sample, not the method detection limit, preceds the asterisk.

NR - An analysis for the parameter was not requested.
TDS - Total dissolved solids.
TOC - Total organic carbon.
TOX - Total organic halogen.
TSS - Total suspended solids.

SOURCE: Addendum to Best Management Practices Plan: Stormwater Sampling Program Results prepared by Roy F. Weston, Inc., October 18, 1988

TABLE 2-3
ASI/IT DATA FOR SURFACE WATER RUNOFF

Parameter	Sample Location and Sample Date																
	ASIT-001 S 1133 3/29/89	ASIT-010 S 1118 3/10/89	ASIT-18 S 1155 3/21/89	ASIT-19 S 1157 3/21/89	ASIT-20 S 1159 3/21/89	ASIT-22 S 1163 3/21/89	ASIT-23 S 1151 3/21/89	ASIT-24 S 1153 3/21/89	ASIT-27 S 1203 5/9/89	ASIT-28 S 1205 5/9/89	ASIT-29 S 1112 3/10/89	ASIT-30 S 1166 3/21/89	ASIT-31 S 1168 3/21/89	ASIT-13 S 1145 3/21/89	ASIT-14 S 1147 3/21/89	ASIT-25 S 1114 3/10/89	ASIT-26 S 1116 3/10/89
Radium-226 pCi/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.1	3.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Radium-228 pCi/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	10.9	4.2	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Chromium µg/L	---	---	---	---	19.9	---	---	---	---	---	---	52.5	45.2	---	---	---	---
Sulfate mg/L	---	---	---	---	129	---	---	---	---	---	---	120	123	---	---	---	---
Total Uranium mg/L	0.02	0.2	0.7	0.9	0.5	0.05	0.4	0.6	9.3	5.8	1.0	8.4	7.4	0.112	0.525	0.247	0.201

TDS - Total dissolved solids.
TOC - Total organic carbon.
TOX - Total organic halogen.
TSS - Total suspended solids.

Source: Fernald RI/FS database

TABLE 2-3
ASI/IT DATA FOR SURFACE WATER RUNOFF

Parameter	Sample Location and Sample Date																
	ASIT-001 S 1133 3/29/89	ASIT-010 S 1118 3/10/89	ASIT-18 S 1155 3/21/89	ASIT-19 S 1157 3/21/89	ASIT-20 S 1159 3/21/89	ASIT-22 S 1163 3/21/89	ASIT-23 S 1151 3/21/89	ASIT-24 S 1153 3/21/89	ASIT-27 S 1203 5/9/89	ASIT-28 S 1205 5/9/89	ASIT-29 S 1112 3/10/89	ASIT-30 S 1166 3/21/89	ASIT-31 S 1168 3/21/89	ASIT-13 S 1145 3/21/89	ASIT-14 S 1147 3/21/89	ASIT-25 S 1114 3/10/89	ASIT-26 S 1116 3/10/89
Aluminum µg/L	---	---	---	---	232	---	---	---	---	---	---	383	395	---	---	---	---
Barium µg/L	---	---	---	---	47.2	---	---	---	---	---	---	57.2	54.6	---	---	---	---
TOC mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TOX µg/L	---	---	---	---	15.0	---	---	---	---	---	---	29.2	16.1	---	---	---	---
TDS mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TSS mg/L	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Chloride mg/L	---	---	---	---	7	---	---	---	---	---	---	60	49	---	---	---	---
Fluoride mg/L	---	---	---	---	0.44	---	---	---	---	---	---	0.85	0.85	---	---	---	---
Nitrate mg/L	---	---	---	---	2.3	---	---	---	---	---	---	9.73	10.9	---	---	---	---
Gross Alpha pCi/L	21	232	---	---	---	---	---	---	---	---	362	---	---	---	---	144	78
Gross Beta pCi/L	---	67	---	---	---	---	---	---	---	---	193	---	---	---	---	56	32
Thorium-228 pCi/L	---	---	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	---	---	---	<1.0	<1.0	<1.0	<1.0	---	---
Thorium-230 pCi/L	---	---	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	---	---	---	<1.0	<1.0	<1.0	<1.0	---	---
Thorium 232 pCi/L	---	---	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	---	---	---	<1.0	<1.0	<1.0	<1.0	---	---
Uranium-234 pCi/L	---	---	62.9	72.6	40.6	10.3	76.9	85.8	---	---	---	653	597	32.6	268	---	---
Uranium-235 pCi/L	---	---	5.3	5.6	3.4	<1.0	6.0	6.7	---	---	---	51.5	38.3	1.6	15.7	---	---
Uranium 238 pCi/L	---	---	244	364	183	18.0	165	195	---	---	---	2840	2506	37	177	---	---

TABLE 2-4
DAMES AND MOORE DATA
FOR SURFACE WATER RUNOFF

Sample Point Location	Date Collected	Total Uranium, mg/l
SW-1	8/11/86	0.38
SW-2	8/11/86	2.53
SW-3	8/11/86	3.76
SW-4	8/11/86	16.42
SW-5	8/11/86	26.55
SW-6	8/11/86	1.21
SW-7	8/11/86	
RO-3	3/85	0.007
RO-4	3/85	28.0
RO-5	3/85	24.0
RO-6	3/85	4.6
RO-7	3/85	0.31
RO-8	3/85	34.0
RO-9	3/85	3.0
RO-10	3/85	3.6
RO-11	3/85	0.83
RO-12	3/85	0.34
RO-13	3/85	0.54
RO-14	3/85	0.48
RO-15	3/85	0.71
RO-16	3/85	0.62
RO-17	3/85	11.0
RO-18	3/85	0.53

SOURCE: WMCO, Aug. 25, 1986, Letter EH (EC): 86-0365.

Table 2-3 is a tabulation of ASI/IT data indicating the analytical results for chemical and radiological parameters in the surface water samples collected on the dates indicated in the table.

Table 2-4 is a tabulation of data collected by Dames and Moore, indicating the analytical results of surface water runoff samples collected on August 11, 1986 and samples collected in March 1985 from the waste pit area. The surface water samples collected in 1986 are designated as "SW" and those collected in 1985 are designated as "RO." Twenty-three sample locations are identified on the table.

2.3.2 Analytical Results

2.3.2.1 Metals

Only two of the four contractors tested for metals, Weston and ASI/IT. Hazardous Substance List (HSL) metals analyses were not included in the analysis of background surface water samples at the site. Therefore, the determination of above background concentrations is not possible at this time.

The highest level for aluminum was 14,400 µg/l which was from the Weston DD-14 sample location south of the K-65 silos. The highest level for aluminum from the ASI/IT data was 395 µg/l from location ASIT-31 (sample 1168) along the western edge of the pits. The samples were not filtered. There are no regulatory limits set for aluminum.

Barium has an established maximum contaminant level (MCL) of 1.0 mg/l (1000 µg/l) as established by the EPA Safe Drinking Water Act (SDWA) interim primary drinking water standards. The limit was not exceeded in any of the samples. The highest detected concentration was 387 µg/l from Weston DD-14. The lowest detected concentration was 47.2 µg/l from ASIT-20 (sample 1159).

The MCL for chromium is 50 µg/l (EPA 1988) and the laboratory detection limit is 10.0 µg/l. Only two samples from the seven Weston sample locations had detectable levels of chromium, which were DD-14 and DD-23 at 12.8 µg/l and 18.5 µg/l, respectively. Of the relevant ASI/IT data, three sample locations were tested for chromium, with all three having detectable levels of chromium. The highest concentration of chromium detected was 52.5 µg/l at sample location ASIT-30, which exceeded the MCL for chromium. Sample location ASIT-30 is between Pits 3 and 5; no other surface water samples had concentrations exceeding the MCL. The lack of

pervasiveness of the chemical throughout the area of interest indicates that chromium is not a principal chemical of concern to this study.

2.3.2.2 Other Water Quality Parameters

Only the Weston samples were analyzed for total organic carbon (TOC). The highest concentration reported was 118 mg/l from location DD-07. No MCLs or any other standard are available for comparison of TOC concentrations.

All samples collected by Weston and ASI/IT were analyzed for total organic halogens (TOX). The highest concentration of TOX was detected at Weston DD-07 with a concentration of 260 µg/l. The highest concentration of TOX at the ASI/IT sample locations was 29 µg/l at sample location ASIT-30 (sample 1166). No standards or MCLs are available for comparison to the TOX levels detected.

Only Weston performed an analysis for total dissolved solids (TDS). The highest concentration was found at sample location DD-07 at 1190 mg/l, which exceeds the EPA Secondary Drinking Water Standards secondary maximum concentration level (SMCL) of 500 mg/l and the Ohio Administrative Code (OAC) standard for TDS, set at 500 mg/l (monthly average) and 700 mg/l (transient).

For total suspended solids (TSS), only the Weston study provided adequate test results. For the seven sample locations given in Table 2-2, the concentrations of TSS ranged from 10 mg/l to 2150 mg/l, with the highest concentration measured at location DD-14. Using the NPDES limits for FMPC discharge, TSS are set at 20 mg/l (daily average) and 40 mg/l (daily maximum). However, there is no MCL for TSS. Four of the sample locations (DD-01, DD-09, DD-14, and DD-23) exceeded the daily average limit of 20 mg/l and one location (DD-07) equalled the limit. The WMCO study provided TSS results for only one sampling date (3/21/89). The concentrations for TSS on this date ranged from 71 mg/l for sample location 28 to 22925 mg/l for sample location 2. These TSS data represent one time grab samples; consequently, comparisons can not be made with data that has been gathered over an extended period of time. The data indicate that on this date TSS concentrations for all the WMCO sample locations exceeded the daily average NPDES discharge limit.

Both the Weston and ASI/IT samples were analyzed for chloride. The highest chloride concentration was found in the Weston sample location, DD-14 at 227 mg/l which does not exceed

the SMCL for chloride set at 250 mg/l. The lowest detectable chloride concentration was found in the ASI/IT data at sample location ASIT-20 (sample 1159) with a concentration of 7 mg/l. Chlorides were found in one sample from Weston location DD-23 at a concentration less than the detection limit of 2.5 mg/l.

Both the Weston and ASI/IT data were analyzed for fluoride. The MCL for fluoride is 1.4 mg/l, while the OAC standard for fluoride is 1.0 mg/l. The highest fluoride concentration found was 1.5 mg/l at sample location DD-12, which exceeds the 1.0 mg/l standard. The concentration of fluoride from two other Weston sample locations, DD-07 and DD-09, exceeds the 1.0 mg/l limit with a concentration of 1.2 mg/l and 1.3 mg/l, respectively. Samples from three ASI/IT sample locations (ASIT-20, ASIT-30, and ASIT-31) did not exceed the 1.0 mg/l concentration for fluoride.

For sulfate, the highest observed concentration was 317 mg/l at Weston sample location DD-01, which is in excess of the OAC standard of 250 mg/l. The highest sulfate concentration for the three ASI/IT samples analyzed for sulfate was 129 mg/l at sample location ASIT-20 (sample 1159). The lowest concentration was 14.3 mg/l at Weston sample location DD-23.

The highest concentration for nitrate was 10.9 mg/l at ASI/IT sample location ASIT-31 (sample 1168), which exceeds the primary MCL and the OAC standard for nitrate set at 10 mg/l. The second highest concentration level was 9.7 mg/l at ASI/IT sample location ASIT-30 (sample 1166). The lowest detectable nitrate concentration was 1.8 mg/l at Weston sample location DD-14.

2.3.2.3 Radionuclides and Gross Radioactivity

Samples collected from a total of 24 sample locations (7 from Weston and 17 from ASI/IT) were analyzed for the concentration of multiple radionuclides including thorium -232, -228, and -230; uranium -234, -235, and -238; radium -226 and -228; and gross alpha and gross beta radioactivity. The Weston surface water samples were not filtered prior to analysis, whereas the surface water samples collected by ASI/IT were analyzed prior to and following filtration. For proper comparison with Weston data, the unfiltered analysis for each ASI/IT sample will be used in this section. The differences in radionuclide concentrations between filtered and unfiltered samples is an important factor in the evaluation of alternatives, however, and will be discussed in Section 5.0.

DOE Order 5400.5 sets guidelines now in effect for the FMPC for the discharge of radionuclides. Concentrations established from these guidelines are called derived concentration guides (DCGs). The DCG is the concentration of a radionuclide in air or water (in this case water) that, under

conditions of exposure for one year by one exposure mode (i.e., ingestion of water), would result in an effective dose equivalent of 100 milirems (mrem).

The DCG for thorium-228 is 400 pCi/l. The concentration for thorium-228, -230, and -232 was not requested for six of the seven Weston sample locations. The sample from location DD-09 was analyzed for thorium-228, -230, and -232, with readings of 0.1 pCi/l, 1.4 pCi/l, and 0.1 pCi/l, respectively. These values are well within the limits set by DOE Order 5400.5. DOE DCGs for thorium-230 and -232 are 300 pCi/l and 50 pCi/l, respectively. For those samples from ASI/IT sample locations which were analyzed for thorium, the results indicate concentrations less than 1.0 pCi/l, which are well within the DOE guidelines.

Samples from all locations, except Weston, were analyzed for total uranium. The highest concentrations of total uranium from the WMCO data were found in the samples collected November 8, 1989 for sample locations 3 and 5, with 15.2 mg/l and 14.9 mg/l, respectively. The highest concentrations of total uranium from the ASI/IT data were found at sample locations ASIT-27 (sample 1203), ASIT-30 (sample 1166), and ASIT-31 (sample 1168), with concentrations of 9.4 mg/l, 8.4 mg/l, and 7.4 mg/l, respectively. The total uranium concentration levels for the remaining ASI/IT sample locations ranged from 0.02 mg/l to 5.8 mg/l.

As indicated from the data provided in the tables, the concentration of uranium varies. The reasons for the variations in the data could be attributed to the amount of rainfall runoff in a given location (at a given time) and the topography of the area, which would affect the flow from area to area and the settling of contaminated suspended solids. Because of flow, the concentration of uranium in one area is also affected by the concentration of uranium coming from another area.

The WMCO data for several sample locations were taken at different times during the year. WMCO sample location 27 had concentrations of uranium ranging from 0.454 mg/l to 11.30 mg/l. This variation in concentration levels could be attributed to the amount of runoff during that year. This sample location is located in such a way that drainage from Drainage Areas H and I, which are described in detail in Section 4.2.4 and located near the Production Area, serve to concentrate the uranium levels. WMCO sample locations 12 and 14 have low concentrations of uranium, which should be expected since their location basically is isolated from the Waste Pit Area and is not affected by drainage from Drainage Areas H and I. WMCO sample location 25 is upstream (flow wise) of sample location 26, but the concentrations do not vary by much (see Table 2-1).

The concentration of uranium is generally higher at sample location 26, which is probably due to drainage from the Waste Pit Area.

In observing ASIT sample points located within the same general area, three sets of sample points can be compared (since they were taken on the same day and are within the same general area).

ASIT sample locations 18 and 19 are located in the same general area (ASIT-18 is east of ASIT-19). The flow is westward and the contamination of uranium increases at ASIT-19 (0.7 mg/l at ASIT-18 verses 0.9 mg/l at ASIT-19). The slight increase in concentration is probably due to ASIT-19 receiving a small level of contaminants from Waste Pit 5. ASIT-23 and 24 can be compared to each other. The concentration of uranium at ASIT-23 is 0.4 mg/l and 0.6 mg/l at ASIT-24. These two sample locations are located south of Waste Pit 1, and concentrations do not vary. ASIT-30 and 31 can be compared with each other also. The concentration of uranium at ASIT 30 is 8.4 mg/l and 7.4 mg/l for ASIT-31; both are located in the proximity of Waste Pit 5. The concentrations of uranium for these two locations also do not vary by much.

As one compares data taken at different time periods, the concentrations will vary. This is due to the amount of runoff and the settling of sediments containing uranium.

The highest concentration of total uranium in surface water from the Dames and Moore data occurred at sample location SW-5, with a concentration of 26.6 mg/l. The total uranium concentration of the remaining sample locations ranged from 1.2 mg/l to 16.4 mg/l. Dames and Moore also analyzed surface water samples from drainage ditches in which sample location RO-8 had the highest concentration of total uranium of 34.0 mg/l. Sample location RO-8 is within Drainage Area C. The uranium concentration of surface water of the remaining sample locations ranged from 0.007 mg/l to 28.0 mg/l.

It should be noted that the conversion factor for pCi/l to µg/l is 1.49 µg/pCi for uranium. Also, 1 mg/l = 1000 µg/l.

The DOE DCG for uranium-234 is 500 pCi/l. Concentrations of uranium from two ASI/IT sample locations exceed this limit. Samples from locations ASIT-30 (sample 1166) and ASIT-31 (sample 1168) have measured concentrations of 653 pCi/l and 597 pCi/l, respectively. Concentrations measured for all other ASI/IT samples ranged between 10.3 pCi/l and 85.6 pCi/l and were well

within the guidelines. All of the Weston sample results are within the DOE guideline. The Weston concentrations ranged from 0.6 pCi/l to 160 pCi/l.

The uranium 235/236 DCG set by DOE is 600 pCi/l. All of the Weston sample concentrations for uranium-235/236 are well within this limit, ranging from 0.3 pCi/l to 21.0 pCi/l. Also, the ASI/IT uranium-235/236 sample concentrations are well within the DOE guideline, ranging from less than 1.0 pCi/l to 51.5 pCi/l.

The DOE DCG for uranium-238 is 600 pCi/l. Concentrations in excess of this limit were observed in a surface water sample from Weston sample location DD-07 at 740 pCi/l and in ASI/IT surface water samples from sample locations ASIT-30 (sample 1166) and ASIT-31 (sample 1168) with readings of 2840 pCi/l and 2506 pCi/l, respectively. The remaining Weston samples had uranium-238 concentrations ranging from 2.4 pCi/l to 310 pCi/l. The uranium-238 concentrations for the remaining ASI/IT samples ranged from 18 pCi/l to 364 pCi/l.

The DOE DCG for radium-226 and -228 is 30 pCi/l. Radium concentrations were measured at only one Weston sample location. The radium-226 and -228 concentrations for Weston sample location DD-14 were 7.0 pCi/l and 4.5 pCi/l, respectively, and are well within DOE guidelines. The radium-226 and -228 concentrations for samples from the ASI/IT sample locations are also well within the DOE guidelines. Detected concentrations for Ra-226 were 3.4 pCi/l at sample location ASIT-29 (sample 1112) and 1.1 pCi/l at sample location ASIT-28 (sample 1205). Concentrations found above the detection limit for Ra-228 are 10.0 pCi/l at sample location ASIT-28 (sample 1205) and 4.2 pCi/l at sample location ASIT-29 (sample 1112). All other ASI/IT sample locations indicate concentrations of less than 1.0 pCi/l for Ra-226 and less than 3.0 pCi/l for Ra-228.

The highest gross alpha and gross beta concentrations in surface water were observed at the Weston sample location DD-07 and were 850 pCi/l and 560 pCi/l, respectively. Gross alpha measurements in the other Weston samples ranged from 8 pCi/l to 450 pCi/l and the gross beta ranged from 13 pCi/l to 380 pCi/l. The gross alpha measurements for the ASI/IT samples ranged from 21 pCi/l to 362 pCi/l and the gross beta measurements ranged from 32 pCi/l to 362 pCi/l.

2.3.3 Summary

A review of the analytical data on storm water runoff within the waste pit area reveals a high degree of variability in concentration patterns. However, three sample locations are generally more heavily contaminated than the other sample locations: Weston sample location DD-07 and ASI/IT

sample locations ASIT-30 and ASIT-31. Sample location DD-07 had the highest concentration of TDS, at 1190 mg/l, which exceeded the applicable limit. Location DD-07 also had the highest concentrations of TOX and TOC. No limit is set for these parameters. Although location DD-07 did not have the highest concentrations of fluoride and uranium, the concentrations of 1.2 mg/l and 740 pCi/l, respectively, exceeded the applicable limits. This sample location had the highest concentration of gross alpha and gross beta, 850 pCi/l and 520 pCi/l, respectively. This sample location is located within drainage area G, downgradient from any likely contributions from the waste pits.

Sample location ASIT-30 had the highest concentration of chromium at 52.5 µg/l which exceeds the MCL of 50 µg/l for chromium, and had the second highest concentration of chloride at 60 mg/l, which did not exceed the applicable limit. This location had the highest concentration of uranium-234 at 653 pCi/l and uranium-238 at 2840 pCi/l, both of which exceed the DOE DCG of 500 pCi/l and of 600 pCi/l, respectively. This ASI/IT sample location is in drainage area D, between Waste Pits 3 and 5.

Sample location ASIT-31 had the highest concentration of nitrate at 10.9 mg/l, which exceeds the limit of 10 mg/l. Sample location ASIT-31 also had high concentration levels of uranium-234 at 597 pCi/l and uranium-238 at 2506 pCi/l, both of which exceeded the DOE DCGs of 500 pCi/l and 600 pCi/l, respectively. This sample location is also in drainage area D.

Concentrations from four other sample locations should be highlighted. Weston sample location DD-14 had the highest concentrations of TSS, at 2150 mg/l, which exceeds the applicable limits. Location DD-14 is located south of drainage area F and the K-65 silos. Surface water from Weston sample location DD-01 had a sulfate concentration of 317 mg/l, and a TSS concentration of 266 mg/l, both of which exceed the limits. This sample location is north of the railroad tracks, away from the waste storage area. The TSS loading may be the result of the cleared borrow area for Waste Pit 4 cover material located just upstream from this point. Also, Weston sample location DD-23 had high concentrations of TSS (although not as high as location DD-14) at 385 mg/l, which exceeds the applicable limit. In addition, Weston sample location DD-09 had high concentrations of TSS at 148 mg/l and fluoride at 1.3 mg/l, both of which exceed the applicable limits. Location DD-09 is located at the south end, downstream of drainage area D.

Since some of the highest values for many parameters analyzed occurred around drainage area D, it can be concluded that this area and the corresponding surface water runoff and drainage ditches

would be the most contaminated. This is an expected result since drainage area D is downgradient from the waste pits, considered to be the principal source of contaminants to storm water runoff. The concentration of uranium increases in samples downstream of the pits, and the measured uranium isotopic content of surface water samples indicates that the uranium is depleted (i.e., less than 0.7 percent uranium-235 by weight). It is not possible, however, to conclusively differentiate any loadings resulting from direct surface water contributions and those from seeps from the pits. Sampling points ASIT-30 and ASIT-31 along Pit 5 indicate the increased potential for contaminant releases via seeps.

2.4 SITE CONDITIONS THAT JUSTIFY A REMOVAL ACTION

The threats posed by the off-site migration of uranium in the storm water runoff from the waste pit area are of a non-time-critical nature; i.e., based on the site evaluation there is a planning period of greater than six months available before on-site activities must begin. The eight factors to be considered in determining the appropriateness of a removal action, as listed in Section 300.415 of the NCP, are:

1. Actual or potential exposure to hazardous substances or pollutants or contaminants by nearby populations, animals, or food chains
2. Actual or potential contamination of drinking water supplies or sensitive ecosystems
3. Hazardous substances or pollutants or contaminants--in drums, barrels, tanks, or other bulk storage containers--that may pose a threat of release
4. High levels of hazardous substances or pollutants or contaminants in soils, largely at or near the surface, that may migrate
5. Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released
6. Threat of fire or explosion
7. Availability of other appropriate federal or state response mechanisms to respond to the release
8. Other situations or factors that may pose threats to public health or welfare and the environment

Of the eight factors to be considered, the potential resulting contamination of drinking water supplies or sensitive ecosystems from this migration, and the associated potential exposure to these contaminants by various receptors, establish the justification for a removal action. The off-site migration of radiological or hazardous substances or pollutants as a result of uncontrolled storm

water runoff from the waste pit area, as reflected in 4 and 5 above, are also relevant to the waste pit area storm water runoff control removal action.

Natural drainage from the waste pit area is primarily westward toward Paddys Run. Storm water runoff from this area carries concentrations of uranium in excess of the DOE DCG for surface water releases. Upon entering Paddys Run, the potential exists for these contaminants to migrate to the Great Miami Aquifer. This aquifer is within the buried valley aquifer of the Great Miami River Basin, which has been designated as a Sole-Source Aquifer by the EPA under Section 1424(e) of the SDWA (EPA 1988). Under this designation, the Regional Administrator of Region V of the EPA has determined that this aquifer is the sole or principal source of drinking water for this area. Contamination of Paddys Run and/or the underlying aquifer may pose potential exposure risks to public health and the environment.

2.4.1 Release Mechanisms

If left uncontrolled, contaminants from the surface of the waste pit area could migrate via storm water runoff westward toward Paddys Run. This migration of radionuclides to Paddys Run is a direct function of the amount of storm water runoff from this area. The flow of storm water runoff from the waste pit area, if averaged over an annual cycle, is estimated to be 23 gallons per minute (gpm) (WMCO 1987). Water from Paddys Run can directly enter the regional aquifer through the highly permeable sediments of the creek. Additionally, surface waters in the waste pit area itself may leach into the underlying till and eventually reach the regional aquifer. However, only the control of surface water runoff to Paddys Run is being considered under this removal action. The infiltration of surface waters within the waste pit area may be concomitantly reduced depending on the removal action alternative selected, but this is not an explicit objective of the removal action. Groundwater issues are being addressed under the RI/FS for both the waste storage units (Operable Unit 1) and the environmental media (Operable Unit 5).

2.4.2 Environmental Fate

As described in the previous section, contaminated storm water runoff from the waste pit area migrates toward Paddys Run. Upon release to the stream, the uranium concentrations would be less than at the site boundary due to dilution by the stream. In addition, some of the contaminants in Paddys Run surface water may adhere to the stream sediments. Surface water contaminants may also be transferred to the groundwater, again at lesser concentrations due to dispersion and dilution within the aquifer.

2.4.3 Potential Risks

Risks of potential health effects for off-site personnel require the presence of contaminants that pose either a radiological or chemical hazard, pathways for potential exposure, and human and environmental receptors. Each of these components is summarized in the following sections (and presented in detail in Appendix C) for the contaminated storm water runoff from the waste storage area.

2.4.3.1 Contaminants of Concern

Storm water data collected to date from the site drainage ditches indicate the presence of radionuclides and metals in the storm water runoff from the waste pit area. Several data exceed established concentration guidelines or limits, but most exceedances are sporadic and within the range of uncertainty in the data. Only uranium represents a potential concern to public health or the environment. For this reason, uranium has been designated as the contaminant of concern for the storm water runoff control removal action. All considered actions that account for public health and environmental protection against uranium would also provide protection against other radionuclides and chemicals, due to the low levels present. Section 2.0 of Appendix C presents additional information regarding determination of chemicals of potential concern.

Uranium is a radiocarcinogen and a chemical toxin. Insoluble uranium compounds primarily pose a radiological hazard resulting from inhalation. Soluble uranium compounds pose both chemical and radiological hazards from ingestion or inhalation. If ingested at sufficiently high rates, these compounds can lead to kidney damage and arterial lesions. Other potential adverse health effects that can result from ingestion of soluble uranium compounds are damage to the cardiovascular, hematopoietic, endocrine, and immunological systems. Section 4.0 of Appendix C presents a detailed toxicity assessment for uranium.

2.4.3.2 Exposure Pathways

Exposure to the contaminants in the storm water runoff can occur as a result of the release of these contaminants to Paddys Run. The contaminants may then be discharged from Paddys Run to the Great Miami River or the underlying sand and gravel aquifer. Paddys Run is not used as a drinking water supply. Ingestion of sediment from the stream is considered a pathway for children. Ingestion of groundwater from the aquifer underlying Paddys Run is an additional potential exposure pathway. Other exposure pathways associated with the groundwater include ingestion of

crops irrigated by the water, ingestion of beef from cattle exposed to uranium through water and crops, and ingestion of milk from cows exposed to uranium through water and crops.

Environmental receptors in Paddys Run include benthic macroinvertebrates and fish. The most common macroinvertebrates in Paddys Run are the non-biting midges (Chironomidae), riffle beetle (*Stenelmis* sp.), mayfly (*Caenis* sp.), and stonefly (*Allocapnia* sp.). Also common are isopods (*Lirceus fontinalis*), caddisflies (*Cheumatopsyche* sp. and *Hydropsyche* sp.), oligochaetes, and blackflies (*Simulium* sp.). The most abundant fish are the bluntnose minnow (*Pimephales notatus*), creek chub (*Semotilus atromaculatus*), and stoneroller minnow (*Campostoma anomalum*). Aquatic vascular plants (e.g., cattails [*Typha* sp.] and sledges [*Carex* sp.]), as well as algae also occur along Paddys Run.

The potential exposure pathways associated with the surface waters of the Great Miami River include direct ingestion as drinking water, ingestion of plants after use of the water for irrigation, and ingestion of meat or milk from livestock exposed to the surface water through direct intake or from irrigated crops. This secondary pathway is also considered in detail for the storm water runoff removal action.

2.4.3.3 Potential Receptors

There is no known use of groundwater with uranium levels exceeding the derived concentration limit of 30 µg/l from the area influenced by infiltration from Paddys Run into the Great Miami Aquifer for drinking water, feedstock watering, or crop irrigation. Residences along Paddys Run Road to the west reportedly use cisterns with imported water. Groundwater monitoring results from commercial and residential wells along New Haven Road in or near the Village of Fernald indicate no elevated levels of uranium in the water supply. These results indicate that the uranium plume either is not present at the level of aquifer pumping or has not yet migrated to these locations. The only known users of groundwater with uranium levels exceeding the derived concentration for uranium in drinking water are the industries located along Paddys Run Road southwest of the projected center of the plume. One of the two industries treats the water to remove uranium and other radionuclides and chemicals prior to its use. Untreated water at the two industries is not used for drinking water supplies or for other purposes that represent a significant risk to users.

Potential future receptors of the uranium in groundwater south of the FMPC include the following:

- Persons who pump groundwater for potable use, crop irrigation, or livestock feeding from areas not currently impacted but located along the future migration pathway of the plume.
- Persons who would use surface waters into which contaminated groundwater has been discharged following pumping.
- Persons who would install a new well for potable use, crop irrigation, or livestock feeding from an area within the plume.

3.0 REMOVAL ACTION OBJECTIVES

The principal objective of the removal action for storm water runoff control in the waste storage area is to reduce or mitigate the release of uranium and other contaminants to Paddys Run, thereby reducing the potential threat to the public and the environment from those exposure pathways associated with such releases. This and other objectives are further defined in Sections 3.1 through 3.3 in terms of response authority scope and purpose and compliance with ARARs and other criteria, advisories and guidance to be considered (TBCs).

3.1 RESPONSE AUTHORITY

Authority for responding to releases or threats of releases from a hazardous waste site is addressed in Sections 104 and 106 of CERCLA. Executive Order 12580 delegates Section 104 response authority to the Secretary of Energy for DOE sites. However, EPA maintains response authority if an action is carried out in response to a Section 106 enforcement order. The waste pit area removal action is being conducted under the 1990 Consort Agreement and Section 300.415 of the NCP which contains CERCLA's removal action authorities.

3.2 SCOPE AND PURPOSE

The scope of the proposed removal action can be broadly defined as management of radioactively contaminated storm water runoff from the waste storage area. The area includes six waste pits, a burn pit, the Clearwell, four concrete silos, and surrounding areas including approximately 20 acres. As discussed in Section 2.4.3.1, the only contaminant of concern for the storm water runoff control removal action is uranium.

The fundamental objective of the removal action for the storm water runoff control is to protect public health and the environment by controlling the release of storm water runoff to Paddys Run with uranium concentrations exceeding the DOE DCG values for surface water discharge of 600 pCi/l for uranium-238 and -235, and 500 pCi/l for uranium-234. The sum of the ratios of the observed concentration of each radionuclide to its corresponding DCG must not exceed 1.0. Related objectives, founded on other risk-based levels for various potential exposure scenarios, include the protection of biotic environments in Paddys Run and the mitigation of contaminants from surface water to the underlying aquifer.

As will be discussed in Section 5.0, the removal action alternatives being considered for the storm water runoff control would satisfy these objectives to varying degrees; therefore, the final selection

of the preferred removal action would balance the effectiveness of each alternative in satisfying these objectives against other decision factors judged to be of particular importance for the problem-specific conditions. Potential adverse impacts of each alternative will also be considered. This selection strategy is being executed so as not to hinder or foreclose viable options for a long-term remedial action for the waste storage area that would fully satisfy all ARARs established for the corresponding operable unit.

3.3 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED

Section 300.415 (i) of the NCP requires that removal actions attain, to the extent practicable considering the exigencies of the situation, a level or standard of control which is applicable or relevant and appropriate to any hazardous substances, pollutants, or contaminants that would remain on site. Other federal and state criteria, advisories, and guidance shall, as appropriate, be considered in formulating the removal action.

Three classifications of ARARs are considered. These include: 1) contaminant-specific ARARs, 2) location-specific ARARs, and 3) action-specific ARARs. Contaminant-specific ARARs address the acceptable amount or concentration of a specific pollutant that may be found in or discharged to soil, water, and air. Location-specific ARARs are based on the specific setting and nature of the site, and action-specific ARARs relate to technology- or activity-based requirements or limitations on the specific response actions taken with respect to the type of wastes. Additionally, three types of TBCs are considered and include: 1) health effects information with a high degree of credibility, 2) technical information on how to perform or evaluate site investigations or remedial actions, and 3) policy.

The identification of potential ARARs and TBCs for the storm water runoff control removal action will be based on the nature of the contamination (radioactively contaminated runoff), the location of the site (within a populated groundwater usage area and within 1.5 miles of the Great Miami River), and the technical scope of the identified removal action alternatives. A summary of these ARARs and TBCs and a discussion of their pertinence to the proposed alternatives are included in Section 5.0.

4.0 REMOVAL ACTION ALTERNATIVES

4.1 DEVELOPMENT OF INITIAL ALTERNATIVES

The objective of the subject removal action is to control the release of contaminated storm water runoff from the waste pit area into Paddys Run. While numerous technologies can be identified as potentially applicable and appropriate to at least partially satisfy this objective, the overall response actions are limited to the following: remove the source of the contaminants; leave the source in place but prevent the release of contaminants into the storm water runoff; and allow the runoff to be contaminated but prevent its release into Paddys Run. The most applicable and appropriate technology for preventing the release of contaminants into the surface runoff is to cap the source materials so that the necessary contact between surface runoff and the contaminants is eliminated. A responsive remedy for preventing the release of contaminated runoff to Paddys Run is to collect the runoff at the downstream end of the drainage area and to provide for adequate treatment prior to discharge to a receiving stream.

In addition to these three baseline alternatives for the storm water runoff removal action, two other alternatives were considered necessary to satisfy the full range of technical and program issues. One is an augmentation of the capping alternative to include a lateral drainage collection sump. This alternative is formulated to more proactively control all the contaminated water; in this case, the subsurface lateral flow resulting from residual infiltration through the cap. The other alternative is the no-action alternative, since it provides a baseline condition against which other alternatives can be compared.

Based on this discussion, the following five alternatives form the initial set of alternatives for the storm water runoff control removal action:

- Alternative 1: No Action
- Alternative 2: Surface Capping
- Alternative 3: Surface Capping with Lateral Drainage Sump Collection
- Alternative 4: Runoff Collection and Treatment
- Alternative 5: Source Removal

4.2 DESCRIPTION OF REMOVAL ACTION ALTERNATIVES

A description of each proposed removal action is provided in the following sections.

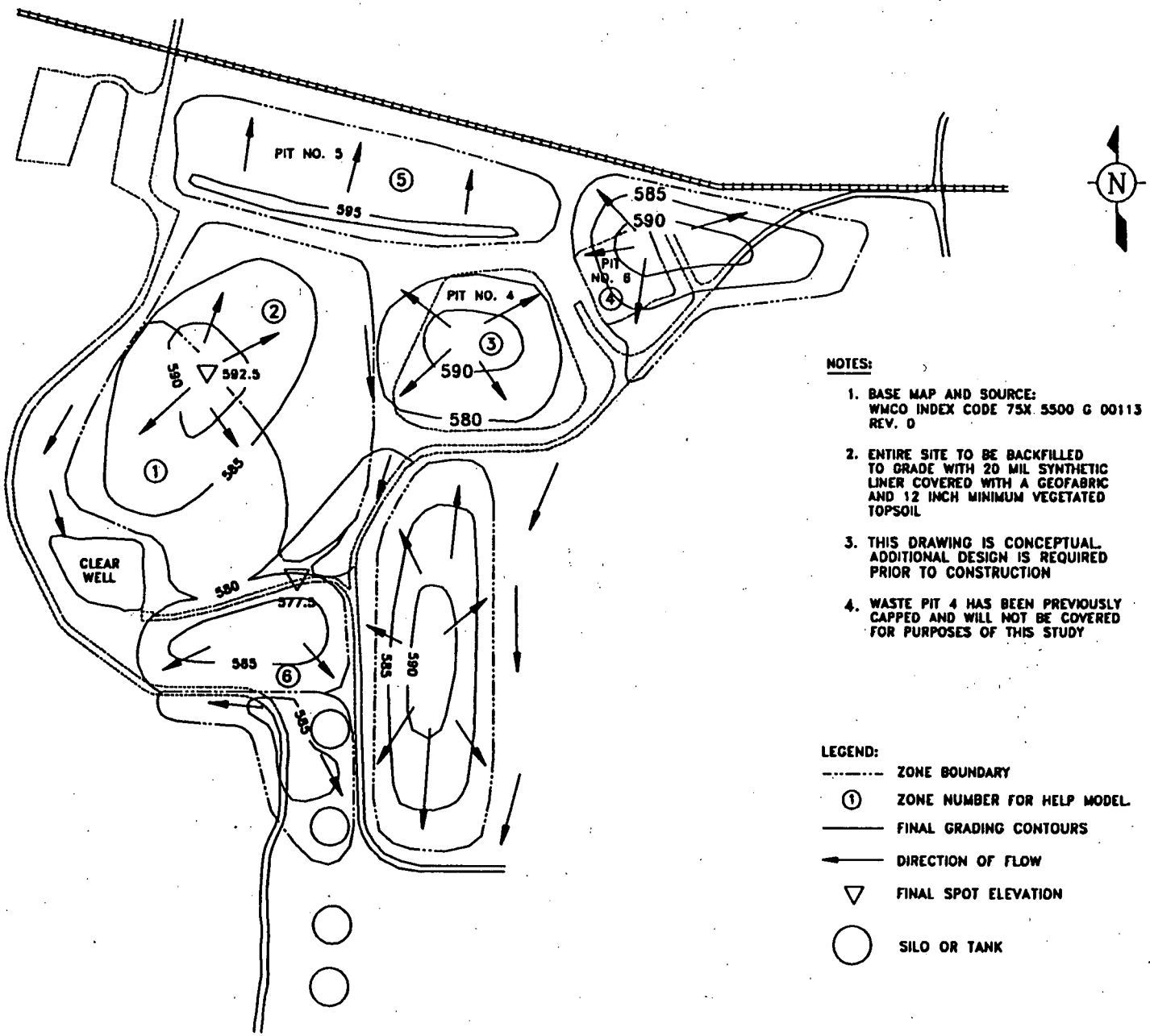
4.2.1 Alternative 1 - No Action

Under the no-action alternative, no additional abatement, remediation, treatment, or security activities would occur at the waste pit area. The relative risk to the public and the environment would remain relatively constant to what is currently present. Any reduction in contamination would be brought about by natural phenomena such as radioactive decay and removal of contaminated soil through erosion. This alternative is being considered as a baseline for comparison with the other alternatives.

4.2.2 Alternative 2 - Surface Capping

This alternative consists of constructing a cap over the surface of the waste pit area to minimize the contact of rainwater with the contaminated soil. The majority of the water would be routed away from the waste pit area for direct discharge into Paddys Run. A small volume of water would be introduced to the contamination via continued infiltration through the cap. The capping system will cover the portions of the waste pit areas located in Drainage Areas B, C, D, E, F, J, and K, as shown in Figure 4-4. The approximate limits of the liner area are shown on Figure 4-1. The basic reasons for this are that the grading of the area and construction of the liners over the entire area would be easier as one continuous placement instead of several separate areas, and would cover unidentified contaminated areas. The site will be graded at a slope of approximately 5 percent to provide proper drainage (Figure 4-1). Waste Pit 4 was covered with an interim cap in 1988. The interim cap consisted of a compacted clay layer and a synthetic liner. This design is adequate for the prevention of runoff contacting contaminated soil; therefore, a new cap will not be placed over Waste Pit 4 as part of this removal action. Before capping Waste Pits 5 and 6, sludge in these pits will be stabilized using a fixative agent such as fly ash. Sludge solidification and capping of these two pits are included due to the release of contamination into Paddys Run, not from runoff due to overtapping, but rather from potential seeps from these two pits.

The additional drainage areas will not be capped since any contamination from these areas are attributed to residual contamination from the source (the waste pits). Capping the source will reduce the release of additional contamination to these other drainage areas and reduce infiltration of storm water into the waste areas. Although contamination exists in the other drainage areas, the fact that the source of the residual contamination will be prevented from releasing additional wastes, and that excessive costs are associated with capping the entire area, a justification cannot be made to cap the entire site for a temporary removal action. Based on the volatile and/or reactive content of materials in the waste pits, consideration will be given to the potential for off-gas build-up and installation of a vapor venting system. In order to reduce the potential for worker exposure and to



NOTES:

1. BASE MAP AND SOURCE: WMCO INDEX CODE 75X 5500 G 00113 REV. 0
2. ENTIRE SITE TO BE BACKFILLED TO GRADE WITH 20 MIL SYNTHETIC LINER COVERED WITH A GEOFABRIC AND 12 INCH MINIMUM VEGETATED TOPSOIL
3. THIS DRAWING IS CONCEPTUAL. ADDITIONAL DESIGN IS REQUIRED PRIOR TO CONSTRUCTION
4. WASTE PIT 4 HAS BEEN PREVIOUSLY CAPPED AND WILL NOT BE COVERED FOR PURPOSES OF THIS STUDY

LEGEND:

- ZONE BOUNDARY
- ① ZONE NUMBER FOR HELP MODEL
- FINAL GRADING CONTOURS
- DIRECTION OF FLOW
- ▽ FINAL SPOT ELEVATION
- ○ SILO OR TANK

FIGURE 4.1 ALTERNATIVE 2 SURFACE CAPPING

minimize waste generation, no soil will be excavated; rather, grading will consist of additional soil placed on the existing surface.

In order to maximize the effectiveness of this alternative, three subalternatives were considered. They are presented below:

1. Compacted clay cap - this type of cap consists of a 24-inch-thick clay cap compacted in 6-inch layers. The desired compaction is to a permeability of 10^{-7} cm/s. This cap will be overlain with 12 inches of topsoil (local soil from the Fincastle series) to protect the clay cap moisture content and to provide an evaporative zone and root structure system. This layer of soil will be planted with native grass such as Kentucky bluegrass and fescue. The cap will be graded to promote drainage.

2. Synthetic liner cap - this type of cap consists of a 20-mil synthetic liner in place of the 24-inch-thick clay cap. The liner will have heat-welded seams and be anchored in place. A layer of geotextile will be placed beneath and above the synthetic liner. This will be covered with a minimum of 12 inches of local topsoil. A vegetation cover, similar to subalternative 1, will be provided.

3. RCRA cap - this type of cap has a construction profile similar to caps designed to satisfy RCRA closure requirements. The cap generally consists, from bottom to top, of a 24-inch-thick compacted clay layer, a 20-mil synthetic liner, a 12-inch sand layer for lateral drainage, a geofabric, and a 12-inch layer of vegetation topsoil.

Each of the subalternatives were evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) model to quantitate the amount of infiltration to the contaminated soil. This infiltration is assumed to contact the soil and travel laterally to Paddys Run. In order to properly evaluate the flow, the waste pit area was broken into separate drainage zones. Zone 1 is an area of approximately 1.67 acres consisting of Pit 1, the southern section of Pit 2, and the southern section of Pit 3. All drainage is designed to drain via natural topographic features. Since this cap, as well as other cap areas, will be overlain with vegetated topsoil, no increase in net runoff volume will be expected. Zone 2 consists of the northern sections of Pits 2 and 3 and the burn area comprise approximately 1.8 acres. Drainage is based on existing natural contours, so drainage is north and southeast. Southeast drainage is discharged to the Clearwell. Zone 3 (1.12 acres) is the outline of Pit 4 which was properly capped in a previous interim corrective action. Zone 4 consists of Pit 6 and the area northeast of Pit 6 and is approximately 2.1 acres. Waste Pit 5 (1.6 acres) comprises Zone 5. The area south of the waste pit area comprises Zone 6 (2.2 acres). The zones are illustrated in Figure 4-1. The RCRA cap had the least amount of annual volume of infiltration

(513 ft^3 cumulative), followed by the liner cap (16,117 ft^3 cumulative), and the clay cap (37,843 ft^3 cumulative) as calculated from the HELP model output. A liner leakage fraction of 0.005 was used to simulate a worst-case scenario due to seam leaks, net infiltration, and potential installation damage. This resulted in a net infiltration volume of 0.58 inch.

In evaluating which subalternative was the most desirable, several factors were considered. Clay soil with little sand material and appropriate permeability characteristics would be required to construct the clay cap. This material would most likely have to be brought in from an off-site source which would greatly increase the cost. These costs include the cost of transportation and decontamination of trucks leaving the waste pits. Additionally, more infiltration would occur than with the synthetic liner.

The synthetic liner cap could use on-site soil for grading since the permeability of the cap is based on the liner properties. This subalternative is superior to the clay cap in removing infiltration and would require the least construction time of the three subalternatives. A detail of this capping system is shown in Figure 4-2.

The RCRA cap would provide an effective solution to infiltration, but would have the highest cost since it would be a combination of the costs of the other subalternatives. As an interim measure, the incremental costs could not be justified. Therefore, the synthetic liner cap was chosen. Additionally, if a final remedial action option was removal, the only contaminated material would be the synthetic liner, which would comprise a small (<1 percent) percentage of the total material removed. Additionally, it would enhance any final remedial action which involved capping.

4.2.3 Alternative 3 - Surface Capping with Lateral Drainage Sump Collection

The surface capping with lateral drainage consists of the use of Alternative 2 with a lateral drainage collection sump. This alternative, shown in Figure 4-3, would intercept all subsurface lateral flow resulting from infiltration through the cap from rainfall. The flow would be collected in an accumulation trench downgradient from the cap. The trench would be sloped to a central collection sump. Lateral flow would be pumped out of the sump on a routine basis from a riser pipe to the Biodenitrification Surge Lagoon. Suspended solids would settle here prior to treatment through the biodenitrification towers and effluent water treatment system. The treated water would then be discharged to the Great Miami River through Manhole 175. The use of the combined cap and

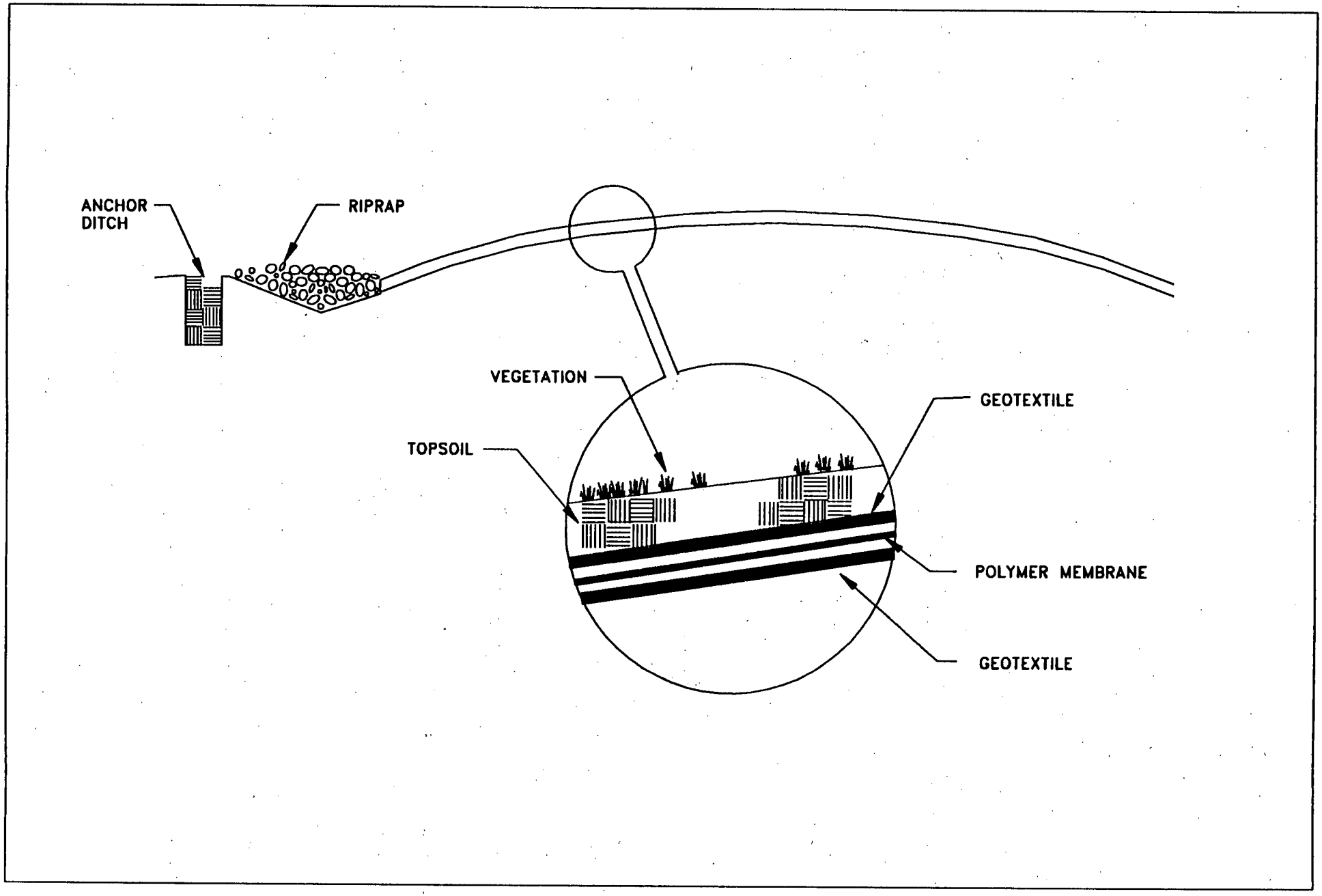


FIGURE 4-2. ALTERNATIVE 2 - COVER PROFILE

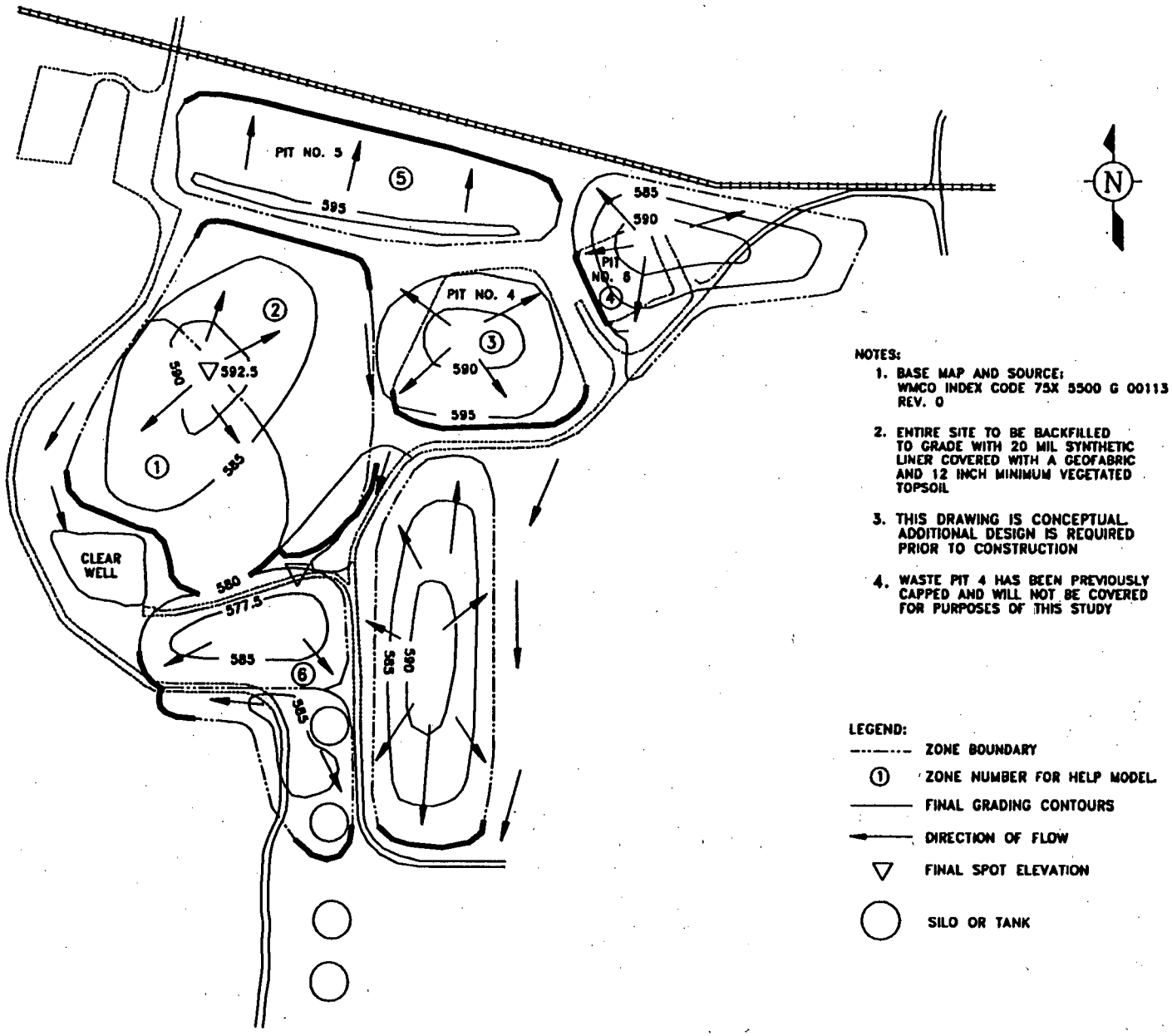


FIGURE 4-3. ALTERNATIVE 3 - CAPPING WITH SUBSURFACE DRAINAGE COLLECTION

collection sump would eliminate the potential release of contaminated infiltrated rainwater from reaching Paddys Run.

4.2.4 Alternative 4 - Runoff Collection and Treatment

This alternative incorporates planned separation of drainage areas within the waste pit area, thus isolating contaminated from noncontaminated storm water runoff, as shown in Figure 4-4 (located in end pocket). Contaminated water will be collected in the existing Clearwell and in a new collection sump and pumping station that will be located south of the Clearwell. Drainage flow control devices will be installed upstream of drainage channels located in the waste pit storage area to restrict peak flows to the new pumping station. The new system will pump the collected runoff to the Biodenitrification Surge Lagoon, where suspended solids would be allowed to settle prior to processing through the biodenitrification towers and effluent water treatment system and before discharge to the Great Miami River through Manhole 175. A pilot scale waste water treatment system will be installed to demonstrate technologies applicable to the future 1100 gpm Advanced Waste Water Treatment System. The demonstration unit will be designed to treat 10gpm of a waste water discharged from the Biodenitrification Surge Lagoon (BSL) with an initial concentration of 1 ppm total uranium to a final effluent concentration of 20 ppb. The facility is planned to be brought on line in March 1991. A Process Flow Diagram (PFD) for this alternative is shown in Figure 4-5 (located in end pocket).

Drainage Area A is expected to be a relatively noncontaminated area if isolated from storm water runoff from adjacent areas. Isolation of Drainage Area A will require modification of existing drainage structures and topography. Prevention of channelized flows from Areas H and I from entering Area A was accomplished in October 1988 by plugging existing culverts and ditches and diverting this flow to the existing underground process area storm sewer. This action significantly reduced total uranium values in subsequent storm water runoff. Flow from Areas C and E will be diverted from Area A by plugging existing ditches and culverts. Diverting overland flow of Area F from entering Area A will require a combination of berms and ditches. A fill area and earthen berm will be required in the area between the metal oxide tanks and the Biodenitrification Surge Lagoon to prevent flow from Area A into Area C. The south end of Area A has an existing utility pipe trench. Storm water runoff from Area A will be diverted under this utility trench. A culvert will be constructed under this trench to direct runoff from Area A southward to an unnamed tributary of Paddys Run.

Drainage Area B is presently collected in the Clearwell. There is some channelized flow along the west side of Area B that enters the northwest corner of the Clearwell through a 12-inch pipe. Present plans are to leave Area B as it exists. Any of the waste pit area that is not presently collected in the Clearwell will be collected in the new perimeter area collection system and sump.

Drainage Area C is the perimeter area on the southeast side of the waste pits. A new sump will be located at the low point of Area C south of the Clearwell. Runoff from Areas D, E, and F will run through Area C and collect in the new sump. The required isolation of Area C is accomplished by existing topography. An outlet culvert discharging to Paddys Run will be plugged and flow will be diverted by a ditch to the new sump. A culvert within Area C currently drains the area west of the Biodenitrification Surge Lagoon under a roadway and directs flow west to Paddys Run. The existing culvert will be modified to provide watershed storage east of the roadway. The restriction will be designed to detain the peak of an anticipated 25-year design frequency storm event. The restriction culvert will be designed to release at a determined maximum rate and be equipped with overflow considerations to protect against upstream flooding.

Drainage Area D is the waste pit perimeter area to the west of the waste pits. Existing topography of Area D allows a large portion of runoff to enter Area G. Correcting this problem will require a combination of berms and ditches along the west side of Area D. The new ditch in Area D will discharge to the main sump at the downstream end of Area C.

Drainage Area E is the perimeter area to the north of the waste pits. Existing topography of Area E allows channelized flow from east to west along the north side of Pit 5. A ditch block will be installed at the west end of Area E in order to direct the flow into Area D and then to the new sump. A ditch plug and flow diversion will be installed at some point along the railroad at the east end of Area E to direct flow to the northwest.

At the western portion of Drainage Area E, where flow will be directed to Area D, a restriction culvert will be placed. In an effort to keep the volume of the new sump and size of the new pumps to a minimum, some watershed storage will be required to reduce the peak discharge for an anticipated 25-year storm event. The restriction culvert will be designed to release at a maximum determined rate as well as be equipped with overflow consideration for upstream flooding protection. This flow restriction will create a temporary detention basin in drainage area E. Steps will be taken to ensure that a maximum permeability of 1×10^{-7} cm/sec exists in this area.

Drainage Area F is the perimeter area of the K-65 silos. A perimeter collection system composed of a combination of ditches and berms will be required around Area F on all sides but the north. Runoff on the north side will be allowed to flow directly to Area C. The perimeter ditch and berm collection system will direct flow along both sides of the silos from the high point on the east side of Area F near the pipe trench.

Drainage Area G is the area west of Area D. Area G covers a section of Paddys Run. By controlling the runoff from the waste pit area, no additional contamination will be discharged into Area G.

Drainage Areas H and I lie within the production area fence line. Grab samples of this runoff indicate levels of uranium that are greater than the DOE DCGs. Drainage Areas H and I were diverted into the existing production area storm sewer system in October 1988, and no longer affect Drainage Area A. Runoff from the Plant 1 storage pad previously flowed thru area H to area A. The remaining runoff from Area A will be acceptable for discharge to Paddys Run.

Drainage Area J currently drains to Area C through a culvert under a roadway. The existing culvert will be modified to provide detention east of the roadway. Steps will be taken to ensure that a maximum permeability of 1×10^{-7} cm/sec exists. Part of the K-65 silo mound originally in Drainage Area F is now included in this area, due to existing topographical features.

Drainage Area K is a new drainage area for Waste Pit 4. Existing topography of Area K directs runoff into Drainage Area J. No modifications are required for Drainage Area K.

In addition to the above required modifications, ongoing and scheduled upgrades of associated on-site wastewater treatment systems are being implemented. These upgrades include the addition of a high-nitrate tank to accommodate volumes of high-nitrate wastewater from the general sump. These high-nitrate wastewaters will be proportionally mixed with wastewaters stored in the Biodenitrification Surge Lagoon. The current biotreatment tower operation of the biodenitrification facility is being upgraded from a two- to a four-tower operation that will accommodate the increased flows from the storm water collection in the waste pit area. An effluent water treatment system will also be implemented that will allow effluent to be sent directly to Manhole 175 and not to the FMPC Sewage Treatment Plant. The effluent treatment for the biodenitrification facility will be a stand-alone, pre-engineered packaged activated sludge treatment system capable of reducing the effluent concentrations of both five-day biochemical oxygen demand (BOD_5) and total suspended

solids (TSS) below 30 mg/L daily average and 45 mg/L daily maximum. The system will be sized to treat low, normal, and high flows (70, 110, and 200 gpm) for the biodenitrification facility. Current flows contributing to the BDN facility are shown in the Block Flow diagram, Figure 4-6. The expected flows resulting from additional storm water collection for Alternative 4 and associated upgrades to the facility are shown in the Block Flow diagram, Figure 4-7.

In addition to the upgrades associated with the BDN facility, the future proposed addition of the AWWT is intended to treat FMPC wastewater discharge to Manhole No. 175 to meet best available technology (BAT) for the removal of radioactivity. DOE Order 5400.5 requires BAT as the required level of treatment for liquid wastes containing radioactive material for stream that contain quantities radioactivity in excess of this order. The streams targeted for treatment are the general sump, biodenitrification facility, sewage treatment plant, waste pit perimeter area, and Storm Water Retention Basin (SWRB). The FMPC's targeted treatment technologies are ion exchange, or reverse osmosis, or a combination of both whichever provides BAT treatment. The final design will be based on treatability studies that are presently being conducted. The FMPC has completed bench scale studies which showed that ion exchange and reverse osmosis are capable of removing uranium. The FMPC is in the process of awarding a contract for testing an onsite demonstration unit. This unit shall provide performance data on ion exchange and reverse osmosis.

The FMPC is also moving forward on the design effort for this facility. Presently, the FMPC is conducting Title I design for the AWWT Facility. This facility is scheduled for completion in the first quarter of FY1994. The AWWT Facility is proposed to treat a total of 1100 gallons per minute (gpm). This treatment flow is comprised of 700 gpm for treatment of the discharge of the SWRB and 400 for treatment of other streams including process wastewater. The waste pit runoff would be handled as part of the process wastewater. The 700 gpm system will include all of the equipment of the 700 gpm system with the addition of reverse osmosis. This facility is designated to treat to a level of approximately 20 parts per billion of uranium.

The FMPC obtained a new National Pollution Discharge Elimination System (NPDES) permit (No. 1I000004*BD) on February 12, 1990. This permit will expire on February 9, 1995.

4.2.5 Alternative 5 - Source Removal

The final alternative to minimizing the release of contaminated runoff from the waste pit area into Paddys Run is the source removal alternative. This alternative would consist of removing all

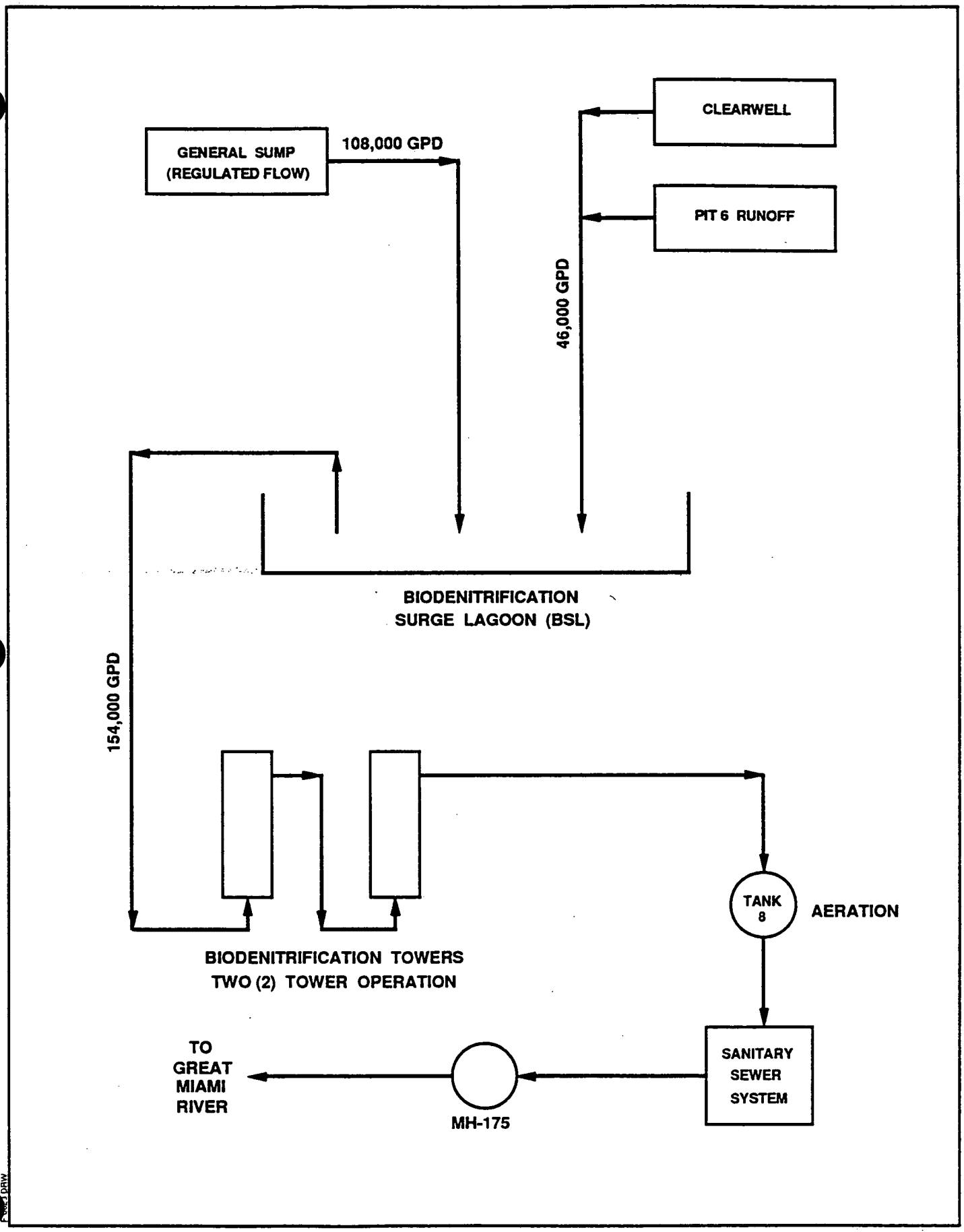


FIGURE 4-6. BLOCK FLOW DIAGRAM - EXISTING FLOW CONFIGURATION THROUGH DEMONSTRATION BIODENITRIFICATION FACILITY

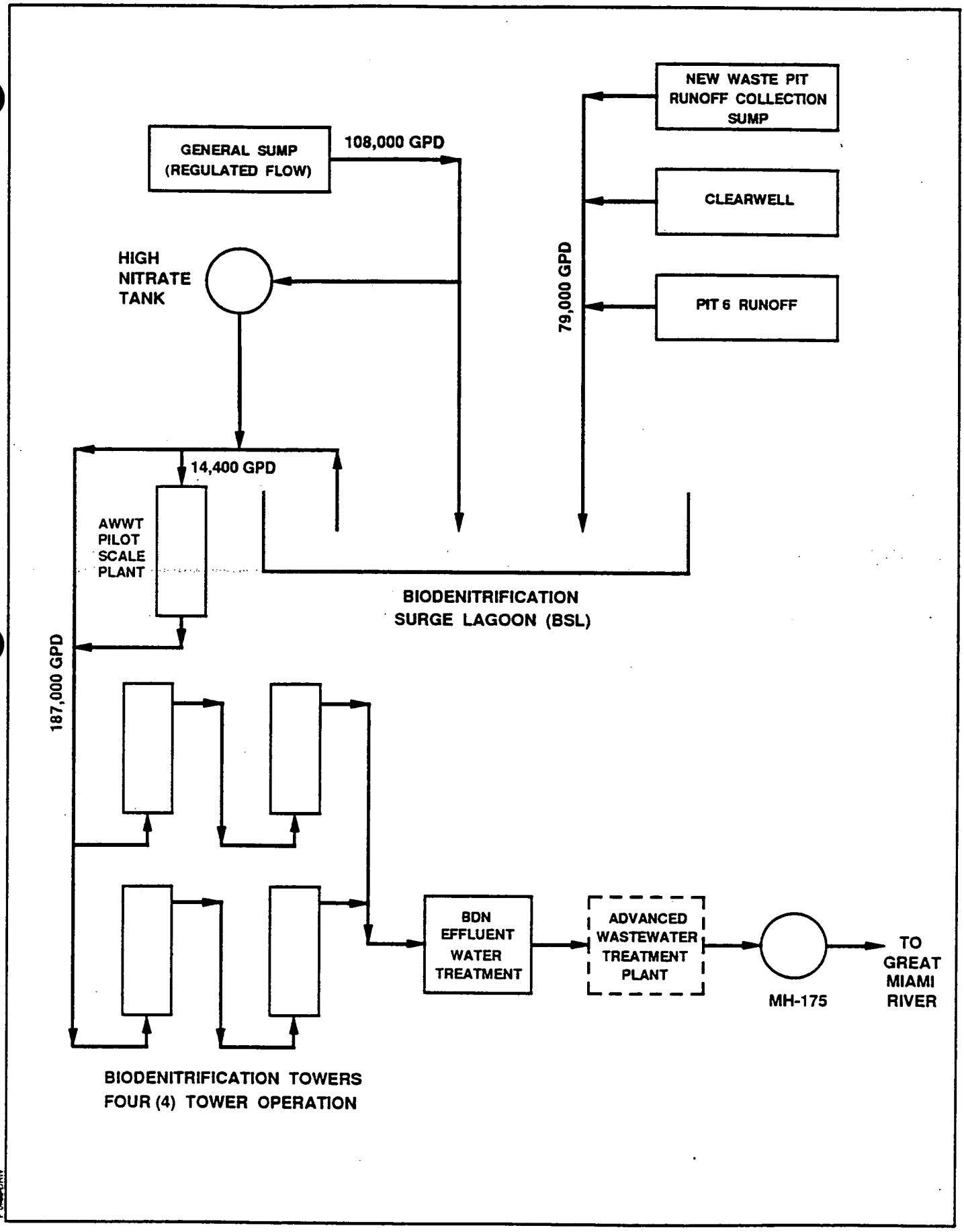


FIGURE 4-7. BLOCK FLOW DIAGRAM - ALTERNATIVE 4 - PROPOSED FLOW CONFIGURATION THROUGH PRODUCTION BIODENITRIFICATION FACILITY

disposed waste and contaminated soil and regrading the site with clean fill. An estimated 444,500 cubic yards of waste and 58,900 cubic yards of contaminated soil would have to be excavated, packaged in waste disposal boxes, and disposed at an approved facility. The removal of the source would eliminate the threat of contaminated runoff entering Paddys Run via the waste pit area.

4.3 SCREENING OF ALTERNATIVES

The five alternatives for the storm water runoff removal action were subjected to an initial screening to ascertain if any could be eliminated from further consideration prior to the detailed evaluation phase. The capping alternative and the runoff collection and treatment alternative were judged to be sufficiently effective and implementable as removal actions to warrant further evaluation in this EE/CA. The no-action alternative was further evaluated as a baseline.

The increased effectiveness introduced by the lateral drainage collection system in Alternative 3 was not considered sufficient to offset the increased cost required for its implementation. In particular, there is no assurance that all infiltration through the cap would move horizontally to the collection system. Additionally, the contaminant loading to Paddys Run would not be significantly improved and probably would not justify the additional $1,490,000 in expenses. The implementation of this additional component could, therefore, be very inefficient in satisfying its primary objective of collecting the infiltrating water. Such flows will be addressed under Operable Unit 1 and possibly under Operable Unit 3 if a particular subsurface flow condition calls for a local action not affecting the final action at other locations. It is also noteworthy that construction of the collection trench would require the excavation of a large volume of material that could be contaminated. Current uncertainty in relation to the actual geographical limits of Waste Pits 1 through 3 and the burn pit would increase this concern since actual waste materials could be encountered, resulting in concern about meeting DOE's as low as reasonably achievable (ALARA) standards.

While fully effective in meeting the removal action objectives as defined in Section 3.0, the waste removal alternative exceeds the scope of the other removal action alternatives that have been developed to also satisfy the same objectives. Waste removal would also introduce far-reaching technical implications (e.g., removal technologies, stabilization technologies, storage facilities, etc.), public health and environmental implications (e.g., transportation and disposal requirements, worker exposure, etc.), administrative implications (e.g., impacts on the final remedial action decision process, and other administrative requirements, etc.), and high cost of implementation (Appendix D). The cost of implementing this alternative would be in excess of $1.1 billion, which corresponds to

an increase of over 400 times the cost of Alternative 4 and over 200 times the cost of Alternative 2. This order of magnitude is not justified from a cost benefit standpoint. Although being eliminated from further consideration as a removal action, this same alternative remains a candidate for the long-term remediation of the waste storage area under the Operable Unit 1 feasibility study.

As a result of this initial screening, only Alternatives 1, 2, and 4 are retained for detailed evaluation in Section 5.0.

5.0 EVALUATION OF ALTERNATIVES

The evaluation of the removal action alternatives is presented in this section. Section 5.1 describes the evaluation criteria. Evaluations of the individual alternatives are presented in Sections 5.2 through 5.4, respectively. A separate discussion of the ARARs and TBCs is presented in Section 5.5.

5.1 EVALUATION CRITERIA

The three alternatives described in Section 4.0 are evaluated according to the following criteria:

- Effectiveness
- Implementability
- Cost

To achieve consistency with the removal action objectives identified in Section 3.0 and to accommodate the selection of a preferred alternative in Section 6.0, the effectiveness and implementability criteria are subdivided into several evaluation components. Each is described in the following sections.

5.1.1 Effectiveness

For purposes of this evaluation of the removal action alternatives, the effectiveness criterion has been subdivided into five components. These include: public health protection; environmental protection; the degree to which the toxicity, mobility, or volume of the contaminants in the storm water runoff would be reduced; the consistency of the alternative with the final remedial action alternatives under consideration for the waste pit area; and other miscellaneous factors important to the overall effectiveness of the action.

5.1.1.1 Public Health

The first component of the effectiveness of an alternative is defined by its ability to ensure the protection of and to minimize impacts to public health. The evaluation of this factor will focus on the extent to which the completed action reduces or mitigates identified threats, as well as compliance with contaminant-specific ARARs or TBCs. This component also involves an assessment of the potential for future exposure to postaction conditions at the site, as well as the potential for failure of the alternative and any resulting threats.

As described in Section 2.4 and Appendix C, Section C 2.0, uranium is the only constituent of the waste pit storm water runoff that could present a public health risk from radiological or chemical exposures through environmental pathways. Therefore, assessment of public health risks to off-site populations will be limited to the radiation doses from, and chemical toxicity of, uranium.

Any exposure pathways associated with the storm water runoff prior to its discharge into Paddys Run are considered to be of low risk potential for purposes of this analysis. The reasons are twofold. First, the entire waste storage area is a controlled entry area and it is assumed that established DOE/WMCO health and safety programs are sufficient to protect individuals from exposure and that the health and safety programs would be followed. Second, the only potential exposure pathway would be associated with isolated events (e.g., the accidental ingestion of contaminated sediment from the drainageways) and would not be easily quantifiable due to its infrequent and stochastic nature.

A related issue is the potential exposure of workers to direct radiation and radon from the nearby K-65 silos and fugitive emissions from Waste Pits 5 and 6 during construction of the selected removal action. Again, because it is assumed that adequate personnel protection would be provided to the workers, it is not necessary or practical to quantitatively address this potential exposure pathway. Rather, the potential for exposure will be directly related to the estimated time of construction and will be reflected in the cost estimates by adjustments to the estimated expenses to achieve adequate worker protection.

Three environmental pathways will be quantitatively evaluated as potentially nontrivial contributors to the exposure of the public in relation to the storm water runoff from the waste pit area. These pathways come into play only when the runoff reaches Paddys Run and include direct ingestion of sediments contaminated as a result of the contaminated runoff, pathways associated with use of groundwater contaminated by aquifer recharge from Paddys Run in off-site areas beyond the southern boundary of the FMPC, and pathways associated with use of surface water from the Great Miami River after discharge from Paddys Run.

The radiocarcinogenic risks calculated for each alternative will be compared with the acceptable range of risks from 10^{-4} to 10^{-6} with the desire to keep all risks below 10^{-6} if practicable.

For the groundwater pathway, a more stringent TBC is used due to the known use of the regional aquifer as a potable water source. In this case, the selected TBC is a 50-year CEDE limit of 4 mrem from an annual intake of radioactive materials in drinking water. The concentration of uranium in drinking water that corresponds to the 4 mrem dose limit is derived to be equal to 20 pCi/l, (or 30 µg/l, assuming equal activity concentrations of uranium-234 and uranium-238).

The calculated annual intake rate was also used to evaluate the potential for chemical toxicity from uranium. The recently published reference dose (RFD) describing an acceptable daily intake of uranium based on its chemical toxicity is 3 µg/kg body weight/day (EPA 1989). The acceptable daily intake corresponds to a uranium concentration in water of approximately 100 µg/l, assuming a 70 kg person ingests two liters of water per day. To calculate the acceptable risk to an individual, a Hazard Index (HI) is calculated by dividing the estimated daily intake by the acceptable daily intake. An HI greater than or equal to unity implies that exposure at this level is potentially detrimental to human health and, conversely, an HI less than unity implies that exposure is acceptable with respect to an individual's risk of chemical toxicity.

5.1.1.2 Environmental Protection

The evaluation of environmental protection will focus on the degree to which the mass loading of uranium to Paddys Run would be reduced, thereby limiting the potential for exposure to environmental receptors such as fish and macroinvertebrates. Additionally, the environmental evaluation will qualitatively consider the extent to which the actions would impact, both beneficially and adversely, the local ecology of the drainageways and any environmentally sensitive areas controlled by location-specific ARARs (e.g., wetlands). The environmental protection component will include the consideration of environmental impacts that may occur during and as a result of the implementation of the removal action.

5.1.1.3 Reduction in Toxicity/Mobility/Volume

Although not required for a removal action, the preference stipulated in SARA for remedies that permanently eliminate or reduce the toxicity, mobility, or volume of waste will be considered in the evaluation of effectiveness. In the case of contaminated storm water runoff, this factor comes into play in two ways. The first involves reductions in the volume of the storm water runoff that becomes contaminated, while the second involves reductions in the mobility of a contaminant or providing for treatment once contaminated runoff is produced. Each is considered to be consistent with the intent of SARA.

5.1.1.4 Consistency with Final Action

The NCP requires that a removal action be consistent with the anticipated final action for the site. In the case of the FMPC, the most direct concern is consistency with the remedial action alternatives currently being evaluated for Operable Unit 1, which includes the waste pits, burn pit, and the Clearwell. A lesser concern is consistency with those clean-up alternatives being considered for the environmental media under Operable Unit 5, since any removal action taken in the waste pit area would simply represent a partial source control rather than an action directly involving the environmental media.

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. Each is discussed in more detail below. 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.

5.1.2.1 Technical Feasibility

Evaluation factors regarding the technical feasibility of an alternative include the ability to construct and operate the alternative, the ability to meet the required process efficiencies or performance goals, compliance with action-specific ARARs, and the previously demonstrated performance of the underlying technologies.

In addition, the technical feasibility criterion is used to evaluate the availability of necessary equipment, materials, and personnel, as well as adequate storage or disposal capacity, if appropriate. Availability also considers any measures that may be required at the completion of the action, including monitoring and the availability of a responsible party to assume these activities.

5.1.2.2 Administrative Feasibility

The evaluation of administrative feasibility of an alternative includes the likelihood of public acceptance, activities necessary for coordination with other agencies, and the ability to obtain necessary approvals or permits.

5.1.3 Cost

The total cost of an alternative is the final factor considered. This factor includes direct capital costs, indirect capital costs, and any postremoval site control costs. The cost estimates are intended

to provide an accuracy between +25 percent and -25 percent. A present-worth analysis is conducted to provide a common basis for comparison.

A discount rate of 10 percent is used over a five-year project duration. The five-year period is used in all alternatives as the expected duration of the removal action. Even though the associated activities or structures may continue to function beyond this period, it has been assumed that they would be incorporated into the final remedial action after five years and that the continuing costs would be accounted for under the evaluation of the final actions in the corresponding feasibility study.

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

5.2.1 Effectiveness: Public Health

Under the no-action alternative, it is assumed that off-site receptors have unrestricted access to the discharged runoff and any affected surface water or groundwater regime. Based on ongoing analyses of existing conditions in Paddys Run and the regional aquifer being performed under the RI/FS, it has been concluded that no imminent and substantial endangerment currently exists for any off-site receptor under the most plausible exposure scenarios. Therefore, the contribution of contaminants to Paddys Run and the aquifer from storm water runoff from the waste storage area does not represent an imminent and substantial endangerment.

It is also necessary to evaluate the radiological and chemical exposures associated with potential (i.e., hypothetical) exposure scenarios. For purposes of this analysis, the hypothetical maximally exposed individuals are considered to be: 1) an individual ingesting sediments from Paddys Run at the point of maximum observed uranium concentration upstream of the Storm Sewer Outfall Ditch; 2) an individual consuming groundwater from the regional aquifer immediately below Paddys Run; and 3) an individual consuming river water below the mouth of Paddys Run. All input data to the exposure models are based on actual field observations under the assumption that previously observed conditions are representative of both current and future conditions if no action is taken. An exception is the concentration in groundwater at the point of concern; the value used in the

analysis is calculated from a groundwater flow and solute transport model assuming that the contaminated storm water runoff is the only flow in Paddys Run (i.e., no dilution water is available prior to leakage into the aquifer).

The observed concentration of uranium (including natural background concentrations) in the sediments of Paddys Run north of the Storm Sewer Outfall Ditch on FMPC property is approximately 5 pCi/g. Assuming that an individual consumes 0.2 grams of this sediment for 90 days a year, the resultant 50-year CEDE would be 0.02 mrem. Since this calculated radiation dose is such a small fraction of the dose limit, the exposure pathway of sediment ingestion is not considered to be a concern even under the no-action alternative. Additionally, the HI calculated for this exposure scenario is approximately 0.01. Note that this analysis conservatively assumes that all the uranium in the sediments of Paddys Run north of the Storm Sewer Outfall Ditch are attributable to storm water runoff from the waste pit area.

The exposure pathways associated with use of groundwater assumed that the estimated concentration of uranium that would be extracted by a hypothetical receptor from a well immediately adjacent to Paddys Run. The concentration of uranium in groundwater was calculated from the following assumptions:

- The concentration of uranium entering the aquifer from Paddys Run remains unchanged from the annual average concentration entering the stream from storm water runoff (1700 µg/l). This value is extremely conservative for two reasons: 1) the 1700 µg/l is greater than both the mean and median concentration values observed at representative sampling locations in the waste storage area, and 2) it does not account for any dilution in Paddys Run between the point of discharge and the assumed off-site location (i.e., a no-flow condition is assumed in Paddys Run, even though storm water runoff is occurring from the waste storage area).

- The rate of leakage is equal to 14 inches per year, which is equal to the recharge value used in the groundwater flow model.

- The contaminated recharge completely mixes with the groundwater passing through the zone of interest.

- Recharge and mixing occur within one 125-by-125-foot model cell, which is commensurate with assuming that the well would have a radius of influence of approximately 125 feet. The conservatism in this assumption is that the recharge is also assigned across the 125-by-125-foot surface area, thereby representing a stream width many times greater than the actual width of Paddys Run under low-flow conditions.

- The groundwater is pumped from a depth of 40 feet.

The resulting concentration value was calculated to be 80 µg/l. The radiation dose (50-year CEDE) calculated for all pathways from groundwater having a concentration of 80 µg/l is approximately 21 mrem, per year of intake. The radiation risk from 5 years of the removal action is 1E-05. The chemical hazard index (HI) for all pathways from groundwater having a concentration of 80 µg/l is 1.6, an unacceptable value.

Calculated intake, radiation doses, risks, and HIs for pathways from the Great Miami River are much less than the corresponding values for the pathways from the regional aquifer.

5.2.2 Effectiveness: Environmental

Under the no-action alternative, the principal objective of reducing the uranium loading to Paddys Run for purposes of improving the environmental community would not be satisfied. The current level of loading would be expected to continue until a final action was implemented in the waste pit area.

Decreases in macroinvertebrate diversity in those reaches of Paddys Run subject to discharges from the FMPC have been observed by both Miami University in 1986 to 1987 and ASI/IT in 1989. This provides circumstantial evidence of an environmental impact associated with site releases. In addition, several fish samples from Paddys Run were found to contain low but detectable levels of uranium.

Wetlands have been delineated along Paddys Run and within most of the drainageways that form an integral part of the storm water runoff collection and conveyance system within the waste pit area (Figure 2-5). These areas include the drainageway between Waste Pit 5 and the railroad tracks to the north, the drainageway running southwest through Drainage Area A, and the ditch from Drainage Area C into Paddys Run. Under the no-action alternative, contaminated discharges would continue to flow through these areas and could represent a long-term threat to the wetlands communities.

No data are available on the local biotic resources within each of the drainageways to substantiate whether the existing flows are causing an adverse impact. Any adverse conditions that do exist would be continued and no improvement would occur under the no-action alternative.

The no-action alternative would have no impacts on noise or air quality, and there would be no

change in existing land use practices or waste management requirements. No cultural resources would be affected.

5.2.3 Effectiveness: Reduction in Toxicity/Mobility/Volume

The no-action alternative would result in no reduction to the amount of runoff being contaminated by the various sources of radionuclides and chemicals within the drainage areas. Likewise, no reduction in contaminant mobility or toxicity would be provided.

5.2.4 Effectiveness: Consistency with Final Action

If no action is selected as the preferred removal action alternative, the feasibility studies for Operable Units 1 and 5 would proceed under the same baseline conditions as currently assumed. The selection of a no-action alternative would have no effect on the selection process for the final, long-term action.

5.2.5 Effectiveness: Other Factors

There are no other factors related to the effectiveness of the no-action alternative.

5.2.6 Implementability: Technical Feasibility

The evaluation of technical feasibility and availability factors related to implementability is not appropriate for the no-action alternative. No construction or monitoring activities over and above those currently practiced are associated with this alternative.

5.2.7 Implementability: Administrative Feasibility

Acceptance of the no-action alternative by the public and the agencies is not likely. No action would maintain conditions that exceed derived discharge limits established under DOE Order 5400.5. In addition, to take no action at this time would represent an inconsistency with the commitments made by DOE to reduce the release of radionuclides and chemicals to surface waters under the Best Management Practices (BMP) Plan for the FMPC.

5.2.8 Implementability: Timeliness

There is no time element involved with the no-action alternative.

5.2.9 Cost

There are no capital or incremental operation and maintenance costs associated with the no-action alternative.

5.3 ALTERNATIVE 2 - CAPPING

5.3.1 Effectiveness: Public Health

There is evidence that a large percentage of the uranium in storm water runoff from the waste storage area is introduced from the waste pits and the perimeter areas. Not only does the concentration in the runoff increase downstream from the pits, but the measured uranium isotopic content of the surface water samples indicates that the uranium is depleted (i.e., less than 0.7 percent uranium-235 by weight) and suggests the source to be materials in the pits. Considering this condition, it can be conjectured that the concentration of uranium in the storm water runoff would decrease to below the DOE-derived concentration limit if the source, the waste pit area, is eliminated by a protective cap. This conclusion is supported by the available data on uranium concentrations upstream from the waste pits (less than 10 µg/l) (Section 2.3), which can be considered representative of residual concentrations once the capping alternative is implemented.

The radiation dose per year of intake calculated for this alternative is 4.3 mrem. The radiation risk for the five years of the removal action is calculated to be 3E-06. The HI is calculated to be 0.3. Each of these is in the acceptable range.

The potential for public health risk could increase if the cover is damaged at some point in the future since contaminants could once again enter the runoff. However, such a condition would be of short duration until maintenance is provided. The resultant level of risk would be insignificant since the continuous, long-term exposure underlying the dose calculations would not be applicable.

Direct exposure to contaminants during construction should be minimal although some excavation into the contaminated area may be necessary for anchoring the cover material. The exposure of workers to direct radiation and radon from the K-65 silos and fugitive emissions from Waste Pits 5 and 6 during the period of field construction would be of more concern. As indicated in Section 5.1, appropriate health and safety protection to minimize this risk would be provided.

5.3.2 Effectiveness: Environmental

By reducing the amount of contaminants entering storm water runoff, the implementation of the capping alternative would satisfy the principal environmental objective of reducing the mass loading of uranium to Paddys Run. This is determined by looking at the area to be capped (Figure 4-1) and the contaminants measured in the surface water runoff (Tables 2-1 and 2-4) compared to the total loading attributed to the total area of concern (Figure 2-6). Additionally, the concentrations of

uranium in the uncapped areas are, on the average, significantly lower than the concentrations found in the capped areas. A residual loading would continue under this alternative, but in general the environmental conditions within Paddys Run would be gradually improved. The same gradual improvement in environmental conditions would occur in any wetland areas downstream from the waste pit area. The wetland area north of Pit 5 may not be improved since no cover is planned for the area adjacent to Pit 5.

Construction of a cap would impact wetlands within the waste pit area itself. The wetland area just west of the metal oxide silos could be disturbed or eliminated, depending on the final boundaries of the cap (Figures 2-5 and 4-1). The wetland occupying the drainageway to the east of the metal oxide silos and running between the silos and the waste pit area would be eliminated by capping, and the wetland in the drainageway running southwest through Drainage Area A could be disturbed by construction activities. However, these areas are relatively small, with a total area of approximately 5.5 acres, and are not considered critical habitat. It is expected that wetland communities would become reestablished in any areas not permanently altered. Paddys Run would not be directly affected by construction activities.

5.3.3 Effectiveness: Reduction in Toxicity/Mobility/Volume

The capping option would not decrease the volume of storm water runoff discharged to Paddys Run from the waste storage area. However, by eliminating the contact between the runoff and the contaminated surficial materials, the potential for contaminant desorption into the runoff would be eliminated. The potential for the resuspension of contaminated soils into the runoff as suspended solids would be also eliminated.

The result would be a significant reduction in both the concentration and mass loading of uranium and any other contaminants in the runoff stream. This condition of eliminating the formation of contaminated surface water can be viewed as both a reduction in waste volume and a reduction in the mobility of the waste materials that exist in the surficial cover of the pits. Post removal monitoring would be performed to determine the effectiveness of the removal action.

5.3.4 Effectiveness: Consistency with Final Action

The potential alternatives for the site are:

1 - Site Cap and Slurry Wall
2 - Waste Stabilization, Site Cap, and Slurry Wall
3 - Waste Vitrification and Site Cap
4 - Waste Removal and Treatment
5 - Waste Removal and Disposal

The capping alternative would be inconsistent with Alternatives 1 to 3 because each requires subsurface remediation. Access to such remediation activities would damage the integrity of the liner and result in replacement of the cap. Alternatives 4 and 5 would require excavation of soil and liner material and removal of this material for treatment or disposal. This would result in a greater volume of waste to be handled. Due to contact with contaminated material during the intervening years, the cover materials added under the removal action may have to be treated as waste material at the time of removal. Future testing would be required to confirm this condition.

5.3.5 Effectiveness: Other Factors

Two other factors are noteworthy when comparing the effectiveness of the capping option with that of the other two alternatives. First, any future disruption of the cap would not significantly affect the long-term effectiveness of the alternative. Any release of contaminants that would result from damage to the cap would be limited to the area of damage and would occur only until maintenance is provided. Second, although protection of the perched groundwater is not a primary objective of this removal action, a capping of the pits would concomitantly reduce infiltration into the pits. This, in turn, would reduce the rate of leakage of contaminated water from the pits into the underlying till and groundwater.

5.3.6 Implementability: Technical Feasibility

Construction of a temporary cap over Waste Pits 1 through 3, the burn pit, and areas near the silos would be straightforward and would utilize only widely practiced and proven technologies. The recent construction of an interim cap over Pit 4 demonstrates the technical feasibility of this option and provides direct evidence that suitable borrow material for a natural cover is available on site. Since no special properties would be required for a synthetic cover, this material would also be generally available. However, construction of a cap over Waste Pits 5 and 6 would require stabilization of pit contents before covering. Suitability of stabilizing agents would need to be determined.

Construction of the cap would require trained operators and craftsmen, but these are readily available locally and have performed work at the FMPC in the past.

5.3.7 Implementability: Administrative Feasibility

For this alternative, substantive requirements of the U.S. Corps of Engineers (COE) may need to be met if any wetlands are destroyed by channel construction. Since the affected wetland area is

under 10 acres in size and would not be characteristically unique, the substantive requirements of a simplified Nationwide Permit should be appropriate.

5.3.8 Implementability: Timeliness

The selection of the capping alternative would require the initiation of a complete design process and would extend the design time (relative to Alternative 4) by several months. The design for Alternative 4 has been completed as part of the FMPC Best Management Practices Plan. The design of the capping alternative would, however, be straightforward.

The construction time (excluding design and bid and award phases) for the capping alternative is estimated to be 12 months, which is somewhat greater than the estimated 10-month construction time for Alternative 4. The highest potential for construction delays would be adverse weather conditions.

The capping alternative would be fully effective immediately upon completion of construction.

5.3.9 Cost

Capital, annual, and present-worth costs were estimated for the capping alternative. Capital costs for this alternative include labor costs, the cost of materials necessary to solidify the sludge in Pits 4 and 5, and to install the cap. Indirect costs for engineering, subcontracting, and contingencies are also included. The total capital cost for this alternative is estimated to be $5,556,000 (Appendix D).

Annual costs for this alternative include only the cost of cap maintenance and have been estimated at 5 percent of the direct capital costs, or $288,500 annually. Based on a 10 percent discount factor and a five-year project period, the present-worth value of this alternative is estimated to be approximately $6,862,300.

5.4 ALTERNATIVE 4 - RUNOFF COLLECTION AND TREATMENT

5.4.1 Effectiveness: Public Health

Three environmental pathways have been quantitatively evaluated as potential contributors to public health risk in relation to storm water runoff from the waste pit area. Alternative 4, which involves the collection of runoff from the waste storage area, eliminates the exposure scenario of pathways from groundwater within the regional aquifer.

The calculated radiation dose for pathways from surface water from the Great Miami River is 0.05 mrem per year of intake. The radiation risk associated with this alternative for five years of the removal action is 3E-08. The HI for this alternative is 0.004. All of these values are in the acceptable range.

The alternative of runoff collection and treatment would increase the potential for direct contact with contaminated runoff because of the provision for temporary storage within the collection system. However, the entire system would be located within a controlled access area and the associated risk would be minimal. A future risk is associated with system breakdown since contaminated runoff could once again enter Paddys Run. However, as with the capping option, such a condition would be short-lived until maintenance is provided and would not result in continuous, long-term exposure.

Under this option, the potential exists for direct exposure to contaminants during construction due to the management of contaminated runoff throughout the period of construction and excavation into the contaminated area during construction of the new ditches. It is assumed that appropriate worker protection would be provided to negate any associated risk. Protection is also assumed against any exposure related to the K-65 silos or fugitive emissions from the waste pits during field construction.

5.4.2 Effectiveness: Environmental

By eliminating the discharge of runoff from the waste pit area to Paddys Run, Alternative 4 would totally satisfy the objective of reducing uranium loadings to the stream. The environmental conditions within Paddys Run would gradually improve as a result.

Any disruption of the local ecological communities during construction would be temporary and reestablishment of the communities would be expected. Construction of the collection ditches would disrupt the areas delineated as wetlands (Figure 2-5). However, these areas, excluding Paddys Run, are relatively small, with a total area of approximately eight acres, and are not considered critical habitat. It is expected that wetland communities would become reestablished in the areas not permanently altered and would develop in the newly constructed drainageways. Paddys Run would not be directly affected by construction activities and environmental conditions would gradually improve, as described above.

TABLE 5-1
URANIUM CONCENTRATIONS: FILTERED VERSUS UNFILTERED SAMPLES

	Total Uranium (µg/l)	
Sample Location	Filtered Sample	Unfiltered Sample
ASIT-001	21 ± 3	18 ± 3
ASIT-010	282 ± 46	231 ± 38
ASIT-018	700 ± 112	667 ± 106
ASIT-019	944 ± 156	930 ± 152
ASIT-020	538 ± 87	530 ± 86
ASIT-022	92 ± 15	54 ± 9
ASIT-023	465 ± 82	433 ± 72
ASIT-024	517 ± 83	576 ± 93
ASIT-027	8148 ± 1360	9318 ± 1499
ASIT-028	5067 ± 835	5779 ± 943
ASIT-029	1228 ± 201	1005 ± 163
ASIT-030	7030 ± 1127	8363 ± 1338
ASIT-031	6853 ± 1144	7380 ± 1210

Any noise or air quality impacts associated with the collection and treatment alternative would be minimal and limited to on-site populations. Alternative 4 would have no effect on the radon flux from the waste pits. This alternative makes no modifications or disruptions to the waste pits as they currently exist. There would be no changes in land use practices, no effect on cultural resources, and no discernable effects on property values or other socioeconomic factors. The construction of the channels and sumps would generate waste material that would be disposed of in accordance with approved site procedures. This does not represent a significant environmental concern.

5.4.3 Effectiveness: Reduction in Toxicity/Mobility/Volume

Although the collection and treatment alternative would eliminate the mass loading of uranium from the waste pit area to Paddys Run, the total system may do little to reduce the volume and mobility of the contaminated runoff until the advanced wastewater treatment plant is on-line. As previously cited, only a maximum 10 percent uranium removal efficiency can be expected as a result of settling in the Biodenitrification Surge Lagoon. The degree of uranium removal in subsequent treatment units is unknown. The estimated discharge of uranium to the Great Miami River is currently approximated to be 1,870 pounds/year. It has been estimated that approximately 150 pounds of uranium/year would be collected by the Waste Pit Area Storm Water Runoff Control Project. Approximately 10 percent of this 150 pounds/year would settle in the Biodenitrification Surge Lagoon (BSL). Therefore, approximately 135 pounds/year would be contributed to the Great Miami River due to this removal action. This estimate takes no additional credit for treatment that would be attained in the pilot scale demonstration treatment system that would be installed at the BSL. Post removal monitoring would be performed to determine the effectiveness of the removal action.

5.4.4 Effectiveness: Consistency with Final Action

A major advantage of the collection and treatment alternative is its consistency with the final remedial program at the FMPC. It is expected that any alternative for final remediation of the waste storage area under Operable Unit 1 would require an upgrade of the storm water collection and control system; therefore, the system proposed under Alternative 4 would likely become a necessary and integral part of the final remedy.

By cutting off contaminated runoff to Paddys Run, a source of continuing release to both the surface water and groundwater beneath Paddys Run is eliminated. Therefore, Alternative 4 can also

be considered as supportive of the long-term remedial action program for the regional environmental media under Operable Unit 5.

5.4.5 Effectiveness: Other Factors

One additional factor that favors the alternative of runoff collection and treatment is that the effectiveness of the remedy has no reliance on the source of the contaminants in the runoff. Therefore, the effectiveness is not affected by any remaining uncertainties as to whether all significant sources are known and accounted for, as is the case under the capping alternative.

There are other factors, however, that work against the long-term effectiveness of this alternative in relation to the capping alternative. First, the disruption of a system component (e.g., the pumping system) would result in the ineffectiveness of the entire system, although this potential problem is minimized by the inclusion of a standby pump and emergency power supplied by a diesel generator. Second, any operational problems with the biodenitrification system, whether or not caused by the proposed surface water contribution, would also compromise system performance.

5.4.6 Implementability: Technical Feasibility

Construction of the storm water collection and pumping systems would utilize only widely practiced and proven technologies. All necessary labor and materials are readily and locally available.

Emphasis would need to be placed on storm water management during the construction of two particular components of the system. First, the collection system would consist of a combination of new drainageways with modifications to existing ditches. These modifications include the installation of flow control structures on contaminated streams and the rerouting of clean storm water controls. Good construction planning is required to minimize discharges during the change over from the old to the new system. Construction planning would need to address issues such as the proper phasing of the major construction portions of this project, necessary silt barriers, and proper handling of potentially contaminated soils. Second, available data on perched groundwater conditions in the waste storage area indicate that the main collection sump would be constructed within a perched groundwater zone. Again, storm water management is necessary to prevent the direct communication between surface water and perched groundwater that could result in an increased discharge of uranium to groundwater.

5.4.7 Implementability: Administrative Feasibility

The transfer of the runoff into the main effluent line from the FMPC would not require a modification of the existing NPDES permit for this discharge point. The addition of storm water runoff from the waste pit area is incorporated under the current permit application.

For this alternative, substantive requirements of the U.S. Corps of Engineers (COE) may need to be met if any wetlands are destroyed by channel construction. Since the affected wetland area is under 10 acres in size and would not be characteristically unique, the substantive requirements of a simplified Nationwide Permit should be appropriate.

5.4.8 Implementability: Timeliness

The collection and treatment of storm water runoff from the waste pit area has been an ongoing consideration of the BMP plan at the FMPC; therefore, design time required for this alternative is minimal.

The construction time for the collection and treatment alternative is estimated to be 10 months. Adverse weather conditions, particularly wet conditions involving considerable storm water runoff, represent the greatest potential for construction delays.

Alternative 4 would be fully effective in meeting the objectives of this removal action as previously stated in this document.

5.4.9 Cost

The total capital cost for Alternative 4 is $3,554,607 (Appendix D). This cost includes direct capital costs for equipment, labor costs, and the cost of materials necessary for the installation of the collection and pumping systems. Indirect capital costs for engineering, subcontracting, and contingencies are also included. The biodenitrification treatment system is already in place, and no costs of the advanced wastewater treatment plant are accounted for under this alternative. The cost of the 10 gpm pilot scale demonstration WWTS is included.

The annual costs for this alternative include the maintenance of the collection and pumping systems and have been estimated at 5 percent of the direct capital costs, or $177,730 annually and an additional $200,000 annual operating costs for the demonstration WWTS for a total annual maintenance and operating cost of $377,730. Based on a 10 percent discount factor and a five-year project period, the present-worth value of this alternative is estimated to be $4,228,400.

5.5 REQUIREMENTS POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE TO THE PROPOSED ACTIONS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED

The ARARs and TBCs for the proposed actions for the waste pit area storm water runoff control are listed in Table 5-2. The potential ARARs follow EPA-recommended classifications: contaminant-specific ARARs, location-specific ARARs, and action-specific ARARs. A discussion of each group and its relation to the proposed actions is given below.

5.5.1 Contaminant-Specific ARARs

The contaminant-specific ARARs apply to all of the proposed removal actions since the contaminant concentration drives the action level for the implementation of the removal action. However, the application of the contaminant-specific ARARs listed in Table 5-2 is complicated by the fact that radionuclides (particularly uranium) have been exempted from most environmental regulations. DOE has been primarily self-regulating for environmental activities and established its own policies for environmental monitoring, waste disposal, and limits of exposure to employees and the public. EPA regulations regarding the handling and disposal of wastes containing radionuclides are regulated under programs set up by the Uranium Mill Tailings Act and the NRC.

Regulations concerning the management and disposal of radioactive waste materials have been generally separated from other hazardous waste regulations. Uranium is excluded from the definition of solid waste (and therefore also from the definition of hazardous waste) under 40CFR261.4(a)(4) "Source, special nuclear, or by-product material as defined by the Atomic Energy Act . . . ." Source is defined under 10CFR20.3(a)(15) as "uranium . . . in any physical or chemical form . . . ." Uranium is also specifically excluded under federal and Ohio water quality standards, drinking water standards, and NPDES discharge criteria. Federal MCLs for uranium are mandated for promulgation but none have yet been proposed by EPA. Thus, where radionuclides are concerned, the process of coordinating DOE regulations with mainstream state and federal environmental regulations is required.

5.5.2 Location-Specific ARARs

The location-specific ARARs are applicable for each alternative regarding the actions' impacts on wetlands and wildlife. The implementation of any action should be conducted in a manner such that minimal disturbance or destruction to wetlands, protected habitats, and/or endangered species is caused by the action.

TABLE 5-2
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Contaminant-Specific ARARs	
Requirement	Application to the Waste Pit Area
Ohio Water Quality Standards (OAC3745-1)	3745-01-04(D) set the criterion applicable to all waters, 3745-01-05 sets forth the antidegradation policy for waters of the state and 3745-1-21 describes the use designations for the Great Miami River; 3745-1-32(c)(9) specifically excludes uranium from the Ohio River stream criteria
Ohio Drinking Water Rules (OAC3745-81)	3745-81-15 and -16 establish MCLs for gross alpha and beta particle activity but specifically exclude uranium
Ohio Radiation Protection Standards (OAC3745-38)	3701-38-13(D) provides concentration limits for discharge of radioactive materials into air or water in unrestricted areas
Safe Drinking Water Act (40CFR141)	
a. Maximum Contaminant Levels (MCLs)	Groundwater MCLs for uranium are mandated for promulgation, but not yet proposed
b. Maximum Contaminant Level Goals (MCLGs)	Considered pursuant to SARA Section 121(d)(2)(A(ii)
Clean Water Act (PL92-500) Federal Ambient Existing Source and New Source Water Quality Criteria (AWQC)	Specifically excludes uranium from consideration in discharges to surface water

TABLE 5-2 (Continued)
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Location-Specific ARARs	
Requirement	Application to the Waste Pit Area
Regulation of Activities Affecting Waters of the U.S. (33CFR320-329), for Ohio (OAC3745-32)	COE regulations apply to construction or other disruptive activities in both wetlands and navigable waters
Endangered Species Act of 1978 (16USC1531)	The effects of No Action and the construction and discharge activities must be considered if endangered species are located in an area impacted by the waste pit area
Fish and Wildlife Coordination Act (16USC661)	The effects on wetlands and protected habitats by No Action and by the construction and discharge portions of the alternatives must be considered if any wetlands or protected habitats are located in the waste pit area
Fish and Wildlife Improvement Act of 1978 (16USC742)	The effects on wetlands and protected habitats by No Action and by the construction portions of the alternatives must be considered if any wetlands or protected habitats are located within the waste pit area
Executive Order 11990 Protection of the Wetlands	This order may affect the administrative ability of alternatives which cause disturbance or destruction of wetlands
Ohio Location Standards (OAC3745-54-18)	Governs the location of hazardous waste treatment, storage, or disposal with respect to floodplains
Ohio Conservancy District Rules governing activities within the boundaries of a conservancy district (ORC6109.19)	May affect the erection of obstruction/facilities within the bounds of the Great Miami River Conservancy District

TABLE 5-2 (Continued)
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Action-Specific ARARs	
Requirement	Application to the Waste Pit Area
U.S. EPA Regulations for Environmental Radiation Protection Standards for Nuclear Power Operations (40CFR190)	NRC standards for radiation doses received by members of the public in the general environment and to radioactive materials introduced into the general environment as a result of operations which are part of the nuclear fuel cycle
U.S. EPA Regulations for Health and Environmental Protection Standards for Uranium and Thorium Mill Tailing (40CFR192)	Established cleanup standards for inactive uranium mill tailing sites; some standards may be applicable to the FMPC remedial response
CWA NPDES Requirements (40CFR121-125) and Ohio requirements for NPDES permit to discharge wastewater to the waters of the state (OAC3745-33)	Program is mandated to state control; there are no standards for uranium discharge, but other limitations or criteria may affect the alternatives which have a discharge component
Ohio River Quality Standards Antidegradation Policy [OAC3745-1-05(A) and OAC3745-1-05(B)]	Applies to the alternatives which discharge to surface waters
RCRA Requirements (40CFR260-279)	Uranium does not qualify as a solid or hazardous waste
Ohio Solid Waste Management Facility operating rules and permit requirements (OAC3745-27 and 37)	These rules may apply to residuals disposal from groundwater treatment facilities
Ohio Hazardous Waste Management Facility operating rules and permits (OAC3745-50 through 70)	These rules may apply to groundwater treatment plant construction operations and permitting
Ohio Corrective Action Program (groundwater protection) (OAC3745-55)	Includes monitoring requirements for hazardous waste management facilities
U.S. EPA Regulations on National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61, Subpart H and Q)	Establishes National Emission Standards for radioactive emissions from DOE facilities

TABLE 5-2 (Continued)
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

Action-Specific ARARs	
Requirement	Application to the Waste Pit Area
Ohio restrictions on fugitive dust emissions (OAC-17-08)	Requires dust control during any construction activities which may take place during the remedial response
OSHA Requirements (29CFR1910, 1926, and 1904)	Required worker safety requirements for exposure while engaged in on-site activities
Ohio General Radiation Protection Standards; all facilities that receive, possess, use, store, transfer, install, service, or dispose of any source of radiation require registration by their handlers (OAC3701-70 and 71)	Required worker safety requirements for exposure while engaged in on-site activities
Atomic Energy Act of 1954 (42USC2011)	This act authorizes the conduct of atomic energy activities
DOE Organization Act (42USC7101)	Established powers and responsibilities of DOE
National Environmental Policy Act (NEPA) of 1969 (42USC4341)	Requires consideration of environmental concern by DOE at the FMPC consistent with national environmental policies and goals and provides a method for accomplishing these goals
NRC Rules for Land Disposal of Radioactive Wastes (10CFR61)	NRC standards may apply for exposure limitations at the FMPC
NRC Regulations for Standards for Protection Against Radiation (10CFR20)	This NRC standard may be relevant and appropriate for compliance of pollution control standards at the FMPC
Ohio requirements concerning pollution in waters of the state (ORC 6111)	Provides for water quality standards

TABLE 5-2 (Continued)
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND OTHER CRITERIA, ADVISORIES, AND GUIDANCE TO BE CONSIDERED FOR THE WASTE PIT AREA STORM WATER RUNOFF CONTROL

TBCs	
Requirement	Application to the Waste Pit Area
Doe Order for Radiation Protection of the Public and Environment (DOE 5400.5)	Section II.1.d, sets the annual not-to-exceed effective dose limit of 4 mrems for human consumption through drinking water and 100 mrems from all radiation exposure via all environmental transport pathways; the DOE-derived concentration guideline for off-site releases of radioactive materials to surface waters applies to the CEDE of 100 mrems with exposure via ingestion only
DOE Order for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program (5400.4)	Authorizes CERCLA activity by DOE at the FMPC
DOE Order for National Environmental Policy Act (NEPA) (5400.1C)	Establishes environmental policies and goals applicable to DOE and the FMPC
DOE Order for Radiological Effluent Monitoring and Environmental Surveillance (5400.XY)	Monitoring requirements for DOE facilities applicable to all alternatives
DOE Order for Hazardous and Radioactive Mixed Waste Management (5400.3)	Regulations by which FMPC currently operates for waste management
DOE Order for Environmental Protection, Safety, and Health Protection Information Reporting Requirements (5481.1)	Safety requirements for FMPC operations to be followed during remedial response actions
DOE Order for Quality Assurance (5700.6B)	Establishes the level of quality assurance for any work done at the FMPC for remedial response
DOE Order for Radioactive Waste Management (5820.2A)	Policies and guidance for FMPC waste and contaminated facility management
Federal Compliance with Pollution Control Standards Executive Order (12088)	Delegates CERCLA and SARA responsibilities to DOE and EPA
Superfund Implementation Executive Order (12580)	NRC rules may apply to alternatives containing groundwater treatment, disposal, or residual handling components

5.5.3 Action-Specific ARARs

Action-specific ARARs regulate the process and operation of removal actions taken to mitigate the impact of the waste pit area storm water runoff. Any actions taken as a result of releases from the FMPC will be under the supervision of DOE and are also subject to RCRA and CERCLA/SARA. The powers and responsibilities of DOE are established by the Atomic Energy Act (42USC2011) and the DOE Organization Act (42USC7101).

The NRC regulation 10CFR20 sets radiation protection requirements for the public and the environment. In general, 10CRF Part 20 is designed to limit radiation hazards caused by NRC-licensed activities. Part 20 contains many substantive requirements including permissible dose levels (in terms of the general public's exposure to radiation), radioactivity concentration limits for effluents, precautionary procedures, and waste disposal requirements. Part 20 establishes a general requirement that radiation exposures should be maintained as low as reasonably achievable (ALARA). Specifically, 10CFR Sections 20.101 - 20.105 establish specific radiation dose limits for the protection of workers and members of the public. Section 20.106 establishes concentrations for radionuclides in airborne and liquid effluents to unrestricted areas. Sections 20.301 and 20.302(a) establish waste treatment and disposal requirements for radioactive wastes.

Additional requirements pertaining to the operation of the FMPC were promulgated under authority of the Atomic Energy Act and set limits on radiation doses received by members of the general public from operations within the uranium fuel cycle. These requirements, as stated in 40CFR190 and regulated by EPA, may be relevant and appropriate to releases of radionuclides and radiation during cleanup actions at the FMPC. Also, cleanup standards for inactive uranium mill tailing sites, as regulated by 40CFR192, may be relevant and appropriate to removal actions at the FMPC.

Monitoring and reporting requirements for DOE operations (including releases) are governed by EPA requirements listed in 40CFR300.

Action-specific ARARs regulating the management of residuals from the treatment and disposal actions at the site are NRC land disposal rules (10CFR61) and RCRA (40CFR, Sections 260 - 279). Worker safety requirements for radiation exposure while handling contaminated wastewater and residuals are governed by Occupational Safety and Health Administration (OSHA) requirements in 29CFR1910, 1926, and 1904. Construction activities in areas unrelated to contamination would be governed under standard OSHA requirements for worker safety in 29CFR.

5.5.4 TBCs

In addition to legally binding laws and regulations, federal and state environmental and public health programs also develop criteria, advisories, and guidance that are not legally binding but may be useful and appropriate to provide adequate protection for public health and the environment. Since most of DOE's operations are exempt from NRC's licensing and regulatory requirements, DOE's requirements for radiation protection and radioactive waste management are contained in a series of internal DOE orders. These DOE orders are not promulgated requirements and are not potential ARARs. However, to the extent that DOE orders are more stringent or cover areas not addressed by existing ARARs, they are considered where necessary to develop a protective remedy.

Since no contaminant-specific ARARs are identified for uranium, for the purpose of this EE/CA, concentrations of uranium for protection of public health and the environment are derived from DOE Order 5400.5. The exposure limit providing protection for public health and the environment from chemical and radiological constituents in the surface water runoff is the total annual CEDE limit of 100 mrem for off-site individuals for radiation exposure via all environmental transport pathways.

A second exposure limit applicable to the storm water runoff removal action is the CEDE limit of 4 mrem from an annual intake of radioactive materials in drinking water. These limits are discussed in Section 5.1.1 and are used as the basis for the public health evaluations for each alternative.

Other orders to be considered include the Federal Compliance with Pollution Control Standards Executive Order 12088 and Superfund Executive Order 12580, which define the authority and scope of DOE compliance with environmental statutes. DOE Order 5400.4 authorizes CERCLA activity by DOE at the FMPC.

In addition to EPA and NRC requirements, monitoring and reporting requirements for DOE operations are also governed by DOE Orders 5484.1, 5700.6B, and 5400.XY. Waste management activities are governed by DOE Orders 5400.3 and 5820.2A. Additionally, DOE Order 5400.1C establishes environmental policies and goals consistent with NEPA at the FMPC.

6.0 SELECTION OF PREFERRED ALTERNATIVE

In Chapter 5.0, three removal action alternatives were evaluated on an individual basis against nine evaluation factors representing the three principal criteria of effectiveness, implementability, and cost. The results of this evaluation are summarized in Table 6-1. A comparative evaluation of these same nine factors, to support the selection of a preferred alternative, is the subject of this chapter.

6.1 ELIMINATION OF NONRESPONSIVE ALTERNATIVES

Based on the evaluation reported in Chapter 5.0 and summarized in Table 6-1, the no-action alternative is shown to be a deficient response action in relation to several factors. First and foremost is the continued release of storm water runoff with uranium concentrations exceeding DOE DCGs, resulting in noncompliance with the established health protective TBC for a hypothetical maximally exposed individual. Although a direct relationship between observed environmental degradation in Paddys Run and the runoff from the waste pit area has not been established, the relative contribution of releases to Paddys Run from the runoff is substantial and some correlation to the observed effects can be assumed. The no-action alternative would prolong any environmental impacts associated with the release. The contribution of uranium to the regional aquifer via leakage from Paddys Run would also remain at its current level if no action is taken to reduce the uranium loading to Paddys Run. For these reasons, the no-action alternative is eliminated from further consideration.

6.2 COMPARATIVE EVALUATION

This evaluation compares the capping alternative (Alternative 2) and the collection and treatment alternative (Alternative 4) in relation to the five effectiveness factors, the three implementability factors, and the present-worth cost factor identified in Table 6-1. Both alternatives are shown to satisfy the important public health protection criterion. Although some differences exist between the alternatives in relation to specific exposure pathways, neither alternative can be given a significant preference in terms of public health protection.

Both alternatives also satisfy the objective of reducing the uranium loadings to Paddys Run for purposes of protecting the aquatic environment of the stream and the aquifer, with the collection and treatment option providing a higher level of protection since no residual loadings of contamination in drainage ditches downstream from the capped pit area are associated with this

TABLE 6-1

SUMMARY OF EVALUATION OF ALTERNATIVES AFTER INITIAL SCREENING

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Effectiveness: Public Health	Does not meet TBC for max. exposed individual; no imminent & substantial risk	All exposure pathways within acceptable risk limits ($< 10^{-5}$)	All exposure pathways within acceptable risk limits ($< 10^{-7}$)
Effectiveness: Environmental	No decrease in uranium loading to Paddys Run; continuation of any current impacts	Significant reduction in uranium loading to Paddys Run; overall improvement elsewhere; potential wetlands impact	Total reduction in uranium loading to Paddys Run; little improvement elsewhere; potential wetlands impacts
Effectiveness: Reduction In Toxicity, Mobility, Volume	No reduction in toxicity, mobility, or volume	Significant reduction in uranium concentration and loading in runoff	No reduction in volume of contaminanted runoff prior to treatment; "End of Pipe" treatment varies with time
Effectiveness: Consistency with final action	No effect on alternatives recommended for final action.	Not consistent with alternatives recommended for detailed analysis for Operable Units 1 and 5 unless capping is selected.	Consistent with all alternatives recommended for detailed analysis for Operable Units 1 and 5
Effectiveness: Other factors	None	Reduction in infiltration and leaching potential	No reliance on controlling the source of contaminants in runoff

TABLE 6-1 - CONTINUED

SUMMARY OF EVALUATION OF ALTERNATIVES AFTER INITIAL SCREENING

Evaluation Factor	Alternative 1 No Action	Alternative 2 Capping	Alternative 4 Collection & Treatment
Implementability: Technical Feasibility	Not Applicable	Straightforward, with readily available labor and materials; special conditions require consideration	Straightforward, with readily available labor and materials; special conditions require consideration
Implementability: Administrative Feasibility	Maintains conditions exceeding DOE limits; inconsistent with previous decision to collect runoff.	No permits required for on-site actions; however, requirements for wetlands must be met	No permits required for on-site actions; however, requirements for wetlands must be met
Implementability: Timeliness	No time element involved	Design required; construction period of approximately 12 months	Design complete; construction period of approximately 10 months
Cost (Present Worth) (I = 10%)	$0	$6,862,300	$4,228,400

alternative. Remedial loadings from uncapped areas (see Figures 2-6 and 4-1), which have been reported as having contaminated sediments and runoff (see Tables 2-1 and 2-4), would still be released into Paddys Run. The concentrations of contamination are due to releases and are considered low enough not to warrant the expense of capping. However, overall environmental improvement is better satisfied by the capping alternative since it also protects the local subsurface environment upstream from Paddys Run and downstream from the waste pit area.

The capping alternative also has the advantage of preventing the contamination of the storm water runoff rather than providing for its treatment after the contamination occurs. However, an uncertainty in source definition could compromise the effectiveness of the capping alternative in achieving this condition. The collection and treatment alternative is preferred under a strict interpretation of the SARA stipulation for providing treatment to the maximum extent practicable. The level of treatment provided would vary due to the planned shift from use of the biodenitrification facility to use of the advanced wastewater treatment plant once the latter is constructed and operating.

The collection and treatment alternative is consistent with the final remedial actions for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5). This CERCLA-based requirement for a removal action is not, however, satisfied by the capping alternative. If removal of the waste pits is selected as the final remedial action, interim capping adds additional costs to the project. The latter alternative would not, however, bias the decision process for the final action or eliminate one or more actions from future consideration.

The capping alternative would be less prone to system failure than the collection and treatment alternative, and any disruptions to the cap would have less impact than disruptions to the collection and treatment system. However, neither case represents a significant public health or environmental concern due to the temporary nature of any disruption, and the differences are not considered to be a principal decision factor.

Conditions that would require special attention during both the engineering and construction activities are associated with both the capping and the collection and treatment alternatives. Again, however, none of these conditions are insurmountable constraints to the technical feasibility of either alternative and are not considered to represent a critical decision factor.

The collection and treatment alternative is preferential from an administrative feasibility standpoint due to the lack of administrative constraints to project approval. Storm water runoff from the waste

pit area has already been included in the NPDES permit for the main FMPC discharge. Additionally, if the wetlands are affected, requirements necessary to meet substantive permitting requirements should not be significant due to the small area and nature of the affected wetland areas.

The collection and treatment alternative is also preferential from a timeliness standpoint. This alternative would be implemented in a shorter time frame. This is due primarily to three factors. The design is nearly complete due to prior consideration of this option under the site's BMP plan, the construction time is shorter, and this alternative is currently provided for as a line-item project in the DOE funding system. The entire funding process may need to be reinitiated for the capping alternative, thus delaying its time to completion.

The present-worth cost of the capping alternative has been estimated to be $6,862,300 and the present-worth cost of the collection and treatment alternative is approximately $4,228,400. This factor favors the collection and treatment alternative since the cost of capping is estimated to be approximately twice the cost of Alternative 4. The long-term remediation costs must also be considered. The collection and treatment system would likely be an integral part of a future action within the waste pit area and any expenditures today would offset future costs. The costs of capping, however, may be nonrecoverable once the final action is selected (since a temporary cap is not expected to be part of the final remedy). Also, the costs of the final action would increase if removal and disposal of the capping material is required under the remedial action.

6.3 PREFERRED ALTERNATIVE

Based on the previous discussions of the comparative evaluation of the capping and the collection and treatment alternatives, the collection and treatment alternative has been selected as the preferred alternative. There are several factors that favor the selection of this alternative. First, it is protective of human health and the environment. Second, the collection and treatment alternative is consistent with all final remedies being considered for both the waste pits (Operable Unit 1) and the regional environmental media (Operable Unit 5). Third, the estimated time for completion of this alternative is shorter than that for the capping alternative. Finally, this alternative can be implemented for approximately two-thirds the cost of the capping alternative while providing equal or greater protection for public health and the environment.

REFERENCES

REFERENCES

Addendum to Best Management Practices Plan: Stormwater Sampling Program Results, prepared by Roy F. Weston, Inc., October 18, 1988.

Dames and Moore, July 1985, "Department of Energy Feed Materials Production Center Groundwater Study Task C Report," White Plains, New York.

Facemire, C.F., S.I. Guttman, D. R. Osborne, and R. H. Sperger, 1990. "Biological and Ecological Site Characterization of the Feed Materials Production Center," prepared for the Feed Materials Production Center, Cincinnati, OH.

Fernald RI/FS Database.

IT Corporation, 1988, "Final Report - Hydrogeologic Study of the FMPC Discharge to the Great Miami River," prepared for the U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN.

Ohio Dept. of Natural Resources, 1974, "Endangered Wild Animals in Ohio," Division of Wildlife, ODNR, Columbus, OH, Publication 316.

Peltier, W. H. and C. I. Weber, 1985, "Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms," EPA/600/4-85/013, Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. EPA, Cincinnati, OH.

Site Environmental Monitoring Data.

U.S. Department of Energy, 1987, "Remedial Investigation and Feasibility Study Report Task 1: Description of the Current Situation Report," Oak Ridge Operations, Oak Ridge, Tennessee.

U.S. Dept. of Energy, March 18, 1988, DOE Order 5400.5, "Radiation Protection of the Public and the Environment," Draft.

U.S. Environmental Protection Agency, July 1988, "Safe Drinking Water Act," Federal Register, Vol. 53, No. 131, Government Printing Office, Washington, D.C.

U.S. Environmental Protection Agency, 1989, "Integrated Risk Information System (IRIS): Reference Dose (RFD) for Oral Exposure for Uranium," Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH.

Weber, C. I., W. H. Peltier, T. J. Norberg-King, and others, 1989, "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms," EPA/600/4-89/001, Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. EPA, Cincinnati, OH.

Westinghouse Materials Company of Ohio, 1986, "Feed Materials Production Center Environmental Monitoring Annual Report for 1985," Document No.2047, U. S. Dept. of Energy, Oak Ridge Operations Office, Contract No. DE-AC05-860R21600, 105 pp.

Westinghouse Materials Company of Ohio, 1987, "Feed Materials Production Center Environmental Monitoring Annual Report for 1986," Document No. 2076, U.S. Dept. of Energy, Oak Ridge Operations Office, Contract No. DE-AC05-860R21600, 133 pp.

Westinghouse Materials Company of Ohio, 1988, "Feed Materials Production Center Environmental Monitoring Annual Report for 1987," Document No. 2135, U.S. Dept. of Energy, Oak Ridge Operations Office, Contract No. DE-AC05-860R21600, 92 pp.

Westinghouse Materials Company of Ohio, August 1986, Letter EH (EC): 86-0365.

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

APPENDIX A

Operable Units 1 and 5 Alternatives Recommended for Detailed Analysis

TABLE A-1
OPERABLE UNIT 1
ALTERNATIVES RECOMMENDED FOR DETAILED ANALYSIS

- Alternative 0: No Action (Baseline)

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

- Alternative 4: Removal - Sludge Treatment and On-Site Disposal

- Alternative 5: Removal - Sludge Treatment and Off-Site Disposal

- In addition, hybrid alternatives may be considered

Reference: Initial Screening of Alternatives for Operable Unit 1
Task 12 Report FMPC RI/FS
U.S. DOE, June 1990

TABLE A-2

OPERABLE UNIT 1
ALTERNATIVE RANKINGS

	Alternative Number			
	0	2	4	5
Short-Term Human Health	1	4	3	2
Short-Term Environmental Protection	1	4	3	2
Long-Term Human Health	1	3	4	5
Long-Term Environmental Protection	1	3	4	5
Reduction in Mobility, Toxicity, and Volume	1	2	4	4
Constructability	5	4	3	3
Reliability	5	4	3	3
Maintenance	1	3	4	5
Special Engineering & Equipment	5	4	3	3
Summation	21	31	31	32
Relative Cost	L	L	M	H

1 = Worst
2 = Below Average
3 = Average
4 = Above Average
5 = Best

Reference: Initial Screening of Alternatives for Operable Unit 1
Task 12 Report FMPC RI/FS
U.S. DOE, June 1990

TABLE A-3

REMEDIAL ACTION ALTERNATIVES
OPERABLE UNIT 5

MEDIUM	PROCESS OPTION	APPLICATION	1 GW: BASELINE SED/SS: NO ACTION	2 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL	3 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL	4 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL	5 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL	6 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, TREATMENT, DISPOSAL	7 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, TREATMENT, DISPOSAL	8 GW: EXTRACT, DISCHARGE SED/SS: SINGLE-LAYER CAP	9 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: SINGLE-LAYER CAP	10 GW: PLUME CONTROL, ON-SITE DISPOSAL SED/SS: EXCAVATE, ON-SITE DISPOSAL	11 GW: RECHARGE AREA MODIFICATION SED/SS: EXCAVATE, ON-SITE DISPOSAL
GROUNDWATER (GW)	MONITORING	TRACK PLUME MOVEMENT	●	●	●	●	●	●	●	●	●	●	●
	EXTRACTION	REMOVE CONTAMINATED GROUNDWATER		●	●	●	●	●	●	●	●	●	
	EXTRACTION/INJECTION	REMOVE AND INJECT UNCONTAMINATED WATER TO CONTROL PLUME										●	
	PAVE CHANNELS THAT CONTRIBUTE TO AQUIFER RECHARGE	PAVE PADDYS RUN AND OUTFALL DITCH											●
	ION EXCHANGE	NEW ON-SITE TREATMENT PLANT			●		●		●		●		
	DISCHARGE TREATED GW TO SW	USE EXISTING FMPC PIPELINE/OUTFALL			●		●		●		●		
	DISCHARGE UNTREATED GW TO SW	USE EXISTING FMPC PIPELINE/OUTFALL		●		●		●		●			
SEDIMENT/SURFACE SOIL (SED/SS)	NO ACTION		●										
	EXCAVATION	REMOVE CONTAMINATED SOIL/SEDIMENTS		●	●	●	●	●	●			●	●
	SINGLE-LAYER CAP	PAVE CONTAMINATED PORTIONS OF PADDYS RUN AND THE STORM SEWER OUTFALL DITCH								●	●		
	SOIL WASHING	WASH SOIL/SEDIMENTS TO REMOVE CONTAMINANTS						●	●				
	ON-SITE DISPOSAL	DISPOSAL OF MATERIAL IN NEW TUMULUS OR RCRA-TYPE CELL		●	●			●	●			●	●
	OFF-SITE DISPOSAL	DISPOSAL IN APPROVED OFF-SITE FACILITY				●	●						

REFERENCE: SEE TABLE 4.

TABLE A-4

RANKING OF OPERABLE UNIT 5 ALTERNATIVES

GENERAL EVALUATION CRITERIA	EVALUATION FACTORS	1 GW: NO ACTION SED/SS: NO ACTION		2 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL		3 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, ON-SITE DISPOSAL		4 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL		5 GW: EXTRACT, ON-SITE TREATMENT DISCHARGE SED/SS: EXCAVATE, OFF-SITE DISPOSAL		6 GW: EXTRACT, DISCHARGE SED/SS: EXCAVATE, TREATMENT, DISPOSAL		7 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: EXCAVATE, TREATMENT, DISPOSAL		8 GW: EXTRACT, DISCHARGE SED/SS: SINGLE-LAYER CAP		9 GW: EXTRACT, ON-SITE TREATMENT, DISCHARGE SED/SS: SINGLE-LAYER CAP		10 GW: PLUME CONTROL SED/SS: EXCAVATE, ON-SITE DISPOSAL		11 GW: RECHARGE AREA MODIFICATION SED/SS: EXCAVATE, ON-SITE DISPOSAL	
		GW[1]	SED SS[2]	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS	GW	SED SS
EFFECTIVENESS	SHORT-TERM PROTECTION OF HUMAN HEALTH	5	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	1	4
	SHORT-TERM PROTECTION OF THE ENVIRONMENT	1	1	4	5	4	5	4	5	4	5	4	5	4	5	4	4	4	4	1	5	1	5
	LONG-TERM PROTECTION OF HUMAN HEALTH	1	1	3	5	5	5	3	5	5	5	3	5	5	5	3	4	5	4	4	5	1	5
	LONG-TERM PROTECTION OF THE ENVIRONMENT	1	1	3	5	5	5	3	5	5	5	3	5	5	5	3	4	5	4	1	5	1	5
	REDUCTION OF MOBILITY, TOXICITY OR VOLUME OF WASTE	1	1	1	2	5	2	1	2	5	2	1	5	5	5	1	2	5	2	1	2	1	2
IMPLEMENTABILITY TECHNICAL FEASIBILTY	CONSTRUCTABILITY	5	5	5	4	4	4	5	5	4	5	5	3	4	3	5	2	4	2	3	4	2	4
	OPERATIONAL RELIABILITY	5	5	5	5	4	5	5	5	4	5	5	3	4	3	5	2	4	2	3	5	4	5
	MAINTENANCE	5	5	5	4	2	4	5	5	2	5	5	4	2	4	5	3	2	3	4	4	4	4
IMPLEMENTABILITY ADMINISTRATIVE FEASIBILITY	AGENCY APPROVALS	1	1	2	3	5	3	2	3	5	3	2	5	5	5	2	4	5	4	1	3	1	3
	AVAILABILITY OF SERVICES	5	5	5	4	3	4	5	3	3	3	5	4	3	4	5	5	3	5	5	4	5	4
	SPECIALIZED EQUIPMENT AND PERSONNEL	5	5	5	4	4	4	5	3	4	3	5	4	4	4	5	5	4	5	5	4	5	4
	SUBTOTAL	35	31	42	45	45	45	42	45	45	45	42	47	45	47	42	39	45	39	31	45	28	45
	TOTAL	66		87		90		87		90		89		92		81		84		76		71	

REFERENCE: INITIAL SCREENING OF ALTERNATIVES FOR OPERABLE UNIT 5, TASK 12 REPORT ASI/IT JUNE 1990.

NOTES:

1. GW = GROUNDWATER COMPONENT
2. SED/SS = SEDIMENT AND SURFACE SOIL COMPONENTS

303317-8465 (FS)

APPENDIX B

Radionuclides Discharge at 001

TABLE B-1

RADIONUCLIDES RELEASED AT DISCHARGE 001, 1986

Radionuclide [1]	Total Curies 1985	Total Curies 1986 [2]	Average Concentration [3] pCi/l	Standard [4] pCi/l	% of Standard [5]
Cs-137	9.2×10^{-3}	$<1.0 \times 10^{-3}$ ($<3.8 \times 10^{7}$)	$<1.5 \times 10^{0}$ ($<5.5 \times 10^{-2}$)	3000	<0.05
Np-237	$<1.7 \times 10^{-4}$	$<1.0 \times 10^{-5}$ ($<3.8 \times 10^{5}$)	$<1.5 \times 10^{-2}$ ($<5.5 \times 10^{-4}$)	3	<0.5
Pu-238	7.5×10^{-6}	$<1.0 \times 10^{-5}$ ($<3.8 \times 10^{5}$)	$<1.5 \times 10^{-2}$ ($<5.5 \times 10^{-4}$)	400	<0.004
Pu-239/240	1.5×10^{-5}	$<1.0 \times 10^{-5}$ ($<3.8 \times 10^{5}$)	$<1.5 \times 10^{-2}$ ($<5.5 \times 10^{-4}$)	300	<0.005
Ra-226	$<3.8 \times 10^{-3}$	$<4.6 \times 10^{-3}$ ($<1.7 \times 10^{8}$)	$<6.6 \times 10^{0}$ ($<2.4 \times 10^{-1}$)	100	<6.6
Ra-228	$<3.6 \times 10^{-3}$	$<4.1 \times 10^{-3}$ ($<1.5 \times 10^{8}$)	$<6.0 \times 10^{0}$ ($<2.2 \times 10^{-1}$)	100	<6.0
Ru-106	$<4.4 \times 10^{-4}$	$<1.0 \times 10^{-2}$ ($<3.8 \times 10^{8}$)	$<1.5 \times 10^{1}$ ($<5.5 \times 10^{-1}$)	600	<2.5
Sr-90	5.2×10^{-3}	9.0×10^{-4} (3.3×10^{7})	1.3×10^{0} (4.8×10^{-2})	1000	0.1
Tc-99	8.3×10^{0}	1.5×10^{0} (5.7×10^{10})	2.2×10^{3} (8.2×10^{1})	100000	2.2
Th-232	$<1.1 \times 10^{-2}$	5.4×10^{-4} (2.0×10^{7})	7.8×10^{-1} (2.9×10^{-2})	50	1.6
U-234	1.5×10^{-1}	1.1×10^{-1} (4.0×10^{9})	1.6×10^{2} (5.7×10^{0})	500	32.0
U-235	7.4×10^{-3}	5.9×10^{-3} (2.2×10^{8})	8.5×10^{0} (3.2×10^{-1})	600	1.4
U-236	4.9×10^{-3}	2.0×10^{-2} (7.4×10^{8})	2.9×10^{1} (1.1×10^{0})	500	5.8
U-238	2.0×10^{-1}	1.8×10^{-1} (6.5×10^{9})	2.5×10^{2} (9.4×10^{0})	600	42.0
Uranium	4.1×10^{-1}	3.1×10^{-1} (1.2×10^{10})	4.5×10^{2} (1.7×10^{1})	550	82.0

EC-TAB-1

1. Radionuclide concentrations in the plant effluent discharged to the Great Miami River through a buried pipeline, (with the exception of the three radium isotopes, thorium, ruthenium, and uranium) are determined from two 6-month composites.
2. Bq in parentheses
3. Bq/l in parentheses
4. As stated in DOE Memo from W.A. Vaughan, August 5, 1985 to Joe LaGrone.
5. Percent of Standard relates to the average value reported.

TABLE B-2

RADIONUCLIDES RELEASED AT DISCHARGE 001, 1987

Radionuclide [1]	Total Curies 1986	Total Curies 1987 [2]	Average Concentration [3] pCi/l	Standard [4] pCi/l	% of Standard [5]
Cs-137	$<1.0 \times 10^{-3}$	$<7.5 \times 10^{-3}$ (2.8×10^{8})	$<9.3 \times 10^{0}$ (3.4×10^{-1})	3000	<0.3
Np-237	$<1.0 \times 10^{-5}$	$<2.4 \times 10^{-4}$ (8.9×10^{6})	$<3.0 \times 10^{-1}$ (1.1×10^{-2})	30	<1.0
Pu-238	$<1.0 \times 10^{-5}$	$<5.6 \times 10^{-5}$ (2.1×10^{6})	$<7.0 \times 10^{-2}$ (2.6×10^{-3})	40	<0.2
Pu-239/240	$<1.0 \times 10^{-5}$	$<5.6 \times 10^{-5}$ (2.1×10^{6})	$<7.0 \times 10^{-2}$ (2.6×10^{-3})	30	<0.2
Ra-226	$<4.6 \times 10^{-3}$	$<4.0 \times 10^{3}$ (1.5×10^{8})	$<5.0 \times 10^{0}$ ($<1.9 \times 10^{-1}$)	100	<5.0
Ra-228	$<4.1 \times 10^{-3}$	$<3.9 \times 10^{-3}$ (1.4×10^{8})	$<4.9 \times 10^{0}$ (1.8×10^{-1})	100	<4.9
Ru-106	$<1.0 \times 10^{-2}$	$<3.3 \times 10^{-2}$ (1.2×10^{9})	$<4.1 \times 10^{1}$ (1.5×10^{0})	6000	<0.7
Sr-90	9.0×10^{-4}	2.2×10^{-3} (8.2×10^{7})	2.8×10^{0} (1.0×10^{-1})	1000	0.3
Tc-99	1.5×10^{0}	2.7×10^{0} (1.0×10^{11})	3.3×10^{3} (1.2×10^{2})	100,000	3.3
Th-228	. . . [6]	$<4.0 \times 10^{-4}$ (1.5×10^{7})	$<5.0 \times 10^{-1}$ (1.8×10^{-2})	400	<0.1
Th-230	. . . [6]	$<4.8 \times 10^{-4}$ (1.8×10^{7})	$<6.0 \times 10^{-1}$ (2.2×10^{-2})	300	<0.2
Th-232	5.4×10^{-4}	$<3.6 \times 10^{-4}$ (1.3×10^{7})	$<4.5 \times 10^{-1}$ (1.7×10^{-2})	50	<0.9
U-234	1.1×10^{-1}	2.4×10^{-1} (8.9×10^{9})	3.0×10^{2} (1.1×10^{1})	500	60.6
U-235	5.9×10^{-3}	1.2×10^{-2} (4.3×10^{8})	1.5×10^{1} (5.4×10^{-1})	600	2.4
U-236	2.0×10^{-2}	1.0×10^{-2} (3.8×10^{8})	1.3×10^{1} (4.8×10^{-1})	500	2.6
U-238	1.8×10^{-1}	2.6×10^{-1} (9.5×10^{9})	3.2×10^{2} (1.2×10^{1})	600	54.1
Uranium	3.1×10^{-1}	5.2×10^{-1} (1.9×10^{10})	6.6×10^{2} (2.4×10^{1})	550	119.6

EC-7483-2

1. Radionuclide concentrations in the plant effluent discharged to the Great Miami River through a buried pipeline, (with the exception of the three radium isotopes, thorium, ruthenium, and uranium) are determined from two 6-month composites.
2. Bq in parentheses
3. Bq/l in parentheses
4. As stated in DOE Draft Order 5480.XX, April 23, 1987.
5. Percent of Standard relates to the average value reported.
6. Not Analyzed in 1986.

TABLE B-3

RADIONUCLIDES RELEASED AT DISCHARGE 001, 1988

Radionuclide[1]	Total Curies 1987	Total Curies 1988[2]	Average Concentration[3] pCi/l	Standard[3,4] pCi/l	% of Standard[5]
Ac-227	...[6]	$< 1.6 \times 10^{-2}$ ($< 5.9 \times 10^{8}$)	$< 2.2 \times 10^{1}$ ($< 8.1 \times 10^{-1}$)	10	< 217
Cs-137	$< 7.5 \times 10^{-3}$	$< 4.9 \times 10^{-3}$ ($< 1.8 \times 10^{8}$)	$< 6.5 \times 10^{0}$ ($< 2.4 \times 10^{-1}$)	3000	< 0.2
K-40	...[6]	$< 6.8 \times 10^{-2}$ ($< 2.5 \times 10^{9}$)	$< 8.4 \times 10^{1}$ ($< 3.1 \times 10^{0}$)	7000	< 1.2
Np-237	$< 2.4 \times 10^{-4}$	$< 3.3 \times 10^{-5}$ ($< 1.2 \times 10^{6}$)	$< 4.5 \times 10^{-2}$ ($< 1.7 \times 10^{-3}$)	30	< 0.2
Pb-210	...[6]	$< 6.6 \times 10^{-3}$ ($< 2.4 \times 10^{8}$)	$< 8.6 \times 10^{0}$ ($< 3.2 \times 10^{-1}$)	30	< 29
Pu-238	$< 5.6 \times 10^{-5}$	$< 1.6 \times 10^{-5}$ ($< 5.9 \times 10^{5}$)	$< 2.2 \times 10^{-2}$ (8.0×10^{-4})	40	< 0.1
Pu-239/240	$< 5.6 \times 10^{-5}$	$< 2.3 \times 10^{-5}$ ($< 8.5 \times 10^{5}$)	$< 2.8 \times 10^{-2}$ ($< 1.0 \times 10^{-3}$)	30	< 0.1
Ra-226	$< 4.0 \times 10^{-3}$	$< 2.4 \times 10^{-3}$ ($< 8.9 \times 10^{7}$)	$< 6.7 \times 10^{0}$ ($< 2.5 \times 10^{-1}$)	100	< 6.7
Ra-228	$< 3.9 \times 10^{-3}$	$< 2.1 \times 10^{-3}$ (7.9×10^{7})	$< 5.6 \times 10^{0}$ ($< 2.1 \times 10^{-1}$)	100	< 5.6
Ru-106	$< 3.3 \times 10^{-2}$	$< 3.2 \times 10^{-2}$ ($< 1.2 \times 10^{9}$)	$< 4.2 \times 10^{1}$ ($< 1.6 \times 10^{0}$)	6000	< 0.7
Sr-90	2.2×10^{-3}	1.2×10^{-3} (4.4×10^{7})	1.6×10^{0} (5.7×10^{-2})	1000	0.2
Tc-99	2.7×10^{0}	5.9×10^{0} (2.2×10^{11})	7.2×10^{3} (2.7×10^{2})	100000	7.2
Th-228	$< 4.0 \times 10^{-4}$	3.2×10^{-4} (1.2×10^{7})	4.1×10^{-1} (1.5×10^{-2})	400	0.1
Th-230	$< 4.8 \times 10^{-4}$	7.4×10^{-4} (2.7×10^{7})	9.2×10^{-1} (3.4×10^{-2})	300	0.3
Th-232	$< 3.6 \times 10^{-4}$	8.7×10^{-5} (3.2×10^{6})	1.1×10^{-1} (4.2×10^{-3})	50	0.2
Th-234	...[6]	$< 7.9 \times 10^{-2}$ (2.9×10^{9})	7.9×10^{1} (2.9×10^{0})	10000	0.8
U-233	...[6]	$< 8.3 \times 10^{-2}$ ($< 3.1 \times 10^{9}$)	$< 9.8 \times 10^{1}$ ($< 3.6 \times 10^{0}$)	500	< 20
U-234	2.4×10^{-1}	2.4×10^{-1} (8.9×10^{9})	3.1×10^{2} (1.2×10^{1})	500	63
U-235	1.2×10^{-2}	1.2×10^{-2} (4.4×10^{8})	1.5×10^{1} (5.6×10^{-1})	600	2.5
U-236	1.0×10^{-2}	1.1×10^{-2} (4.2×10^{8})	1.5×10^{1} (5.5×10^{-1})	500	3.0
U-238	2.6×10^{-1}	2.8×10^{-1} (1.0×10^{10})	3.4×10^{2} (1.3×10^{1})	600	57
U-total[9]	5.2×10^{-1}	5.5×10^{-1} (2.0×10^{10})	6.9×10^{2} (2.5×10^{1})	550	125

1. Radionuclide concentrations in the plant effluent discharged to the Great Miami River through the effluent pipeline (with the exception of the two radium isotopes) are determined from two 6-month composites.
2. Bq in parentheses.
3. Bq/l in parentheses.
4. As stated in DOE Draft Order 5400.xx, March 18, 1988.
5. Percent of standard relates to the average value reported.
6. Not analyzed in 1987.
7. Not analyzed in 1988.
8. Not applicable.
9. Total uranium does not include U-233, which was not detected in any samples in 1988.

APPENDIX C

Risk Assessment

C1.0 INTRODUCTION

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was jointly signed by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (U.S. EPA) pertaining to environmental impacts associated with DOE's Feed Material Production Center (FMPC) in Fernald, Ohio. The FFCA is intended to ensure that environmental impacts associated with past and present activities at the FMPC are thoroughly and adequately investigated so that appropriate response actions can be formulated, assessed, and implemented.

In response to the FFCA, DOE initiated a Remedial Investigation/Feasibility Study (RI/FS) pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The FFCA was amended on April 9, 1990, by a Consent Agreement which incorporated an operable unit approach to the RI/FS and identified specific removal actions to be conducted by DOE.

One of the operable units (Operable Unit 1) includes those facilities utilized for the storage/disposal of radiological and chemical wastes from FMPC operations. Related facilities that now contain similar waste types are also included. These facilities include Waste Pits 1, 2, 3, 4, 5, and 6; the burn pit; and the Clearwell. Analytical results indicate that elevated concentrations of uranium are present in the storm water runoff from the waste pit area. Because of the associated potential threat to human health and the environment, DOE is pursuing a removal action to control the storm water runoff from this area pending the outcome of the RI/FS and the implementation of a final remedial action for the waste storage units.

Once a non-time-critical removal action is deemed appropriate (which applies to storm water runoff from the waste pit area since there is more than six months time available for planning), an engineering evaluation/cost analysis (EE/CA) is performed to analyze removal action alternatives and to support the selection of a preferred alternative. An essential part of the EE/CA is the assessment of health risks associated with each removal action alternative. This appendix presents the results of the human health risk assessment for the EE/CA for storm water runoff from the waste pit area. The risk assessment is performed for the "no action" alternative as well as for each removal action alternative. The results of this risk assessment are used as part of the evaluation of removal action alternatives.

The process used in this risk assessment for the waste pit area generally follows EPA guidance for human health risk assessments (EPA 1989a). The first step in the completion of the risk assessment involves the identification of all constituents, both radionuclides and hazardous chemicals, of potential concern. Results of this step of the risk assessment are given in Section C2.0.

Once chemicals and radionuclides of potential concern are identified, the process is directed toward the exposure assessment (Section C3.0) that includes both the characterization of an exposure setting and the identification of exposure pathways. Exposure pathways are identified by describing how humans may be exposed to contaminants originating from storm water runoff from the waste pit area. Each pathway consists of:

- A source of contamination
- A mechanism for transporting the contaminant through an environmental medium to a point of exposure
- A potential receptor at the point of exposure
- A route of exposure.

The concentrations of contaminants are estimated at potential exposure points for the present and future time intervals. Where possible, direct measurements are used to determine current exposure point concentrations. In other cases, environmental transport models are used to predict current and future concentrations. Intakes of the constituents of concern are estimated on the basis of hypothetical exposure scenarios for both present and future land-use conditions.

The toxic characteristics of chemicals of concern are then evaluated to identify potential adverse effects on human health. These effects include impacts on the function of body organs and the induction of cancer. When possible, an estimate is made of the relationship between the extent of potential exposure to the contaminant and the probability and/or severity of identified adverse effects. Section C4.0 presents toxicity information for the chemicals of potential concern.

The characterization of risk follows the exposure and toxicity assessments. In this step, the probability that an individual may develop a fatal cancer over a lifetime as a consequence of exposures to chemicals and radionuclides within storm water runoff from the waste pit area is estimated from potential intakes and contaminant-specific dose-response relationships. In addition,

comparisons are made between estimated potential intakes and the threshold values for non-carcinogenic effects. The risk characterization is presented in Section C5.0.

The results of the risk assessment are summarized in Section C6.0. A discussion of the uncertainties associated with the risk assessment is also presented in Section C6.0.

C2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

Surface water sampling within the waste pit are has been performed for many years. Analytical results of surface water sampling are summarized in Section 2.3 of the main text of the EE/CA report. Although analyses have been primarily directed toward determining the concentration of uranium, concentrations of other radionuclides as well as inorganic and organic chemicals have been measured in surface water samples in recent years.

Most surface water samples from the waste pit area have above-background concentrations of uranium isotopes. Other radionuclides, including technetium-99, radium-226, and radium-228, are found in above-background concentrations in a fraction of the samples, and in specific locations within the waste pit area. There is not an indication of pervasive contamination of surface water by radionuclides other than uranium within the waste pit area.

Detectable concentrations of several inorganic chemicals have been found in surface water samples collected within the waste pit area. Most concentrations of inorganic chemicals are less than background concentrations and the remainder are slightly above background at a few locations, which indicates isolated, low-level contamination of surface water with inorganic chemicals. Four organic compounds were detected in surface water samples. Each had concentrations just above the detection limits in a small percentage of samples. Since all four are common laboratory contaminants and since they were low concentrations in only a few samples, they are excluded from further consideration. Such exclusion is in accordance with recommended practice.

The presence of detectable concentrations of radionuclides (other than uranium) and inorganic chemicals in surface water samples from the waste pit area is not sufficient cause to select these radionuclides and chemicals as chemicals of concern. Their presence indicates that further evaluation of potential transport to offsite receptors is in order. It is also unreasonable to conclude that concentrations of radionuclides and chemical in surface water from isolated areas of the waste pit area are equal to concentrations of these radionuclides and chemicals in storm water runoff from the waste pit area.

Since Paddys Run receives nearly all of the surface water drainage from the waste pit area, measured concentrations of radionuclides and chemicals within Paddys Run are indicative of the radionuclides and chemicals which are being transported from the site. Such transport is essential for final determination of chemicals of concern. The most comprehensive surface water data for

Paddys Run are given in the three most recent Environmental Monitoring Annual Reports for the FMPC (WMCO 1987, WMCO 1988, WMCO 1989). These reports clearly indicate that only uranium is being transported from the site via Paddys Run in above-background concentrations. It is with the preceding rationale that uranium is concluded to be the only chemical of concern for the waste pit area storm water runoff.

C3.0 EXPOSURE ASSESSMENT

This section presents the estimation of contact, or exposure, between human and environmental receptors and uranium in storm water runoff from the waste pit area. The general procedure for conducting an exposure assessment is (EPA 1989a):

- Characterization of exposure setting
- Identification of exposure pathways
- Quantification of exposures.

Assumptions of the exposure setting, exposure pathways, and exposure assessment parameters are selected to represent the reasonable maximum exposure (RME) conditions at the site. Use of the RME scenarios is consistent with EPA guidance for exposure assessments (EPA 1989a). Nevertheless, as discussed in Section 3.4, assumptions used in this assessment will tend to overestimate potential exposures of nearby residents.

This section addresses each step of the exposure assessment.

C3.1 CHARACTERIZATION OF EXPOSURE SETTING

A complete description of the physical setting of the FMPC and surrounding area is given in Section 2.0 of the report and from the references cited therein. The following is a brief summary of that description.

The FMPC site is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. The production area is a tract of approximately 136 acres near the center of the FMPC site. The villages of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the plant.

The FMPC was constructed and operations began at the Fernald site in the early 1950s. A variety of chemical and metallurgical processes were utilized at the FMPC for the manufacture of uranium products. Large quantities of liquid and solid wastes were generated by these various operations.

Prior to 1985, solid and slurried wastes from FMPC processes were disposed of in the on-site Waste Storage Area. This area, which is located west of the production facilities, includes six low-level radioactive waste storage pits, a burn pit, two earthen-bermed concrete silos containing K-65

residues (i.e., high specific activity and low-level uranium-bearing residues from the pitchblende refining process), a concrete silo containing metal oxides, two lime sludge ponds, and a sanitary landfill.

Storm water runoff from much of the waste pit area and other affected areas within the western portion of the FMPC enters Paddys Run, a tributary of the Great Miami River. Paddys Run originates just north of the FMPC and flows south-southeast along the western edge of the site and, for a part of the year, is a dry streambed with occasional rainfall-induced flows.

The area is underlain by the regionally important Great Miami Aquifer. This aquifer serves as a principal source of domestic, municipal, and industrial water throughout the region. A portion of the flow in Paddys Run is known to enter this aquifer downstream from the waste pit area as a result of leakage through the stream bottom.

C3.2 IDENTIFICATION OF EXPOSURE PATHWAYS

Human exposures can potentially occur as contaminants are transported from the site via storm water runoff. Since there can be storm water runoff via Paddys Run to the Great Miami River, exposure scenarios along both Paddys Run and the Great Miami River must be considered. Also, since Paddys Run is known to enter the Great Miami Aquifer, exposure scenarios which consider use of contaminated groundwater must be included.

The following potential exposure pathways are considered for both Paddys Run, the Great Miami River, and water pumped from the Great Miami Aquifer:

- Ingestion of drinking water
- Ingestion of irrigated food crops
- Inhalation of resuspended materials following irrigation
- Inhalation of resuspended materials from sediment in dry stream beds
- Inhalation of materials released from water during showering
- Ingestion of sediment from stream beds
- Ingestion of meat from cattle which have ingested drinking water and/or irrigated forage
- Ingestion of milk from cattle which have ingested drinking water and/or irrigated forage

- Ingestion of fish from contaminated streams
- Ingestion of fowl which have ingested drinking water and/or irrigated feed
- Ingestion of eggs, cheese, or other animal products from animals which have ingested drinking water and/or irrigated feed
- External radiation dose from submersion in air near resuspended radioactive materials following irrigation
- External radiation dose from radioactive materials deposited onto soil following irrigation
- External radiation dose from radioactive materials deposited in sediment
- External radiation dose from radioactive materials in sediment in dry stream beds
- External radiation dose from immersion in a stream
- External radiation dose at the stream surface from radioactive materials in a stream.

Because of the intermittent nature of water flow in Paddys Run and because of the availability of a generous supply of water from the Great Miami River and potable water from the Great Miami Aquifer, water from Paddys Run is not used as a potable water supply or for irrigation. The intermittent flow of Paddys Run does not support sufficient quantities or varieties of fish for human consumption. The list of potential exposure pathways via Paddys Run is thus reduced to include the following:

- Inhalation of resuspended materials from sediment in dry stream beds
- Ingestion of sediment from stream beds
- External radiation dose from radioactive materials in sediment in dry stream beds.

Potential exposure pathways for groundwater pumped from the Great Miami Aquifer include:

- Ingestion of drinking water
- Ingestion of irrigated food crops
- Inhalation of resuspended materials following irrigation
- Inhalation of materials released from water during showering
- Ingestion of meat from cattle which have ingested drinking water and/or irrigated forage

- Ingestion of milk from cattle which have ingested drinking water and/or irrigated forage
- Ingestion of fowl which have ingested drinking water and/or irrigated feed
- Ingestion of eggs, cheese, or other animal products from animals which have ingested drinking water and/or irrigated feed
- External radiation dose from submersion in air near resuspended radioactive materials following irrigation
- External radiation dose from radioactive materials deposited onto soil following irrigation

Potential exposures pathways for contaminated surface water which flows into the Great Miami River include:

- Ingestion of drinking water
- Ingestion of irrigated food crops
- Inhalation of resuspended materials following irrigation
- Inhalation of materials released from water during showering
- Ingestion of sediment from stream beds
- Ingestion of meat from cattle which have ingested drinking water and/or irrigated forage
- Ingestion of milk from cattle which have ingested drinking water and/or irrigated forage
- Ingestion of fish from contaminated streams
- Ingestion of fowl which have ingested drinking water and/or irrigated feed
- Ingestion of eggs, cheese, or other animal products from animals which have ingested drinking water and/or irrigated feed
- External radiation dose from submersion in air near resuspended radioactive materials following irrigation
- External radiation dose from radioactive materials deposited onto soil following irrigation
- External radiation dose from radioactive materials deposited in sediment from a stream

- External radiation dose from immersion in a stream
- External radiation dose at the stream surface from radioactive materials in a stream.

Potential future receptors of the uranium in storm water runoff from the waste pit area of the FMPC include the following:

- Persons who pump contaminated groundwater for potable use, crop irrigation, or livestock feeding
- Persons who would use contaminated surface water for potable use, crop irrigation, livestock feeding, recreational use, and fishing
- Persons who live adjacent to Paddys Run.

Evaluation of the contribution of each of the pathways to the overall exposure of potential receptors to uranium in surface water or sediment along Paddys Run was performed by considering the chemical-specific environmental transport parameters for uranium, along with typical human activities reported for the area. From this evaluation, the sole potential exposure pathway of concern for surface water or sediment along Paddys Run is ingestion of sediment from stream beds. Additionally, due to the relatively high standard rate of intake of sediment by children and the low standard rate of intake of sediment by adults, this pathway is of concern only for children who would play in the stream bed.

Evaluation of the relative contribution of each of these pathways to the overall exposure of potential receptors to uranium in water pumped from the Great Miami River Aquifer and in water in the Great Miami River was also performed by considering the chemical-specific environmental transport parameters for uranium, along with typical human activities reported for the area. From this evaluation, for both the Great Miami Aquifer and the Great Miami River, four exposure pathways contributed more than 95 percent of the total calculated dose from uranium. These pathways are:

- Ingestion of drinking water
- Ingestion of irrigated vegetables
- Ingestion of meat from cattle which have ingested drinking water and irrigated forage
- Ingestion of milk from cattle which have ingested drinking water and irrigated forage.

This last pathway contributes less than two percent of the total calculated dose from uranium, but it is included because of typical perception of its significance.

C3.3 QUANTIFICATION OF EXPOSURES

Uranium is potentially ingested as a consequence of each exposure pathway. The quantity of uranium which could be ingested via each exposure pathway is estimated with standard mathematical models (equations). Although these models are taken from NRC Regulatory Guide 1.109 (1977), subsequent guidance documents, calculation models, and computer codes from the NRC and other Federal Agencies use these standard models.

Each model is presented in the following sections along with the values of the parameters used within the model. Since ingestion of sediment is a potential exposure pathway for children playing in Paddys Run, it is considered separate from the four potential exposure pathways for contaminated water in the Great Miami River and contaminated water pumped from the Great Miami Aquifer.

C3.3.1 Ingestion of Drinking Water

Intake via ingestion of contaminated drinking water is calculated using the following equation:

$$I_{DW} = (C_w)\ (IR)\ (EF)\ (ED)\ (FI)\ /\ (BW)\ (AT)$$

where

I_{DW}	=	normalized daily intake of contaminated drinking water, (mg/kg/day),
C_w	=	concentration of uranium in drinking water, (mg/l),
IR	=	ingestion rate, (l/day),
EF	=	exposure frequency, (days/yr),
ED	=	exposure duration, (yrs),
FI	=	fraction of ingested water from contaminated source, (unitless),
BW	=	body weight, (kg), and
AT	=	averaging time, (equal to ED x EF), (days).

The radiation dose received via ingestion of contaminated drinking water for one year is calculated using the following equation:

$$CEDE = (C_w)\ (DCF)\ (IR)\ (EF)\ (FI)$$

where

CEDE	=	committed effective dose equivalent, (mrem),
C_w	=	concentration of uranium in drinking water, (pCi/l),
DCF	=	dose conversion factor for ingestion of uranium, (mrem/pCi),
IR	=	ingestion rate, (l/day),
EF	=	exposure frequency, (days/yr), and
FI	=	fraction of ingested water from contaminated source (unitless).

The values used for the parameters in this section are given below:

Parameter	Value
IR	2 l/day (maximum) 1 l/day (average)
EF	365 days/yr
ED	70 yrs.
FI	1.0
BW	70 kg
DCF	2.5E-04 mrem/pCi

Substituting the parameter values into each equation yields the following:

I_{DW} (mg/kg/day)	$\simeq$	C_w (mg/l) x 2.86E-02	(maximum)
I_{DW} (mg/kg/day)	$\simeq$	C_w (mg/l) x 1.43E-02	(average)
CEDE (mrem)	$\simeq$	C_w (pCi/l) x 1.83E-01	(maximum)
CEDE (mrem)	$\simeq$	C_w (pCi/l) x 9.13E-02	(average)

Note that in each equation the intake or radiation dose is proportional to the uranium concentration in drinking water. Calculation of the intake or radiation dose is performed by multiplying the uranium concentration in drinking water (in appropriate units mg/l or pCi/l) by the factor in each equation.

C3.3.2 Ingestion of Irrigated Vegetables

Intake via ingestion of contaminated vegetables is calculated using the following equation:

$$I_v = (C_v)\ (IR)\ (EF)\ (ED)\ (FI)\ /\ (BW)\ (AT)$$

where

I_v	=	normalized daily intake of contaminated vegetables, (mg/kg/day),
C_v	=	concentration of uranium in vegetables, (mg/kg),
IR	=	ingestion rate, (kg/day), and
FI	=	fraction of ingested vegetables from contaminated source, (unitless)

The remaining parameters are the same as those defined in Section 3.3.1.

The radiation dose received via ingestion of contaminated vegetables for one year is calculated using the following equation:

$$CEDE = (C_v)\ (DCF)\ (IR)\ (EF)\ (FI)$$

where

C_v	=	concentration of uranium in/on vegetables, (pCi/kg)
IR	=	ingestion rate, (kg/day), and
FI	=	fraction of ingested vegetables from contaminated source, (unitless).

The remaining parameters are the same as those defined in Section 3.3.1.

The value for C_v is calculated for uranium with the following equation:

$$C_v = (C_w)\ (R)\ [\{(FC)\ [1 - \exp(-E)\ (TW)]\ /\ (Y)\ (E)\} + [(FR)\ (B_v)\ (TS)\ /\ (SD)]]$$

where

C_w	=	concentration of uranium in water used for irrigation, (in appropriate units mg/kg or pCi/kg),
R	=	average irrigation rate, ($l/m^2/hr$),
FC	=	fraction of deposited activity retained on crops, (unitless),
E	=	effective removal rate constant, (1/hr),
TW	=	duration of irrigation during growing season, (hrs),
Y	=	agricultural productivity per unit area, (kg/m^2),
FR	=	fraction of the year crops are irrigated, (unitless),
B_v	=	concentration factor for uptake of uranium from soil by edible parts of the crop, (mg/kg or pCi/kg net weight per mg/kg or pCi/kg dry soil),
TS	=	duration of exposure of soil to contaminated water, (hours), and
SD	=	effective surface density for soil, [kg (dry soil)/m^2].

The values used for the parameters in this section are given below:

Parameter	Value
IR	0.219 kg/day (maximum), 0.079 kg/day (average)
EF	365 days/yr
ED	70 yrs
FI	1.0
BW	70 kg
DCF	2.5E-04 mrem/pCi
R	0.118 $l/m^2/hr$
FC	0.25
E	2.1E-03 1/hr
TW	2160 hrs
Y	2 kg/m^2
FR	0.25
B_v	2.0E-03
TS	8.8E+03 hrs
SD	240 kg/m^2

Substituting these parameter values into each equation yields the following:

I_v (mg/kg/day)	$\simeq$	C_w (mg/l) x 2.17E-02	(maximum)
I_v (mg/kg/day)	$\simeq$	C_w (mg/l) x 8.08E-03	(average)
CEDE (mrem)	$\simeq$	C_w (pCi/l) x 1.39E-01	(maximum)
CEDE (mrem)	$\simeq$	C_w (pCi/l) x 5.03E-02	(average)

C3.3.3 Ingestion of Beef

Intake via ingestion of contaminated beef is calculated using the following equation:

$$I_B = C_B\ (IR)\ (EF)\ (ED)\ (FI)\ /\ (BW)\ (AT)$$

where

I_B	=	normalized daily intake of contaminated beef, (mg/kg/day),
C_B	=	concentration of uranium in beef, (mg/kg),
IR	=	ingestion rate, (kg/day),
FI	=	fraction of ingested meat from contaminated beef, (unitless).

The remaining parameters are the same as those defined in Section 3.3.1.

The radiation dose received via ingestion of contaminated beef for one year is calculated using the following equation:

$$CEDE = (C_B)\ (DCF)\ (IR)\ (EF)\ (FI)$$

where

C_B = concentration of uranium in beef, (pCi/kg).

The remaining parameters are the same as those defined previously.

The value of C_B is calculated for uranium with the following equation:

$$C_B = (TC)\ [(C_v)\ (IF) + (C_w)\ (IW)]$$

where

TC = transfer coefficient for uranium, (mg/kg per mg/kg/day),

C_v = concentration of uranium in vegetation (forage) as calculated by the equation of Section 3.3.2, (mg/kg),

IF = ingestion rate of contaminated forage, (kg/day),

C_w = concentration of uranium in water as calculated by the equation of Section 3.3.1, (mg/l), and

IW = ingestion rate of contaminated water, (l/day).

The values used for these parameters in this section are:

Parameter	Value
IR	0.301 kg/day (maximum), 0.260 kg/day (average)
EF	365 days/yr
ED	70 yrs
FI	1.0
BW	70 kg
DCF	2.5E-04 mrem/pCi
R	0.118 $l/m^2/hr$
FC	0.25
E	2.1E-03 1/hr
TW	2160 hrs
Y	2 kg/m^2
FR	0.25
B_v	2.0E-03
TS	8.8E+03 hr
SD	240 kg/m^2
TC	1.0E-02 day/kg
IF	25 kg/day
IW	50 l/day

Substituting these parameters into each equation yields the following:

I_B (mg/kg/day)	$\simeq$	C_w (mg/l) x 9.64E-03	(maximum)
I_B (mg/kg/day)	$\simeq$	C_w (mg/l) x 8.35E-03	(average)
CEDE (mrem)	$\simeq$	C_w (pCi/l) x 6.15E-02	(maximum)
CEDE (mrem)	$\simeq$	C_w (pCi/l) x 5.33E-02	(average)

C3.3.4 Ingestion of Milk

Intake via ingestion of contaminated milk is calculated using the following equation:

$$I_M = C_M \text{ (IR) (EF) (ED) (FI) / (BW) (AT)}$$

where the terms are analogous to the terms listed in Section 3.3.3.

The radiation dose received via ingestion of contaminated milk for one year is calculated using the following equation:

$$\text{CEDE} = (C_M) \text{ (DCF) (IR) (EF) (FI)}$$

where the terms are analogous to the terms listed in Section 3.3.3.

The value of C_M is calculated for uranium with the following equation:

$$C_M = \text{(TC) } [(C_V) \text{ (IF)} + (C_w) \text{ (IW)}]$$

where the terms are analogous to the terms listed in Section 3.3.3.

The values used for these parameters are the same as those listed in Section 3.3.3, with the following exceptions:

Parameter	Value	
IR	0.849 l/day	(maximum)
	0.301 l/day	(average)
TC	6.0E-04 day/l	
IW	60 l/day	

Substituting these parameters into each equation yields the following:

I_M	$\simeq$	C_w (mg/l) x 1.69E-03	(maximum)
I_M	$\simeq$	C_w (mg/l) x 6.42E-04	(average)
CEDE	$\simeq$	C_w (pCi/l) x 1.08E-02	(maximum)
CEDE	$\simeq$	C_w (pCi/l) x 4.10E-03	(average)

C3.3.5 Intake From All Pathways From Contaminated Groundwater or River Water

Since each equation for calculating the intake of uranium or the CEDE is linear with respect to C_w the total intake or CEDE from all pathways can be expressed as follows:

$$I \text{ (mg/kg/day)} = I_{DW} + I_V + I_B + I_M$$

or

I (mg/kg/day)	=	C_w (mg/l) x 6.16E-02	(maximum)
I (mg/kg/day)	=	C_w (mg/l) x 3.14E-02	(average)
CEDE (mrem)	=	C_w (pCi/l) x 0.394	(maximum)
CEDE (mrem)	=	C_w (pCi/l) x 0.199	(average)

Therefore, in order to calculate the normalized daily average intake of uranium or the radiation dose (CEDE), the concentration of uranium in the groundwater or river water supply is substituted into the equations shown above.

C3.3.6 Ingestion of Sediment by Children

Intake via ingestion of sediment is calculated using the following equation:

$$I_s = (C_s)\ (IR)\ (EF)\ (ED)\ (FI)\ /\ (BW)\ (AT)$$

where

I_s	=	normalized daily intake of contaminated sediment, (mg/kg/day),
C_s	=	concentration of uranium in sediment, (mg/g),
IR	=	ingestion rate, (g/day), and
FI	=	fraction of ingested sediment from contaminated source, (unitless).

The remaining parameters are the same as in Section 3.3.1.

The radiation dose received via ingestion of contaminated sediment for one year is calculated using the following equation:

$$CEDE = (C_s)\ (DCF)\ (IR)\ (EF)\ (FI)$$

where

CEDE	=	committed effective dose equivalent, (mrem),
C_s	=	concentration of uranium in sediment, (pCi/g),
DCF	=	dose conversion factor for ingestion of uranium, (mrem/pCi),
IR	=	ingestion rate, (g/day),
EF	=	exposure frequency, (days/yr), and
FI	=	fraction of ingested sediment from contaminated source, (unitless).

The values used for the parameters in this section are given below:

Parameter	Value
IR	0.2 g/day (maximum)
EF	90 days/yr
ED	6 yrs.
FI	1.0
BW	36 kg (9 yr - 12 yr old)
DCF	2.5E-04 mrem/pCi

Substituting the parameter values into each equation yields the following:

I_s (mg/kg/day)	$\simeq$	C_s (mg/g) x 5.56E-03
CEDE (mrem)	$\simeq$	C_s (pCi/g) x 4.5E-03

C3.3.7 Uranium Concentrations in Water Supplies

For each alternative, groundwater could be pumped from the Great Miami Aquifer or the Great Miami River and used as drinking water for humans and animals and for irrigation of food crops and forage. The concentration of uranium in groundwater as a consequence of charging of the Great Miami Aquifer along Paddys Run with surface water runoff from the waste pit area is based on the following assumptions for the no-action alternative:

- The concentration of uranium entering the aquifer from Paddys Run remains unchanged from the annual average concentration entering the stream from storm water runoff (1700 µg/l). This value is extremely conservative for two reasons: 1) the 1700 µg/l is greater than both the mean and median concentration values observed at representative sampling locations in the waste storage area, and 2) it does not account for any dilution in Paddys Run between the point of discharge and the assumed off-site location (i.e., a no-flow condition is assumed in Paddys Run, even though storm water runoff is occurring from the waste storage area).

- The rate of leakage is equal to 14 inches per year, which is equal to the recharge value used in the groundwater flow model.

- The contaminated recharge completely mixes with the groundwater passing through the zone of interest.

- Recharge and mixing occur within one 125-by-125-foot model cell, which is commensurate with assuming that the well would have a radius of influence of approximately 125 feet. The conservatism in this assumption is that the recharge is also assigned across the 125-by-1256 foot surface area, thereby representing a stream width many times greater than the actual width of Paddys Run under low-flow conditions.

- The groundwater is pumped from a depth of 40 feet.

The concentration of uranium in groundwater is calculated for Alternatives 2 and 3 by assuming that there is an 80 percent reduction of the uranium entering Paddys Run from storm water runoff from the Waste Pit Area. For Alternative 4, it is assumed that no uranium goes to Paddys Run via storm water runoff from the Waste Pit Area. The calculated concentrations of uranium in the Great Miami Aquifer as a consequence of storm water runoff from the Waste pit Area for each alternative are given in Table C3-1.

The above-background concentration of uranium in the Great Miami River is calculated for each alternative assuming all of the storm water runoff goes to the River. Dilution of the released quantities is assumed to occur throughout the year under low flow conditions (280 cubic feet per second or 2.5E+11 l/yr). This assumes that the Great Miami River flows all year at a rate of only one-fifteenth (6.7%) of the average annual flow rate.

Obviously, the storm water runoff cannot go simultaneously to both the Aquifer and the River. Both calculations are given to show the bounding conditions of the assessment. Because of the significant dilution of the storm water runoff in the River (even at low flow conditions for the River), the calculated above-background concentrations of uranium in the River are very low.

TABLE C3-1
ABOVE-BACKGROUND CONCENTRATIONS OF URANIUM IN WATER

Alternative	Concentration in Aquifer* (pCi/l)	(µg/l)	Concentration in River** (pCi/l)	(µg/l)
1	53	80	0.21	0.31
2	11	17	0.04	0.06
3	11	17	0.04	0.06
4	0	0	0.13	0.20

* Assumes all uranium in storm water runoff from the waste pit areas goes into the Great Miami Aquifer via Paddys Run.

** Assumes all uranium in storm water runoff from the waste pit area goes into the Great Miami River via Paddys Run.

TABLE C3-2
CALCULATED INTAKES AND RADIATION DOSES

Alternative		I (mg/kg/day) max	I (mg/kg/day) avg	CEDE (mrem) max	CEDE (mrem) avg
1	Aquifer	4.9E-03	2.5E-03	21.0	11.0
	River	1.9E-05	9.7E-06	0.08	0.04
2	Aquifer	10.E-03	5.3E-04	4.3	2.2
	River	3.7E-06	1.9E-06	0.02	0.01
3	Aquifer	1.0E-03	5.3E-04	4.3	2.2
	River	3.7E-06	1.9E-06	0.02	0.01
4	Aquifer	0	0	0	0
	River	1.2E-05	6.3E-06	0.05	0.03

The above-background concentration of uranium in the Great Miami River is calculated for each alternative with the following assumptions:

Alternative 1	1700 µg/l at 23 gpm via Paddys Run
Alternative 2	340 µg/l at 23 gpm via Paddys Run
Alternative 3	340 µg/l at 23 gpm via Paddys Run
Alternative 4	1530 µg/l at 13 gpm via Paddys Run and 20 µ/lg at 10 gpm via FMPC liquid effluent line

A summary of the calculated above-background concentrations (C_w) of uranium in the Great Miami River for each alternative is given in Table C3-1. Calculated normalized intakes and radiation doses are given in Table C3-2.

C3.3.8 Uranium Concentration in Sediment

Concentrations of uranium in sediment in Paddys Run were measured extensively in 1987 and 1988 (WMCO 1988, WMCO 1989). To properly estimate the concentration of uranium in sediment due to surface water runoff from the waste pit area, the highest concentration of uranium measured in sediment from Paddys Run north of its confluence with the storm sewer outfall ditch is used. The maximum measured concentration of uranium in sediment in this area is 5.15 pCi/g (including background of 2.9 pCi/g). The next concentration is therefore approximately 2.3 pCi/g (3.4 µg/g).

The normalized daily intake and the radiation dose from an annual intake are respectively:

I = (0.0034 mg/g) x (5.56E-03)

I = 1.9E-05 mg/kg/day

and

CEDE = (2.3 pCi/g) x (4.50E-03)

CEDE = 1.0E-02 mrem

If the background concentration of uranium in sediment is included, the calculated intakes and doses are:

I = (0.0077 mg/g) x (5.56E-03)

I = 4.3E-05 mg/kg/day

and

CEDE = (5.15 pCi/g) x (4.50E-03)

CEDE = 2.3E-02 mrem

C3.4 UNCERTAINTIES WITHIN THE EXPOSURE ASSESSMENT

A major source of uncertainty in the exposure assessment is associated with modeling transport of uranium in surface water runoff from the waste pit area through environmental media to human receptors. Site-specific transport parameters were not always available for use in Section 3.3 and, as a consequence, parameter values were chosen which would not underestimate the intake of uranium. An excellent example of this is the assumption that all drinking water, vegetables, meat, and milk was ingested throughout each year from pathways contaminated with uranium in surface water runoff from the waste pit area.

Another major source of uncertainty which necessarily overestimates the average annual intake and radiation dose from contaminated river water is the assumption that dilution of storm water runoff to the River will occur at low flow conditions throughout each year. If average flow conditions for the Great Miami River had been used in the exposure assessment, the calculated above-background concentrations, the calculated uranium intakes and the calculated uranium doses would have been lower by a factor of approximately 15.

C3.5 SUMMARY OF EXPOSURE ASSESSMENT

Four potential exposure pathways to human receptors from water contaminated by surface water runoff from the waste pit area have been identified. The intakes of uranium and the radiation doses have been calculated for each pathway and each removal action alternative. The risks associated with exposures from all pathways are addressed quantitatively in the risk characterization presented in Section C5.0. A separate calculation has been performed for the potential intake and radiation dose for ingestion of sediment from Paddys Run. The risks associated with this pathway are also addressed in Section C5.0.

C4.0 TOXICITY ASSESSMENT

As explained in Section C2.0, uranium is the only chemical of potential concern associated with the storm water runoff from the waste pit area. Potential health hazards from exposure to uranium are reviewed in this section.

Uranium is a heavy metal found in several isotopic states, all of which are radioactive. Both radiocarcinogenic and chemical toxicity health hazards are presented by uranium when taken into the body. The target organ for uranium chemical toxicity is the kidney; the primary target organs for the radiocarcinogenic effects are the lung and bone.

C4.1 NONCARCINOGENIC EFFECTS

The chemical toxicity of uranium is the only noncarcinogenic health effect from potential exposure pathways from the storm water runoff from the waste pit area. Pharmacokinetic and pharmacodynamic studies used to understand the toxicity of uranium and to develop a threshold effect dose limit are summarized below.

C4.1.1 Pharmacokinetics

The primary chemically-induced health effect of uranium is nephritis, or kidney damage. Symptoms of this include albuminuria (elevated protein in the urine) and glycosuria (elevated sugar in the urine). In general, uranium compounds are not easily absorbed across the human gastrointestinal tract. Soluble uranium compounds demonstrate the best absorption, but in a study where patients drank a solution of uranyl nitrate hexahydrate, a water soluble compound, only 0.5 percent of the ingested quantity was found to be absorbed (Hursh et al. 1969). Most recently, uranium metabolic models have estimated the fractional gastrointestinal (GI) absorption from the GI tract to the blood to be 0.6 percent (Wrenn et al. 1987). Although human data for dermal exposure are minimal, water-insoluble uranium compounds are not absorbed in significant amounts across the skin and are not believed to pose a risk to humans under this exposure route (Yuile 1973).

Once absorbed into the bloodstream, uranium compounds are metabolically converted to uranyl ions. The uranyl ion acts as a ligand in the systemic circulation, binding to the plasma proteins and bicarbonate present in the circulation. While this uranyl-bicarbonate complex is stable at the pH of the plasma, the pH change that occurs at the kidney as the urine is acidified favors dissociation of

the complex. This leaves the uranyl ion free to bind to the tissues in the proximal tubule wall, resulting in cellular necrosis (Leggett 1989).

In addition to being the only soft tissue that stores uranium in any appreciable amount, the kidney is also the main organ of excretion (Hursh and Spoor 1973). Approximately 70 percent of an uptake of uranium has been estimated to be excreted by the kidney within 24 hours of intake (Berlin and Rudell 1979). Uranium not excreted is stored in both the kidney and the bone. While uranium has an affinity for kidney tissue, it also has an affinity for the phosphate groups in the bone structure.

C4.1.2 Human Studies

Human data on exposure to uranium compounds comes mainly from acute studies on terminal and/or volunteer patients in the years 1940 to 1960. Single injections of 70 to 100 µg/kg of uranium nitrate to terminally ill patients resulted in proteinuria and increased levels of catalase in the urine (Berlin and Rudell 1979, Luessenhop et al. 1958). In another study, patients were given uranyl nitrate injections ranging from 6.3 to 71 µg U/kg. One of the early signs of renal damage, the appearance of the enzyme catalase in the urine, occurred in patients receiving 55 or 71 µg U/kg (Hursh and Spoor 1973, Leggett 1989).

C4.1.3 Animal Studies

Laboratory animals demonstrate a great deal of variation in their responses to acute intravenous toxicity studies, with rabbits and guinea pigs appearing to be the most sensitive. The acute intravenous toxicity of soluble uranium compounds like uranyl nitrate is very high: the approximate dose at which 50 percent of the test organisms did not survive (LD_{50}) for rabbits is 0.1 mg/kg; for guinea pigs, 0.3 mg/kg; for rats, 1 mg/kg; and for mice, 10-20 mg/kg (Stokinger 1982).

In chronic animal experiments, sublethal threshold doses of uranium have been demonstrated (Leggett 1989). Though the exact mechanism of tolerance is not known, it is believed that regenerated kidney tissue is associated with tolerance. When uranium exposure ceases, the regenerated epithelium will be transformed into renal tubular tissue (Yuile 1973).

An extensive chronic feeding study was performed on rabbits, rats, and dogs, for periods of 30 days, 1 year, and 2 years (Maynard and Hodge 1949). These animals received uranium doses of 2.8, 14, and 71 mg/kg/day in the diet. Rabbits were maintained for 30 days, dogs for 1 year, and rats for 1 and 2 years. For all species, water soluble compounds were more toxic than insoluble

compounds, and lowest observed adverse effect levels (LOAELs) were established for all compounds and each species (Maynard and Hodge 1949). In all cases, the LOAEL could be established within the first 30 days (EPA 1989c). Of the three species, rabbits appeared to be the most sensitive, with renal damage exhibited at all administered dose levels. The renal damage was judged to be only moderate at the lower doses, but moderately severe at the highest dose. Based on this, the lowest uranium dose of 2.8 mg/kg/day was established as the LOAEL by EPA (Maynard and Hodge 1949, EPA 1989c).

C4.1.4 Regulatory Guidance

The EPA (1989c) has recently established a reference dose (RFD) for uranium of 3 µg/kg/day. This reference dose is based on the LOAEL of 2.8 mg/kg/day from the Maynard and Hodge (1949) bioassay and an uncertainty factor of 1,000. The uncertainty factor accounts for intraspecies and interspecies variability in toxicological response and for the use of the LOAEL. No factor of 10 has been included to account for the short duration of the exposure (30 days), because it has been shown that chronic nephrotoxic effects can be adequately characterized with experiments of acute/subacute duration (EPA 1989c).

Because of the numerous uncertainties associated with the determination of an acceptable intake, a pharmacokinetic model and the suggested acceptable threshold dose for uranium levels in the kidney are used to calculate an acceptable uranium intake. The National Council on Radiation Protection and Measurements (NCRP) (Wrenn et al. 1985) proposed a single compartment model with long-term retention in the kidney.

Based on the NCRP model, the acceptable daily intake of uranium is 186 µg/day. In terms of intake by a 70-kilogram adult, the acceptable intake is 2.7 µg/kg/day, or approximately 3 µg/kg/day, in good agreement with the RfD determined using animal data. An RfD of 3 µg/kg/day is used in Section C5.0.

C4.2 CARCINOGENIC EFFECTS

Assessment of the lifetime radiocarcinogenic risk of fatal cancer from exposure to radiation is performed using a somatic whole body risk coefficient of 125 x 10^{-6} rem^{-1} published by the NCRP (NCRP 1987). The NCRP presents a tabulation of risk coefficients associated with various body tissues. The sum of the tissue-specific risk coefficients equals the total whole body risk coefficient of 165 x 10^{-6} rem^{-1}. The total whole body risk coefficient of 165 x 10^{-6} rem^{-1} includes the somatic whole body risk of 125 x 10^{-6} rem^{-1} and the genetic risk of 40 x 10^{-6} rem^{-1}. The somatic whole

body risk is used in the risk characterization in Section C5.0 to quantify the risk of fatal cancers in individuals exposed to ionizing radiation. The risks of health effects in offspring of individuals exposed to ionizing radiation (genetic risks) have not been demonstrated in humans.

All of these risk coefficients quantify risk as deaths per unit dose equivalent received (rem^{-1}). The risk coefficients presented by the NCRP are consistent with the recommendations of the ICRP in Publication 26 (ICRP 1977).

The somatic whole body risk coefficient is used for radiation exposure of specific tissues from internally deposited radionuclides after the committed dose equivalents are expressed as risk-weighted committed dose equivalents. Risk-weighted committed dose equivalents are committed dose equivalents for each tissue that have been multiplied by the appropriate risk-weighting factor for each tissue (ICRP 1977). The risk-weighted committed dose equivalents for tissues are summed over all tissues to give the committed effective (whole body) dose equivalent (CEDE). The CEDE is the quantity of radiation dose used throughout this exposure and risk assessment.

C4.3 UNCERTAINTIES RELATED TO TOXICITY INFORMATION

Toxicity information used in the human health assessment incorporates considerable uncertainty. This is because toxicity information is often based upon modeled projections that are based upon empirical studies of animals or humans exposed to radiological or hazardous agents under circumstances that differ from the circumstances of exposure in a site-specific human health assessment. Four principal sources of uncertainty that are incorporated into the human health assessment for both chemical and radiological toxicity are:

- The use of dose-response relationships (models) based on exposures at high doses to predict low-dose effects
- The use of dose-response relationships based on acute exposures to predict effects from chronic exposures
- The use of dose-response relationships based on laboratory animal studies to predict effects on humans
- The use of dose-response relationships based on human study populations that may be significantly different from the populations of concern in the site-specific human health assessment.

The radiological risk coefficient and the uranium chemical toxicity reference dose presented in this toxicity assessment incorporate conservative assumptions that are considered to overestimate risk.

This conservatism is built into the risk estimates because of the uncertainties that are associated with risk estimation.

The whole body risk coefficient selected by the NCRP incorporates a conservative assumption for radiation protection purposes. This assumption is that the dose-response relationship used to estimate risk is linear without threshold throughout the range of dose equivalent and dose equivalent rates of importance in routine radiation protection (NCRP 1987).

The EPA uranium chemical toxicity reference dose of 3 µg/kg/day (EPA 1989c) is based on a published LOAEL of 2.8 mg/kg/day (Maynard and Hodge 1949) and an uncertainty factor of 1,000. The uncertainty factor is included to compensate for intraspecies and interspecies variability in toxicological response.

C5.0 RISK CHARACTERIZATION

This section provides a characterization of the potential health effects associated with the intake of uranium in storm water runoff from the waste pit area. In accordance with methods described by EPA (1989a), a health protective approach that is likely to overestimate rather than underestimate risk is used. A quantitative evaluation of the lifetime risk associated with exposure to uranium for the five-year period of the removal action is presented.

C5.1 CARCINOGENIC EFFECTS

Radiocarcinogenic risks from exposure to uranium are calculated using the estimated radiation dose (CEDE) and the risk coefficient presented in Section C4.0. The total radiation doses from the annual exposure to uranium via the four pathways for each removal action alternative are given in Table C3-2. The total radiation dose as a consequence of releases during the five years of the removal action are listed in Table C5-1. Risks of fatal cancer are calculated by multiplying the total radiation dose by the radiation risk coefficient of 125×10^{-6} rem^{-1} or 1.25×10^{-7} $mrem^{-1}$. These calculated risks are also given in Table C5-1.

TABLE C5-1

RADIATION DOSES AND CANCER RISKS FOR REMOVAL ACTION ALTERNATIVES

Alternative		CEDE (mrem) (max)	CEDE (mrem) (avg)	Risk (max)	Risk (avg)
1	Aquifer	105	55	1E-05	7E-06
	River	0.4	0.2	5E-08	3E-08
2	Aquifer	22	11	3E-06	1E-06
	River	0.1	0.05	1E-08	6E-09
3	Aquifer	22	11	3E-06	1E-06
	River	0.1	0.05	1E-08	6E-09
4	Aquifer	0	0	0	0
	River	0.3	0.2	3E-08	2E-08

For Alternatives 1, 2, and 3, radiation doeses and risks are determined from pathways from the aquifer (the high of the two cases). For Alternative 4, there is not contribution to radiation dose and risk from the aquifer, so that the radiation dose and risk are from the River pathways.

Ingestion of uranium in sediment gives an additional radiation dose of 1.0E-02 mrem for each of the five years of the removal action. The total radiation dose is therefore 0.05 mrem. The additional risk corresponding to this radiation dose is 6E-09.

C5.2 NONCARCINOGENIC EFFECTS

The potential health consequence of the noncarcinogenic effects of chemicals is evaluated by comparing estimated intakes (Section C3.0) with the RfD, which represents an estimate of the level of intake that would not result in adverse health effects (i.e., a "threshold" effect). The parameter of interest is the hazard index (HI) defined as:

$$HI = I/RfD$$

where

HI = hazard index (unitless),
I = intake (µg/kg/day),and
RfD = reference dose (µg/kg/day) = 3 µg/kg/day.

This approach is different from the probabilistic approach used to evaluate carcinogens. Note that an HI ratio of 0.01 does not imply a 1 in 100 chance of adverse effect, but indicates that the estimated intake is 100 times less than the reference dose.

The identified potential exposure to elemental uranium in storm water runoff from the waste pit area is from ingestion of drinking water, vegetables, meat and milk. Table C3-2 presented the estimated uranium intake for each removal action alternative. The proper RfD to use in this evaluation may be a subchronic RfD because the exposure occurs over only five years of the total 70-year lifetime. It is assumed that the chronic RfD is appropriate for use in this situation because the chronic effect of uranium toxicity, nephrotoxicity, is the same effect that would be of concern during the five-year exposure.

The calculated intake and hazard index for each alternative assuming maximum exposure conditions and average exposure conditions are given in Table C5-2.

TABLE C5-2

URANIUM INTAKE AND HAZARD INDICES FOR REMOVAL ACTION ALTERNATIVES

	Alternative	I (mg/kg/day) (max)	(avg)	HI (max)	(avg)
1	Aquifer	4.9E-03	2.5E-03	1.6	0.8
	River	1.9E-05	9.7E-06	0.006	0.003
2	Aquifer	1.0E-03	5.3E-04	0.3	0.2
	River	3.7E-06	1.9E-06	0.001	0.0006
3	Aquifer	1.0E-03	5.3E-04	0.3	0.2
	River	3.7E-06	1.9E-06	0.001	0.0006
4	Aquifer	0	0	0	0
	River	1.2E-05	6.3E-06	0.004	0.002

With the exception of the maximum intake scenario from the aquifer for Alternative 1, the HI values are less than 1.0 for each alternative. This indicates that calculated average daily intakes are below the chemical toxicity level for uranium.

C5.3 UNCERTAINTIES

The risk characterization integrates environmental sampling, transport analysis, exposure analysis, and toxicological data. Uncertainties associated with each step of the risk assessment process impact the results of the risk characterization. The uncertainties associated with analysis of the environmental sampling data, transport results, exposure estimates, and toxicological data have been qualitatively presented in previous sections. This risk characterization strives to minimize the probability that uncertainties may result in an underestimation of the actual health hazards associated with the operable unit. Thus, each step of the process has incorporated bias intended to overestimate the potential hazards being addressed.

C6.0 SUMMARY

Uranium is the only chemical of concern as determined by evaluation of the available surface water runoff data. There is no evidence that organic chemicals are present as contaminants of concern in the surface water runoff. Inorganic chemicals are not found in concentrations which exceed background concentrations and/or detection limits for the surface water runoff.

Four exposure pathways were determined to contribute nearly all of the potential exposure from uranium in storm water runoff from the waste pit area. These hypothetical pathways all involved ingestion of materials contaminated with uranium from the pumped groundwater. These materials are drinking water, vegetables, meat, and milk. An exposure assessment was performed using standard models and transport parameters to determine the intake and radiation dose from each exposure pathway. The contributions from these pathways were combined to yield relationships between concentrations of uranium in water and uranium intakes and radiation doses. Pathways for water from both the Great Miami Aquifer and the Great Miami River were considered.

Radiation doses (CEDE) calculated for the no-action alternative ranged from 0.03 mrem to 11 mrem per year for average ingestion rates. Radiation doses ranged form 0.05 mrem to 21 mrem per year for maximum ingestion rates.

The normalized daily intake of uranium and the radiation dose were calculated for the hypothetical scenario of ingestion of sediment from Paddys Run by a child. Both the intake and radiation dose were a small fraction of the corresponding values for other pathways

Radiocarcinogenic risks calculated for the five-year period of the removal action ranged from 3E-08 for Alternative 4 to 1E-05 for Alternative 1, assuming maximum ingestion rates.

The only chemical intakes calculated for the potential exposure scenarios which exceeded the chronic reference dose of 3 μg/kg/day occurred for Alternative 1. Alternatives 2, 3, and 4 had acceptable calculated intakes, based on chemical toxicity of uranium.

REFERENCES

APPENDIX C
REFERENCES

Berlin, M., and B. Rudell, 1979, "Uranium," Handbook on Toxicology of Metals, edited by L. Friberg et al., North-Holland Biomedical Press.

Hursh, J.B., W.R. Neuman, T. Toribara, H. Wilson, and C. Waterhouse, 1969, "Ingestion of Uranium by Man," Health Physics, Volume 17, pp. 619-621.

Hursh, J.B. and N.L. Spoor, 1973, "Data on Man," Uranium, Plutonium and the Transuranic Elements, edited by C.H. Hodge, J.N. Stannard and J.B. Hursh.

International Commission on Radiological Protection (ICRP), 1977, "Recommendations of the International Commission on Radiological Protection," Annals of the International Commission on Radiological Protection, Publication 26, Pergamon Press, New York.

Leggett, R.W., 1989, "The Behavior and Chemical Toxicity of U in the Kidney: A Reassessment," Health Physics, Volume 57:3, pp. 365-383.

Luessenhop, A.J., J.C. Gallimore, W.H. Sweet, E.G. Struxness, J. Robinson, 1958, "The Toxicity in Man of Hexavalent Uranium Following Intravenous Administration," American Journal of Roentgenology, Volume 79, pp. 83-100.

Maynard, E.A. and H.C. Hodge, 1949, "Studies of the Toxicity of Various Uranium Compounds When Fed to Experimental Animals," in: The Pharmacology and Toxicology of Uranium Compounds, Volume 1, edited by C. Voegtlin and H.C. Hodge.

National Council on Radiation Protection and Measurements (NCRP), 1987, "Recommendations on Limits for Exposure to Ionizing Radiation," Report 91, National Council on Radiation Protection and Measurements, Bethesda, Maryland.

Stokinger, H.E., 1982, "Uranium," Patty's Industrial Hygiene and Toxicology, third edition.

U.S. Environmental Protection Agency (EPA), 1989a, "Risk Assessment Guidance for Superfund, Human Health Evaluation Manual (Volume I), Interim Final," EPA 540/1-89/002, Office of Emergency and Remedial Response, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1989b, "Integrated Risk Information System (IRIS)," computer database, U.S. Environmental protection Agency.

U.S. Environmental Protection Agency (EPA), 1989c, "Exposure Factors Handbook," EPA 600/8-89/043, July 1989, Office of Health and Environmental Assessment.

U.S. Nuclear Regulatory Commission (NRC), 1977, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Regulatory Guide 1.109, U.S. Nuclear Regulatory Commission, Office of Standards Development.

Westinghouse Materials Company of Ohio (WMCO), 1987, "Feed Materials Production Center Environmental Monitoring Report for 1986," FMPC-2076, UC-41, prepared by Westinghouse Materials Company of Ohio.

Westinghouse Materials Company of Ohio (WMCO), 1988a, "Feed Materials Production Center Environmental Monitoring Annual Report for 1987," FMPC-2135, UC-41, prepared by Westinghouse Materials Company of Ohio.

Westinghouse Materials Company of Ohio (WMCO), 1989a, "Feed Materials Production Center Environmental Monitoring Annual Report for 1988," FMPC-2173, UC-707, prepared by Westinghouse Materials Company of Ohio.

Westinghouse Materials Company of Ohio (WMCO), 1989b, "Engineering Evaluation/Cost Analysis for the Removal Action Waste Pit Area Stormwater Runoff Control," prepared by Westinghouse Materials Company of Ohio for the U.S. Department of Energy, September 1989.

Wrenn, M.E., P.W. Durbin, B. Howard, J. Lipsztein, J. Rundo, E.T Still, D.L. Wilis, 1985, "Metabolism of Ingested U and Ra," Health Physics, Volume 48:5, pp. 601-633.

Wrenn, M.E., P.W. Durbin, D.L. Wilis, N.P. Singh, 1987, "The Potential Toxicity of U in Water," Journal of the American Water Works Association, Volume 79, pp. 177-184.

Yuile, C.L., 1973, "Animal Experiments (Chapter 3)," Uranium, Plutonium and the Transuranic Elements, edited by Hodge, Stannard and Hursh.

APPENDIX D

Cost Estimates for Alternatives

COST ESTIMATE FOR ALTERNATIVE 2
SURFACE CAPPING

I. Backfill Site

Assume on-site borrow area

$3.00/cy transport, grading, and compaction[1]

Zone 1	Approximately 1 ft over 72,750 sq ft	=	2,690 cy		
Zone 2	Approximately 1 ft over 78,000 sq ft	=	2,890 cy		
Zone 3	None required				
Zone 4	Backfill Pit 6 (5 ft x 8100 sq ft) and approximately 1 ft over 91,500 sq ft	=	4,880 cy		
Zone 5	Backfill Pit 5 (4 ft x 52,000 sq ft)	=	7,700 cy		
Zone 6	Approximately 1 ft over 71,800 sq ft	=	2,660 cy		
			20,820 cy x $3.00	=	$62,460
	Mobilization/Demobilization				$20,000

II. Solidify Sludge in Pits 4 and 5

$4.00/cu ft labor and material[2]

Volume: Pit 5 (5 ft avg depth x 52,000 sq ft) = 260,000 cu ft

Pit 6 (3 ft avg depth x 8100 sq ft) = 24,300 cu ft

(260,000 + 24,300) x $4.00 = $1,137,200

III. Liner and Geofabric Installation

$3.50/sq ft, material and labor[3]

$10.00/linear ft, anchor material and labor

Area of approximately 10.5 acres or 457,400 sq ft

Liner Cost: 457,400 sq ft x $3.50 = $1,600,900

Anchor Cost: 6,000 ft perimeter x $10.00 = $60,000

[1] "Building Construction Costs Data 1989," Means.
[2] Historical Costs for Waste Pit 6, WMCO 1990.
[3] Telephone Quote, Felon Wilson at Seaman Corporation, (615) 691-9476

COST ESTIMATE FOR ALTERNATIVE 2
-Continued-

IV. Top Soil

Area: 457,400 sq ft x 1 ft avg = 457,400 cu ft = 16,940 cy

$3.00/cy x 16,940[1]	= $50,820
Mobilization/Demobilization	= $5,000

V. Vegetation - (Seed, Fertilizer, and Mulch)

Area: 457,400 sq ft x $.10/sq ft	= $45,740

SUBTOTAL	$2,982,120
CONSTRUCTION MANAGEMENT @ 24%	$715,710
SUBTOTAL	$3,697,830
CONTINGENCY @ 30%	$1,109,350
TOTAL (CONSTRUCTION)	$4,807,180
ENGINEERING AND SUBCONTRACT ADMINISTRATION	$961,440
TOTAL (PROJECT COST)	$5,768,600

COST ESTIMATE FOR ALTERNATIVE 3
SURFACE CAPPING WITH LATERAL DRAINAGE

I. Excavation of Trench at Lower Elevations

Zone	Volume Required[1]	Length[2]	Profile of Cut[3]
1	3,537	600 ft	4 ft x 5 ft
2	3,792	500 ft	5 ft x 5 ft
3	162	400 ft	2 ft x 2 ft
4	747	125 ft	4 ft x 5 ft
5	3,379	525 ft	4.5 ft x 5 ft
6	4,500	600 ft	5 ft x 5 ft

Total Soil Excavated (length x profile)

Area			
1	600 x 4 x 5	=	444 cy
2	500 x 5 x 5	=	463 cy
3	400 x 2 x 2	=	59 cy
4	125 x 4 x 5	=	93 cy
5	525 x 4.5 x 5	=	438 cy
6	600 x 5 x 5	=	556 cy
			2,053 cy

Cost to excavate using a backhoe, 8 cy/hr x $100/hr[4]

2,053 cy/8 x $100 = $25,660

II. Disposal Costs[5]

2,053 cy/13.3 = 154 Containers

a. Cost of Containers - 154 x $600/each = $92,400

b. Transportation to NTS (4 containers/load) - 154/4 x $6,000 = $231,000

c. Disposal Cost of NTS - 2053 cy x $324/cy[6] = $665,170

[1]Infiltration from HELP output
[2]Length of base
[3]Void ratio estimated at 30%
[4]Building Construction Costs Data 1989," Means
[5]Final Environmental Impact Statement, "Long Term Management of the Existing Radioactive Waste and Residues at the Niagara Falls Storage Site," U.S. DOE, Washington, DC (April 1986)
[6]U.S. EPA, Remedial Action Costing Procedures Manual, EPA/600/8-87/049

COST ESTIMATE FOR ALTERNATIVE 3
-Continued-

III.	Trench Fill Material (D_{50}=3")[4]	
	Cost @ $12/cy = 2,053cy x $12 =	$24,640
IV.	Sumps and Riser for Each Trench[4]	
	6 @ $5,000 =	$30,000

SUBTOTAL	$1,068,870
CONSTRUCTION MANAGEMENT @ 24% EXCLUDES DISPOSAL	19,270
SUBTOTAL	$1,088,140
CONTINGENCY @ 30%	326,440
SUBTOTAL	$1,414,580
COST OF CAP (ALTERNATIVE 2)	$4,629,700
TOTAL (CONSTRUCTION)	$6,044,000
ENGINEERING AND SUBCONTRACT ADMINISTRATION	$1,011,000
TOTAL (PROJECT COST)	$7,055,000

COST ESTIMATE FOR ALTERNATIVE 4
RUNOFF COLLECTION AND TREATMENT

ESTIMATE SUMMARY	
GENERAL CONTRACTOR - PRIME	$ 699,391
ELECTRICAL SUBCONTRACT	87,185
MECHANICAL SUBCONTRACT	204,401
FENCING SUB-SUBCONTRACT	7,366
INSTRUMENT AND SUB-SUBCONTRACT	24,613
SUBTOTAL[1]	$1,022,956
CONSTRUCTION MANAGEMENT @ 24%	245,504
SUBTOTAL	$1,268,460
WASTE DISPOSAL	525,000
SUBTOTAL	$1,793,460
LINING FOR NORTH DETENTION BASIN	16,310
LINING FOR EAST DETENTION BASIN	20,106
CONTINGENCY @ 30%	548,963
TOTAL (CONSTRUCTION)	$2,378,839
ENGINEERING & SUBCONTRACT ADMINISTRATION @ 20%	$475,768
CAPITAL COST FOR PILOT SCALE WWTS	500,000
TOTAL (PROJECT COST)	$3,354,607

[1]"Cost Estimate Design Review for EH&S Improvements, Phase IV, Vol 3." A.M. Kinney, Inc., 1989, and additional cost estimate A. M. Kinney, Inc. 1990.

COST ESTIMATE FOR ALTERNATIVE 5
SOURCE REMOVAL

I.	Excavation Required[1] - 3.5 cy Dragline @ $2.00/cy[2]	
	503,400 cy x $2.00 =	$1,006,800
II.	Disposal Costs[3]	
	503,400 cy/13.3 = 37,850 containers	
	a. Cost of Containers	
	37,850 x $600/each =	22,710,000
	b. Transportation to NTS (4 containers/load)	
	37,850/4 = 9,463 x $6,000 =	56,775,000
	c. Disposal Cost at NTS	
	503,400 cy x $1,485/cy[4] =	$747,549,000
		$828,041,000
III.	Site Backfill	
	-Assume on-site borrow area	
	-$3.00/cy[2] transport, grading, and compaction	$1,510,200
	Mobilization/Demobilization	$5,000
IV.	Vegetation (Seed, Fertilizing & Mulch)	
	284,375 ft[2] 0.10 ft[2] [2] =	28,438
	SUBTOTAL	$829,584,600
	CONSTRUCTION MANAGEMENT @ 24%, EXCLUDES DISPOSAL	612,100
	SUBTOTAL	$830,196,700
	CONTINGENCY @ 30%	249,059,010
	TOTAL	$1,079,255,700
	DESIGN @ 20% (EXCLUDING DISPOSAL)	$50,444,300
	TOTAL (PROJECT COST)	$1,129,700,000

[1]See Volume of Waste at Waste Pit Area Calculation
[2]"Building Construction Cost Data 1989," Means
[3]Final Environmental Impact Statement, "Long-Term Management Waste and Residues at the Niagara Falls Storage Site," U.S. DOE Washington, DC (April 1986)
[4]Low-Level Radioactive Waste Disposal Facilities: Conceptual Designs and Assessment Summary Report prepared for the Texas Low-Level Radioactive Waste Disposal Authority, February 1987

APPENDIX E

Present Worth Calculations

EE/CA PRESENT WORTH CALCULATIONS

Alternative 2 - Capping

Capital Costs		$ 5,768,600
Assume Annual Costs	0.05 x 5,768,600 =	288,500
n = 5 years		
i = 10%		

Present Worth

5,768,600 + (P/A, 10%, 5 years)[1] (288,500)
5,768,600 + (3.7908)[1] (288,500)
6,862,246
~ 6,862,300

Alternative 4 - Runoff Collection and Treatment

Capital Costs		$ 3,554,607
Assume Annual Costs	0.05 x 3,554,607 =	177,730
n = 5 years		
i = 10%		

Present Worth

3,554,607 + (3.7908)[1] (177,730)
4,228,345
~ 4,228,400

[1] Lindeburg, Michael R., Civil Engineering Reference Manual, Professional Publications, 1986, Pages 2-27, Interest Factors.

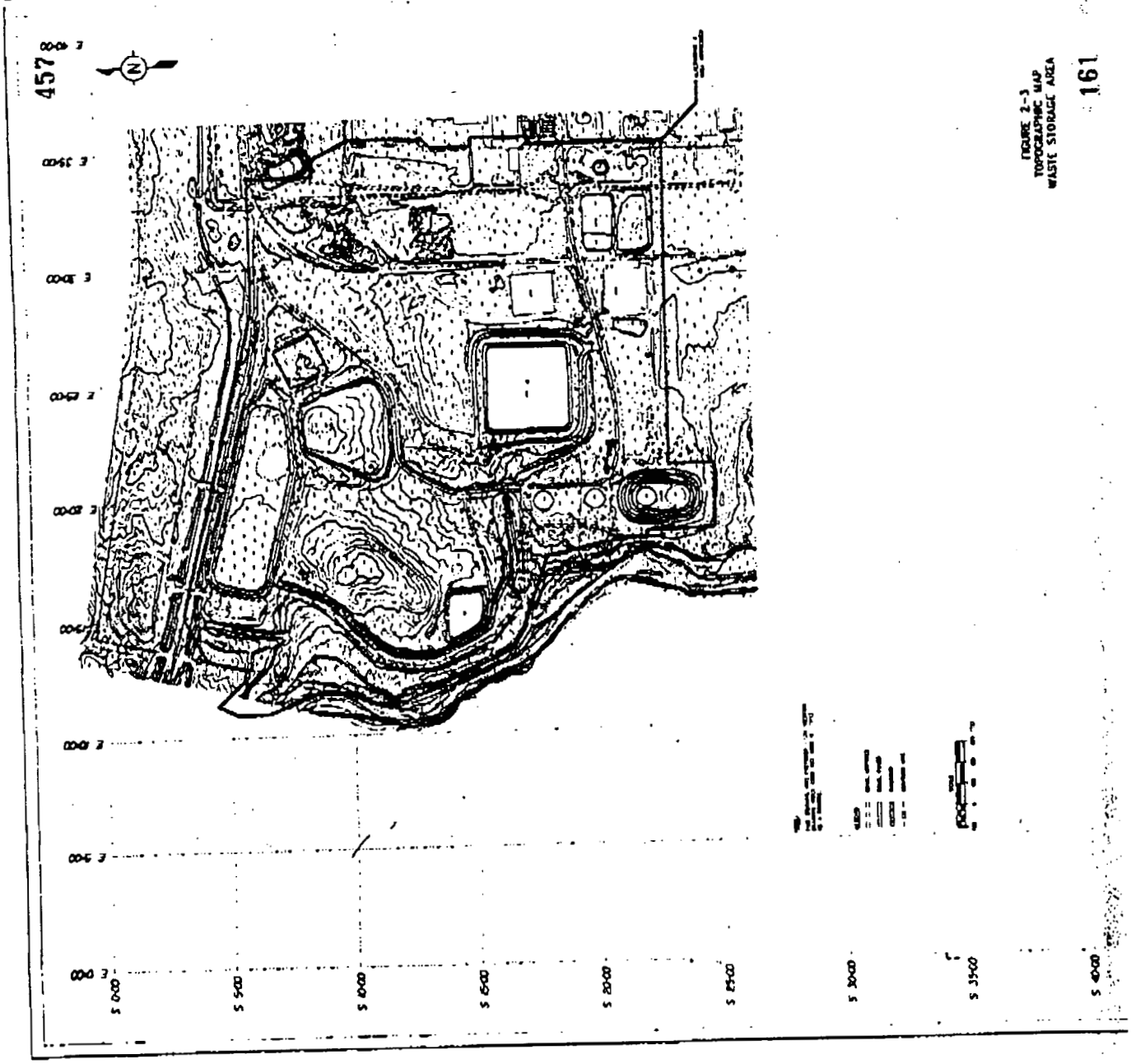


FIGURE 2-3
TOPOGRAPHIC MAP
WASTE STORAGE AREA

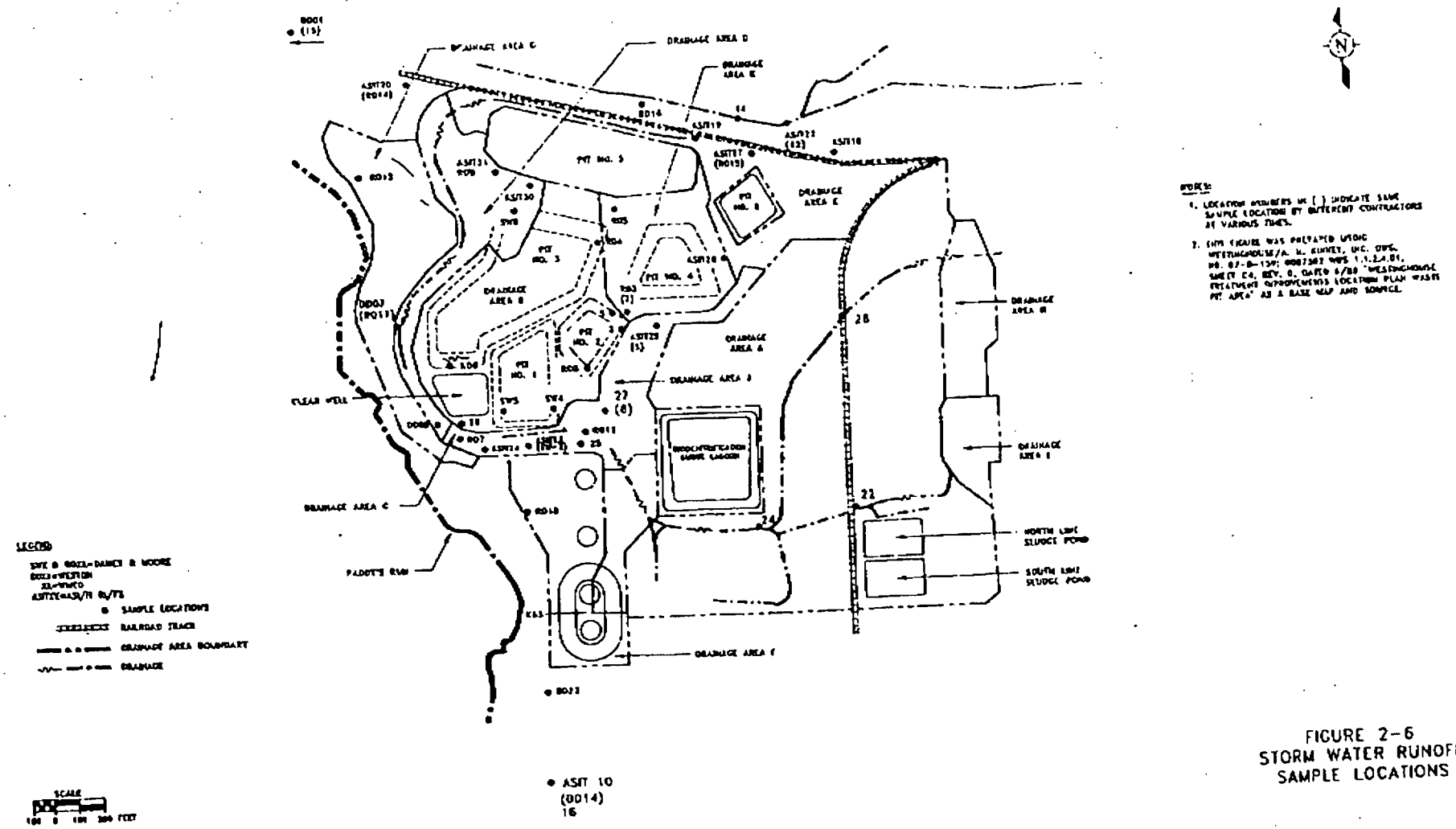


FIGURE 2-6
STORM WATER RUNOFF
SAMPLE LOCATIONS

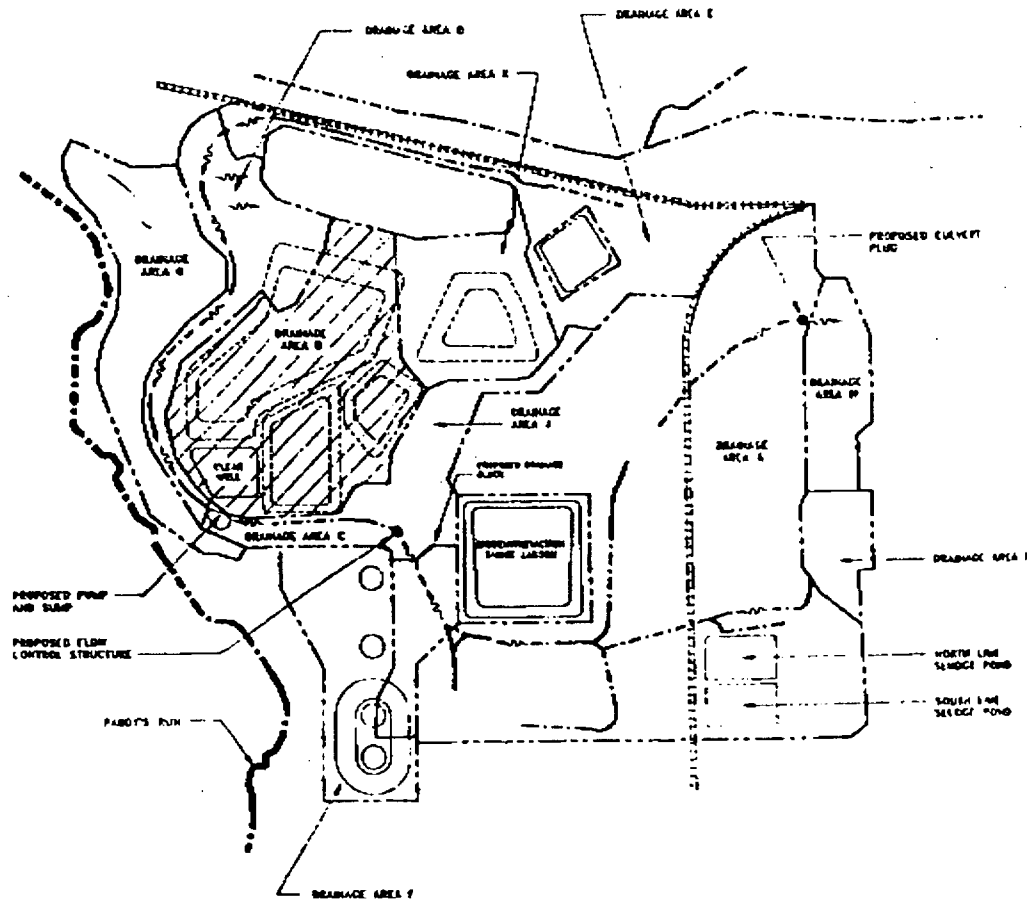


FIGURE 4-4
ALTERNATIVE 4
RUNOFF COLLECTION AND TREATMENT

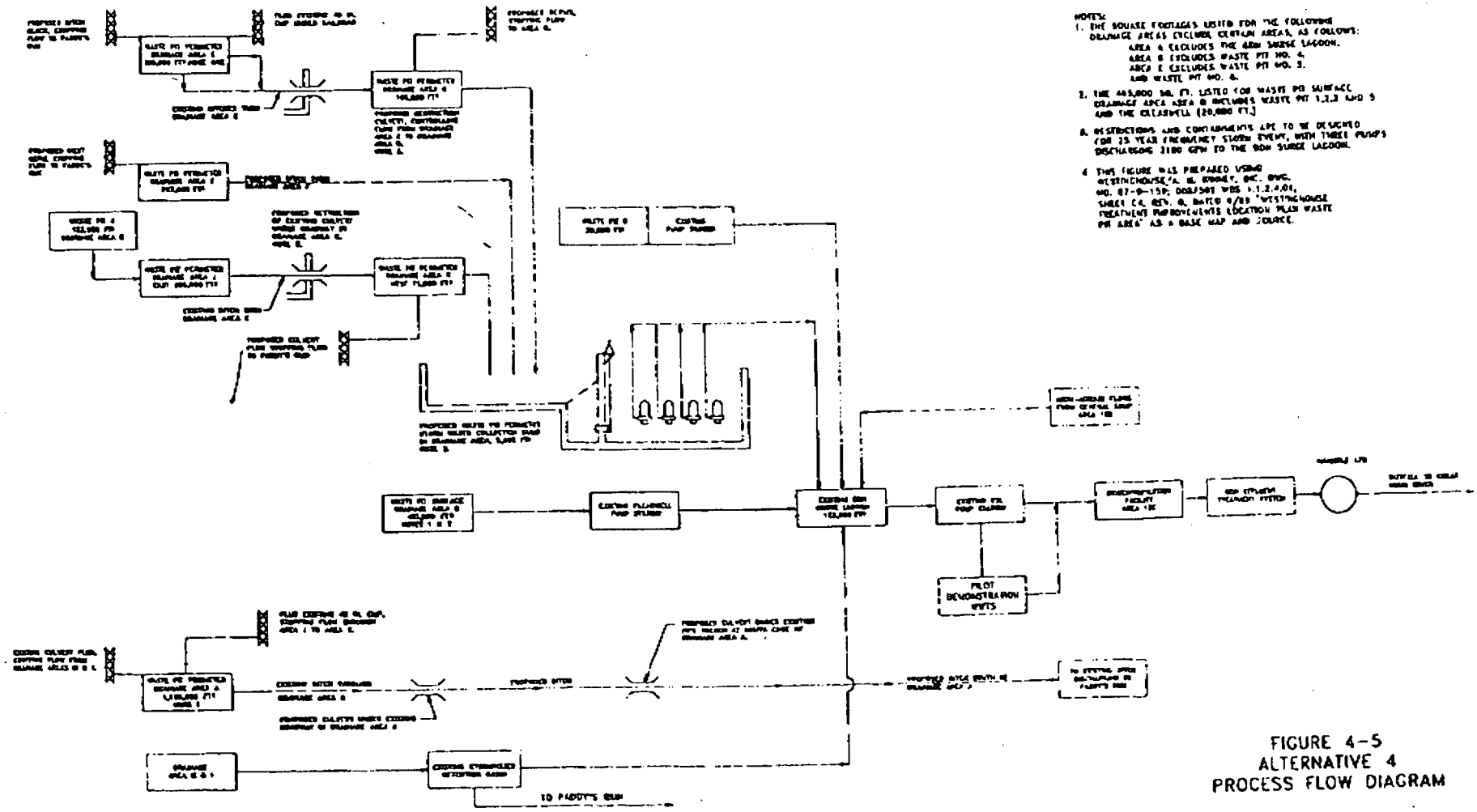


FIGURE 4-5
ALTERNATIVE 4
PROCESS FLOW DIAGRAM

PUBLIC ENVIRONMENTAL INFORMATION CENTER
% Westinghouse Mat'l Co. of Ohio
P. O. Box 398704
Cincinnati, Ohio 45239-8704

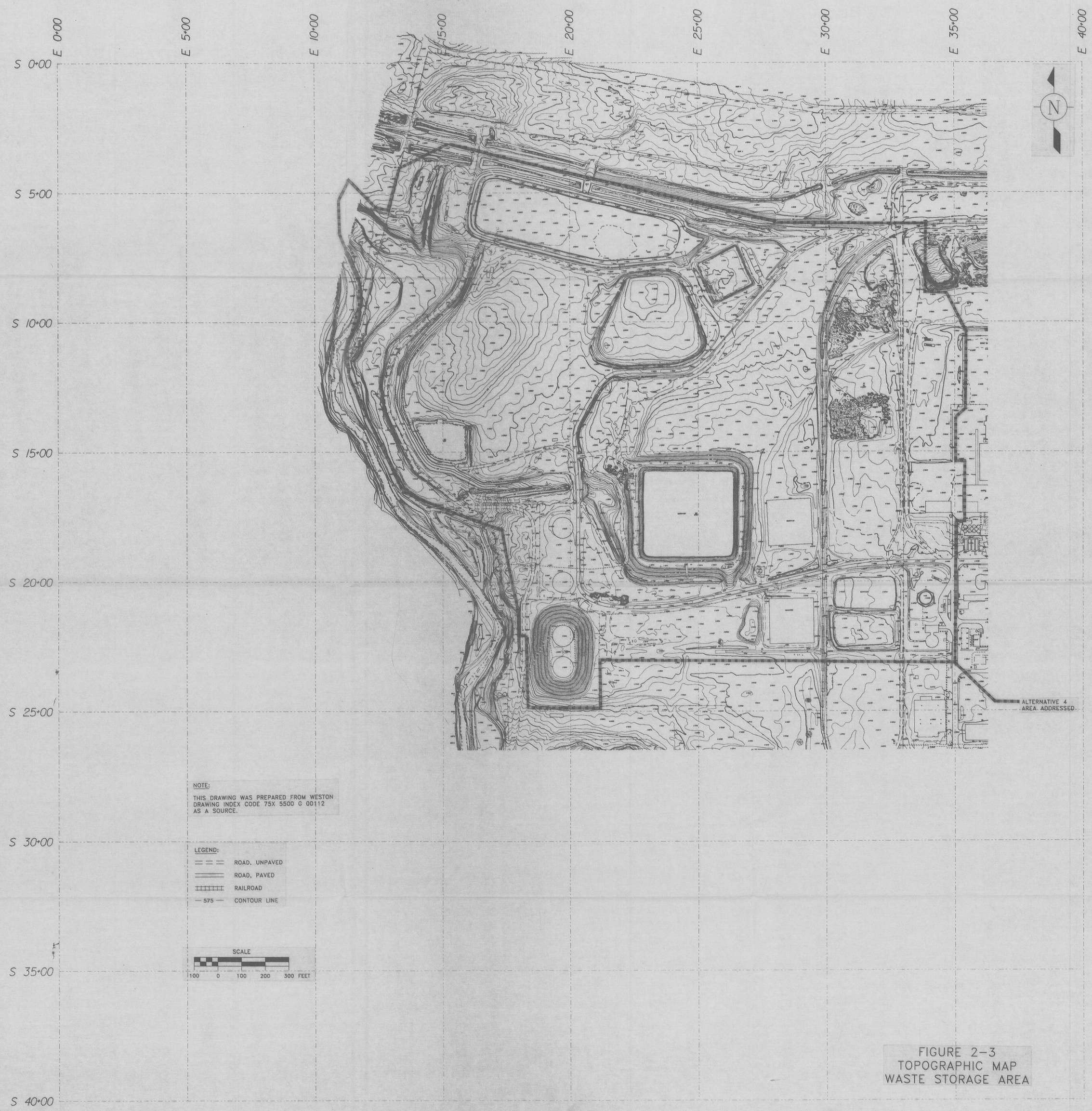
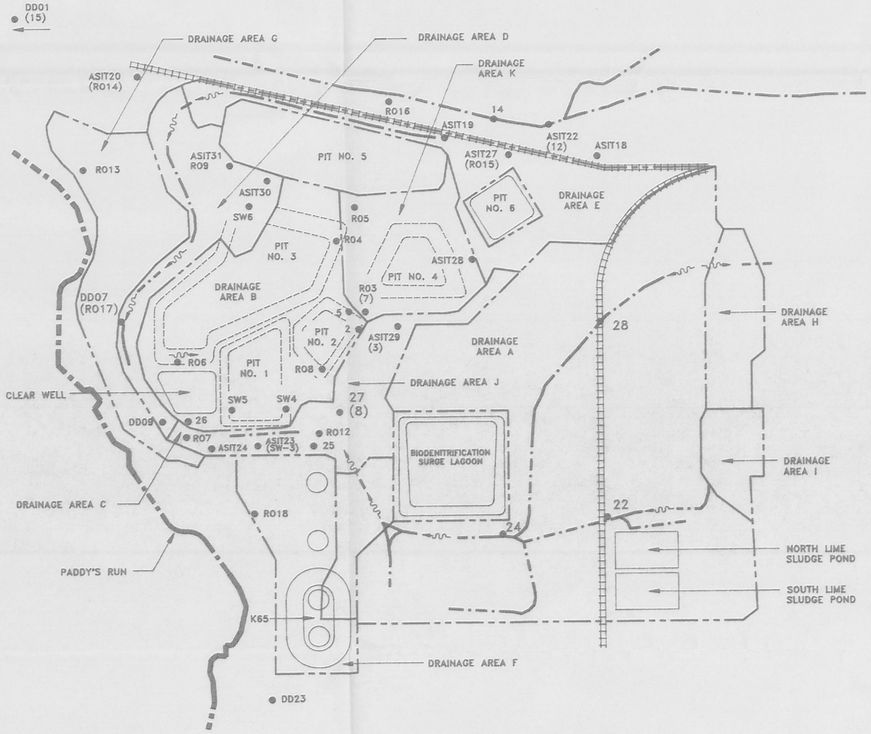


FIGURE 2-3
TOPOGRAPHIC MAP
WASTE STORAGE AREA

106788_1



LEGEND:

SWX & ROXX=DAMES & MOORE
DDXX=WESTON
XX=WMCO
ASITXX=ASI/IT RI/FS

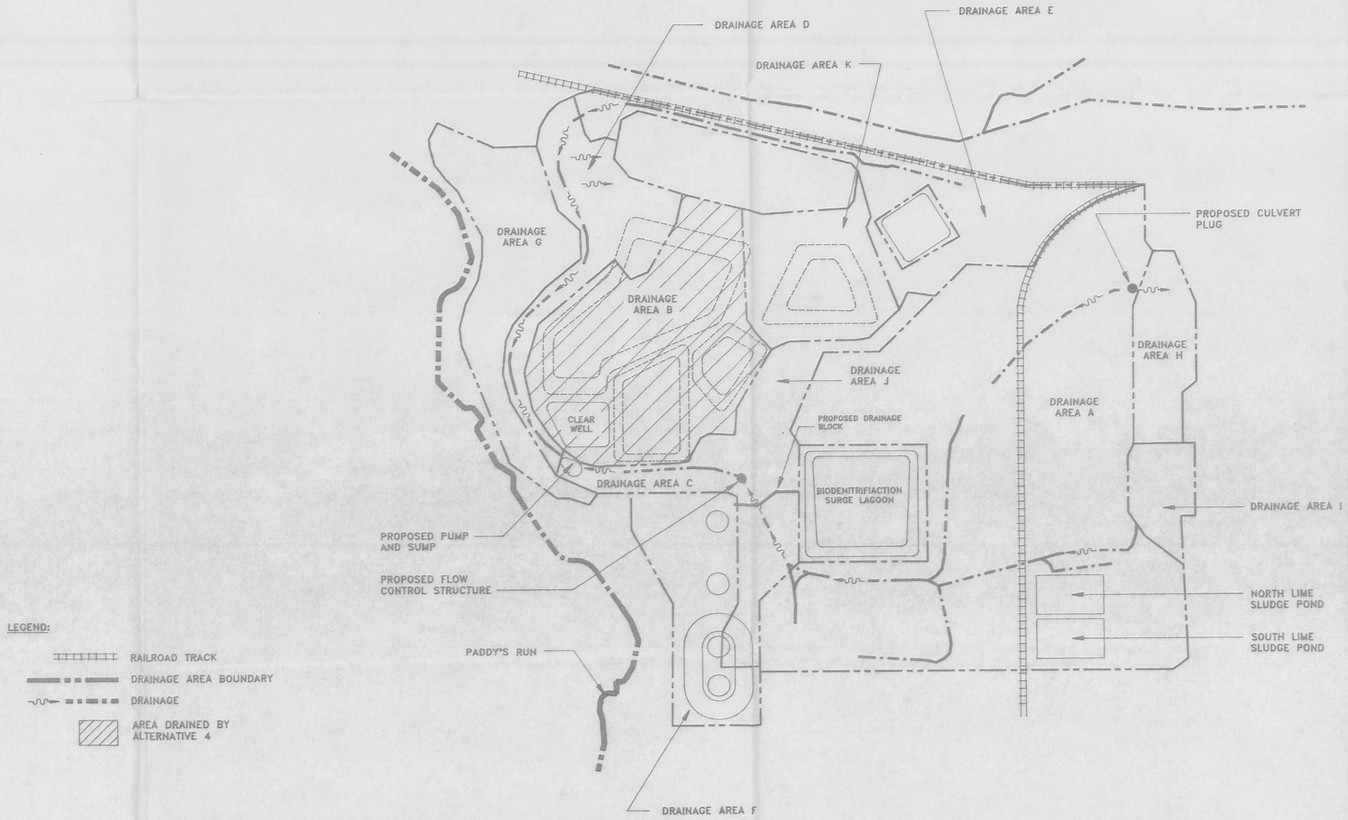
- SAMPLE LOCATIONS
- RAILROAD TRACK
- DRAINAGE AREA BOUNDARY
- DRAINAGE

NOTES:

1. LOCATION NUMBERS IN ( ) INDICATE SAME SAMPLE LOCATION BY DIFFERENT CONTRACTORS AT VARIOUS TIMES.
2. THIS FIGURE WAS PREPARED USING WESTINGHOUSE/A. M. KINNEY, INC. DWG. NO. 87-D-158; 0087502 WBS 1.1.2.4.01, SHEET C4, REV. 0, DATED 6/89 "WESTINGHOUSE TREATMENT IMPROVEMENTS LOCATION PLAN WASTE PIT AREA" AS A BASE MAP AND SOURCE.

FIGURE 2-6
STORM WATER RUNOFF
SAMPLE LOCATIONS

106788_2



NOTE:
THIS FIGURE WAS PREPARED USING WESTINGHOUSE/A. M. KINNEY, INC. DWG. NO. 87-D-159; 0087502 WBS 1.1.2.4.01, SHEET C4, REV. 0, DATED 6/89 "WESTINGHOUSE TREATMENT IMPROVEMENTS LOCATION PLAN WASTE PIT AREA" AS A BASE MAP AND SOURCE.

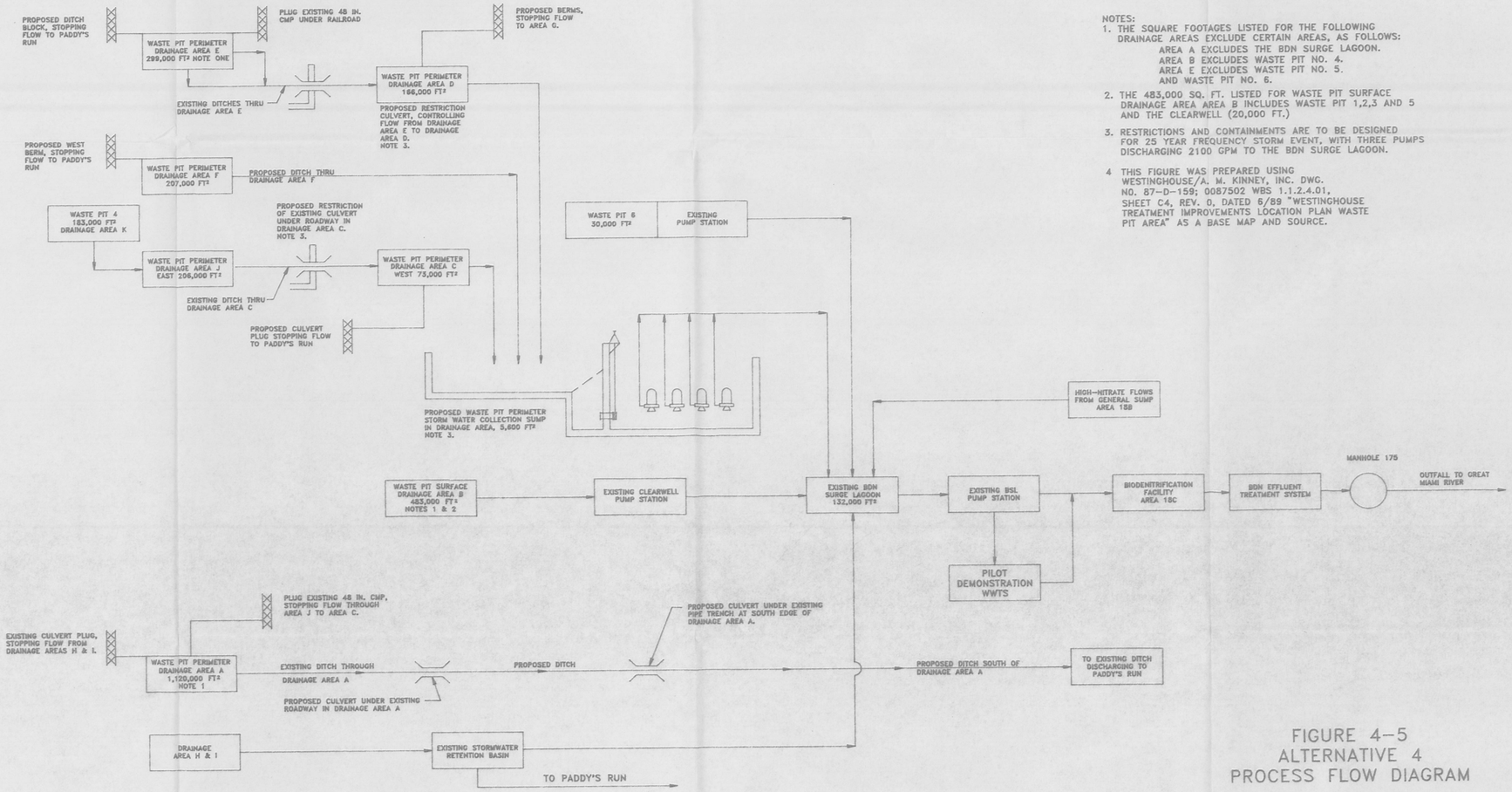
LEGEND:

- RAILROAD TRACK
- DRAINAGE AREA BOUNDARY
- DRAINAGE
- AREA DRAINED BY ALTERNATIVE 4

SCALE
100 0 100 200 FEET

FIGURE 4-4
ALTERNATIVE 4
RUNOFF COLLECTION AND TREATMENT

10688-3



NOTES:

1. THE SQUARE FOOTAGES LISTED FOR THE FOLLOWING DRAINAGE AREAS EXCLUDE CERTAIN AREAS, AS FOLLOWS:
   AREA A EXCLUDES THE BDN SURGE LAGOON.
   AREA B EXCLUDES WASTE PIT NO. 4.
   AREA E EXCLUDES WASTE PIT NO. 5.
   AND WASTE PIT NO. 6.
2. THE 483,000 SQ. FT. LISTED FOR WASTE PIT SURFACE DRAINAGE AREA AREA B INCLUDES WASTE PIT 1,2,3 AND 5 AND THE CLEARWELL (20,000 FT.)
3. RESTRICTIONS AND CONTAINMENTS ARE TO BE DESIGNED FOR 25 YEAR FREQUENCY STORM EVENT, WITH THREE PUMPS DISCHARGING 2100 GPM TO THE BDN SURGE LAGOON.
4. THIS FIGURE WAS PREPARED USING WESTINGHOUSE/A. M. KINNEY, INC. DWG. NO. 87-D-159; 0087502 WBS 1.1.2.4.01, SHEET C4, REV. 0, DATED 6/89 "WESTINGHOUSE TREATMENT IMPROVEMENTS LOCATION PLAN WASTE PIT AREA" AS A BASE MAP AND SOURCE.

FIGURE 4-5
ALTERNATIVE 4
PROCESS FLOW DIAGRAM

106788_4