7069 U-007-404.9

FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 5 - VOLUME 1 - MAIN TEXT AND APPENDICES A THROUGH C - JUNE 1995 **FINAL**

06/00/95

DOE-1244-95
DOE-FN EPAS
750
REPORT

FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 5

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 1
Main Text and
Appendices A through C

JUNE 1995

U.S. DEPARTMENT OF ENERGY
FERNALD AREA OFFICE

FINAL

7069

FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 5

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 1
Main Text and
Appendices A through C

JUNE 1995

U.S. DEPARTMENT OF ENERGY
FERNALD AREA OFFICE

FINAL

000002

TABLE OF CONTENTS

	PAGE
List of Tables	x
List of Figures	xiv
List of Acronyms	xvi
Executive Summary	ES-1
1.0 Introduction	1-1
1.1 Purpose and Need for Decision	1-5
1.2 Organization of the Report	1-6
1.3 Scope and Role of Operable Unit 5	1-10
1.3.1 History of the FEMP as an NPL Site and Basis for Listing	1-10
1.3.2 Scope of Operable Unit 5	1-11
1.3.3 Role of Operable Unit 5 Within the FEMP RI/FS Process (Integration of Operable Unit 5 With Other Operable Units)	1-12
1.3.4 Remedial Design/Remedial Action Process (RD/RA)	1-15
1.3.5 Removal Action Process	1-15
1.4 Integration of Operable Unit 5 with Other Regulatory/Decision Processes	1-19
1.4.1 Integration of the Operable Unit 5 RI/FS with NEPA	1-19
1.4.2 Interaction of the Operable Unit 5 RI/FS with Other Regulatory Processes and Requirements	1-21
1.4.2.1 Integration of Operable Unit 5 with the Federal Facility Compliance Act	1-21
1.4.2.2 Integration With Natural Resource Trustee Activities	1-22
1.4.2.3 RCRA/CERCLA Integration With State of Ohio Hazardous Waste Management Program	1-22
1.4.2.4 Interaction of Operable Unit 5 with the State of Ohio Underground Storage Tank Program	1-30
1.4.3 Interaction of Operable Unit 5 with the Fernald Citizens Task Force	1-32
1.5 Background Information	1-33
1.5.1 Site Description and History	1-33
1.5.2 Nature and Extent of Contamination	1-34
1.5.2.1 Historical Releases	1-34
1.5.2.2 Summary of Operable Unit 5 RI Report Findings	1-36
1.5.2.2.1 Surface Soil and Subsurface Soil	1-37
1.5.2.2.2 Groundwater	1-39

7069

TABLE OF CONTENTS
(Continued)

	PAGE
1.5.3 Baseline Risk Assessment Results	1-47
1.5.4 Uncertainties Identified Through the Remedial Investigation	1-51
1.5.5 Postremediation Investigation Information	1-52
2.0 Remedial Action Objectives and Estimates of Affected Media	2-1
2.1 Development of Remedial Action Objectives	2-3
2.1.1 Methods	2-6
2.2 Land Use Objectives and Associated Receptors	2-8
2.2.1 Land Use Objectives	2-9
2.2.2 Receptor Scenarios	2-13
2.3 Constituents of Concern	2-18
2.4 Risk-based Preliminary Remediation Goals	2-19
2.5 Screening to Ensure Protection of Groundwater	2-19
2.6 Cross-Media Preliminary Remediation Goals	2-24
2.7 Chemical-Specific Arars And TBC Criteria	2-31
2.7.1 Drinking Water and Groundwater ARARs and TBC Criteria	2-31
2.7.2 Surface Water ARARs and TBC Criteria	2-34
2.7.3 Soil ARARs and TBC Criteria	2-35
2.7.4 Sediment ARARs and TBC Criteria	2-37
2.7.5 Air Emissions ARARs and TBC Criteria	2-37
2.7.6 Radiation ARARS and TBC Criteria	2-38
2.7.7 Ecological Criteria	2-38
2.7.8 ALARA Requirements	2-42
2.8 Modified Preliminary Remediation Goals	2-46
2.9 Analytical Detection Limits	2-46
2.10 Background Concentrations	2-51
2.11 Preliminary Remediation Levels	2-51
2.12 Remedial Action Objectives	2-55
2.13 Remedial Action Footprint and Volume Estimates	2-55
2.13.1 Soil and Sediment Excavation Volumes and Footprints	2-76
2.13.1.1 Methods	2-76
2.13.1.2 Volume Estimates	2-86
2.13.1.3 Footprints	2-90
2.13.2 Estimate of Perched Groundwater Requiring Remediation	2-100
2.13.3 Great Miami Aquifer	2-101
2.13.4 Surface Water	2-103
2.14 FS Strategy to Address RI Data Limitations	2-107

400000

TABLE OF CONTENTS
(Continued)

PAGE

3.0 Identification and Screening of Technologies and Process Options 3-1
3.1 General Response Actions 3-1
3.1.1 Groundwater General Response Actions 3-2
3.1.2 Soil and Sediment General Response Actions 3-3
3.2 Identification and Initial Screening of Technologies and Process Options 3-4
3.2.1 Criteria for Identification and Screening of Technologies and Process Options 3-4
3.2.2 Summary of Screening of Technologies and Process Options for Groundwater 3-5
3.2.3 Summary of Screening of Technologies and Process Options for Soil and Sediment 3-5
3.3 Evaluation of Technologies and Process Options 3-5
3.3.1 Criteria for Evaluating Technologies and Process Options 3-5
3.3.1.1 Effectiveness Evaluation 3-18
3.3.1.2 Implementability Evaluation 3-18
3.3.1.3 Cost Evaluation 3-18
3.3.2 Summary of Evaluation of Technologies and Process Options for Groundwater 3-18
3.3.3 Summary of Evaluation of Technologies and Process Options for Soil and Sediment 3-19

4.0 Development and Screening of Alternatives 4-1
4.1 Development of Preliminary Alternatives 4-3
4.1.1 Criteria for Developing Preliminary Alternatives 4-3
4.1.2 Land Use Objectives 4-5
4.1.2.1 Land Use Objective 1: Full Unrestricted Use 4-6
4.1.2.2 Land Use Objective 2: Establishment of a Consolidated Waste Management Area, With Unrestricted Use of the Remaining Areas of the Property 4-6
4.1.2.3 Land Use Objective 3: Establishment of a Consolidated Waste Management Area With Restricted Use of the Remaining Areas of the Property 4-6
4.1.2.4 Land Use Objective 4: Restricted Use of the Entire On-Property Area 4-7
4.1.3 Waste Acceptance Criteria 4-8
4.1.4 Perched Groundwater Remedial Strategy 4-11
4.1.4.1 Excavation Approach 4-13
4.1.4.2 Remedial Action Footprints 4-14
4.1.4.3 Verification and Certification Sampling Activities 4-14

PAGE

4.1.5 Great Miami Aquifer Remedial Strategy 4-16
4.1.5.1 Active Restoration of Affected Areas of the Great Miami Aquifer 4-17
4.1.5.2 Identification of Remedial Action Area Footprints and Groundwater Treatment Levels 4-18
4.1.5.3 Remedy Performance Analysis 4-21
4.1.5.4 Geographic Outliers and Anomalies 4-23
4.1.5.5 Verification and Certification Sampling Activities 4-24
4.1.5.6 Results of Optimization Evaluations 4-24
4.1.6 Soil and Sediment Remedial Strategy 4-27
4.1.6.1 Designation of Principal Threat Materials for Operable Unit 5 4-28
4.1.6.2 Strategy for Managing Excavated Materials Contaminated with RCRA-Regulated Constituents 4-29
4.1.7 Strategy for Groundwater, Storm Water and Wastewater Treatment 4-44
4.1.8 Flora, Fauna, and Cultural Resource Considerations 4-46
4.2 Overview of Preliminary Alternatives by Land Use Objective 4-47
4.2.1 Land Use Objective 1: Full Unrestricted Use 4-53
4.2.2 Land Use Objective 2: Establishment of a Consolidated Waste Management Area, with Unrestricted Use of the Remaining Area of the Property 4-53
4.2.3 Land Use Objective 3: Establishment of a Consolidated Waste Management Area with Restricted Use of the Remaining Area of the Property 4-54
4.2.4 Land Use Objective 4: Restricted Use of the Entire On-Property Area 4-54
4.2.5 No Action 4-55
4.3 Description of Alternatives 4-55
4.3.1 No-Action Alternative - No Further Action Over any Removal or Remedial Action that Has Already Occurred 4-55
4.3.2 Alternative 1 - Excavation of Soil (Including Perched Groundwater Zones) with Off-Site Disposal; Extraction of Contaminated Groundwater with Treatment Before Discharge 4-56

TABLE OF CONTENTS
(Continued)

PAGE

4.3.3 Alternatives 2A, 3A, and 4A - Excavation of Soil (Including Perched Groundwater Zones) with Segregation and, Depending on Contaminant Concentrations, Direct Placement in an On-Property Disposal Cell or Shipment to an Off-Site Disposal Facility; Extraction of Great Miami Aquifer with Treatment Before Discharge 4-60
4.3.3.1 Alternative 2A 4-67
4.3.3.2 Alternative 3A 4-68
4.3.3.3 Alternative 4A 4-68
4.3.4 Alternatives 2B, 3B, and 4B - Excavation of Soil (Including Perched Groundwater Zones) with Segregation and, Depending on Contaminant Concentrations, Direct Placement in an On-Property Consolidation Area with Cap or Shipment to Off-Site Disposal; Extraction of Contaminated Groundwater with Treatment Before Discharge 4-71
4.3.4.1 Alternative 2B 4-78
4.3.4.2 Alternative 3B 4-78
4.3.4.3 Alternative 4B 4-80
4.3.5 Alternatives 2C, 3C, and 4C - Excavation of Soil (Including Perched Groundwater Zones) with Segregation, and Depending on Contaminant Concentrations, Direct Placement in an On-Property Consolidation Area with an Earthen Cover or Shipment to an Off-Site Disposal Facility; Extraction of Great Miami Aquifer with Treatment Before Discharge 4-83
4.3.5.1 Alternative 2C 4-88
4.3.5.2 Alternative 3C 4-89
4.3.5.3 Alternative 4C 4-89
4.4 Screening of Alternatives 4-92
4.4.1 Introduction and Purpose 4-92
4.4.1.1 Effectiveness 4-94
4.4.1.2 Implementability 4-94
4.4.1.3 Cost 4-94
4.4.2 No-Action Alternative 4-95
4.4.3 Alternative 1 4-96
4.4.4 Alternatives 2A, 3A, and 4A 4-100
4.4.5 Alternatives 2B, 3B, and 4B 4-104
4.4.6 Alternatives 2C, 3C, and 4C 4-109

TABLE OF CONTENTS
(Continued)

	PAGE
4.5 Alternatives Retained	4-114
4.6 Modification of Remedial Alternatives Following Initial Screening	4-117
5.0 Detailed Analysis of Alternatives	5-1
5.1 Purpose of Detailed Analysis	5-1
5.2 Land Use Objectives, Remedial Action Alternatives and Components	5-1
5.2.1 Land Use Objectives	5-3
5.2.2 Overview of Alternatives	5-3
5.2.2.1 No Action Alternative	5-4
5.2.2.2 Alternative 1 - Excavation and Off-Site Shipment	5-5
5.2.2.3 Alternatives 2A, 3A and 4A - Engineered Disposal Facility	5-6
5.2.2.4 Alternatives 2C, 3C and 4C - Off-Site Shipment	5-6
5.2.3 Remedial Action Components	5-7
5.3 National Contingency Plan Criteria for Evaluating Remedial Alternatives	5-9
5.3.1 Overall Protection of Human Health and the Environment	5-9
5.3.2 Compliance with ARARs	5-11
5.3.3 Long-Term Effectiveness and Permanence	5-12
5.3.4 Reduction of Toxicity, Mobility, or Volume	5-12
5.3.5 Short-Term Effectiveness	5-13
5.3.6 Implementability	5-13
5.3.7 Cost	5-14
5.4 Individual Analysis of Alternatives	5-15
5.4.1 No-Action Alternative	5-16
5.4.1.1 Detailed Description	5-16
5.4.1.2 Assessment	5-16
5.4.2 Alternative 1 - Excavation and Off-Site Shipment	5-18
5.4.2.1 Detailed Description	5-18
5.4.2.2 Assessment	5-27
5.4.3 Alternative 2A - Engineered Disposal Facility	5-50
5.4.3.1 Detailed Description	5-52
5.4.3.2 Assessment	5-61
5.4.4 Alternative 2C - Off-Site Shipment	5-78
5.4.4.1 Detailed Description	5-78
5.4.4.2 Assessment	5-85

TABLE OF CONTENTS
(Continued)

	PAGE
5.4.5 Alternative 3A - Engineered Disposal Facility	5-95
5.4.5.1 Detailed Description	5-95
5.4.5.2 Assessment	5-102
5.4.6 Alternative 3C - Off-Site Shipment	5-111
5.4.6.1 Detailed Description	5-111
5.4.6.2 Assessment	5-118
5.4.7 Alternative 4A - Engineered Disposal Facility	5-125
5.4.7.1 Detailed Description	5-127
5.4.7.2 Assessment	5-132
5.4.8 Alternative 4C - Off-Site Shipment	5-140
5.4.8.1 Detailed Description	5-140
5.4.8.2 Assessment	5-145
5.5 Irreversible and Irretrievable Commitment of Resources	5-152
5.6 ARAR Compliance Issues for On-Property Disposal	5-153
5.6.1 State of Ohio Siting Requirements	5-154
5.6.2 CERCLA Waiver Requirements	5-157
5.6.2.1 Degree of Protection	5-158
5.6.2.2 Level of Performance	5-159
5.6.2.3 Reliability into the Future	5-160
5.6.2.4 Time Required for Results	5-161
5.6.3 Conclusion	5-161
6.0 Comparative Analysis of Alternatives	6-1
6.1 Scope of the Operable Unit 5 Remedy Decision	6-1
6.2 Evaluation of Land Use Objectives	6-2
6.2.1 Comparison of Land Use Objectives 1 and 2	6-2
6.2.2 Comparison of Land Use Objectives 2 and 3	6-3
6.2.3 Comparison of Land Use Objectives 3 and 4	6-4
6.3 Residual Risk Level Considerations	6-5
6.4 Comparison of the Alternatives	6-7
6.4.1 Threshold Criteria	6-7
6.4.1.1 Overall Protection of Human Health and the Environment	6-19
6.4.1.2 Compliance With Applicable or Relevant and Appropriate Requirements	6-20
6.4.2 Primary Balancing Criteria	6-20
6.4.2.1 Long-Term Effectiveness and Permanence	6-20
6.4.2.2 Reduction of Toxicity, Mobility, or Volume Through Treatment	6-21

PAGE

6.4.2.3 Short-Term Effectiveness 6-22
6.4.2.4 Implementability 6-23
6.4.2.5 Cost Considerations 6-25

7.0 Site-Wide Integrations of Remedial Actions 7-1
7.1 Adopted Site-Wide Remedy 7-1
7.1.1 Waste Types and Estimated Volumes 7-3
7.1.2 On-Property Disposal Facility 7-5
7.1.3 Off-Property Disposal 7-7
7.1.4 Schedules for Remedial Actions 7-9
7.1.5 Long-Term Custodial Care, Maintenance, and Monitoring 7-9
7.1.6 Key Uncertainties for the Adopted Site-Wide Remedy 7-11
7.2 Residual Risk Assessment for the Adopted Site-Wide Remedy 7-12
7.2.1 Identification of Constituents of Concern 7-12
7.2.2 Receptors 7-14
7.2.3 Pathways of Exposure 7-14
7.2.4 Receptor Risk Reduction 7-15
7.2.4.1 On-Property Farmer 7-18
7.2.4.2 Groundskeeper 7-18
7.2.4.3 Expanded Trespasser 7-18
7.2.4.4 Undeveloped Park User 7-26
7.2.4.5 Off-Property Resident Farmer 7-26
7.2.5 Interpretation of the Risk Reduction Results 7-26
7.2.5.1 Background 7-27
7.2.5.2 Conclusions 7-28
7.3 Significant Features of the Adopted Site-Wide Remedy 7-28

Bibliography BB-1

TABLE OF CONTENTS
(Continued)

PAGE

APPENDICES

A FEMP Background Information

B Potential Applicable or Relevant and Appropriate Requirements and To Be Considered Requirements for Operable Unit 5

C Calculations of Risk-Based Preliminary Remediation Goals for the Operable Unit 5 Feasibility Study

D Soil Washing Treatability Study

E Off-Site Disposal Facility Waste Acceptance Criteria

F Fate and Transport Modeling

G Short-Term Risk Assessment

H Comprehensive Response Action Risk Evaluation for Operable Unit 5

I National Environmental Policy Act Cumulative Impact Analysis

J Floodplain/Wetland Assessment for the Operable Unit 5 Preferred Alternative

K Cost Estimates for Operable Unit 5 Remedial Alternatives

L Detailed Remedial Alternative Component Descriptions

M Screening and Evaluation of Technologies and Process Options

LIST OF TABLES

NUMBER	TITLE	PAGE
1-1	FEMP Hazardous Waste Management Units	1-24
1-2	Status of FEMP Underground Storage Tanks	1-31
2-1	Receptors Considered Under Each of the Four Land Use Objectives	2-10
2-2	Summary of Receptor Exposure Pathways by Land Use	2-14
2-3	Constituents of Concern in Each Medium for Each Operable Unit	2-20
2-4	Results of Risk-Based Preliminary Remediation Goals Screening	2-25
2-5	Preliminary Remidation Goals for Soil With Cross-Media Impact	2-30
2-6	Groundwater Chemical-Specific ARARs and TBCs	2-32
2-7	ARARs/TBCs for Surface Water	2-36
2-8	Benchmark Toxicity Values for Soil from the Site-Wide Ecological Risk Assessment	2-40
2-9	Benchmark Toxicity Values for Surface Water and Sediment from the Site-Wide Ecological Risk Assessment	2-43
2-10	Lowest Reasonable and Achievable Detection Threshold for Both Chemical and Radiological Analysis	2-48
2-11	95th Percentile Background Concentrations of COCs by Medium	2-52
2-12	Preliminary Remediation Levels for Soil	2-56
2-13	Preliminary Remediation Levels for Sediment	2-60
2-14	Preliminary Remediation Levels for Surface Water	2-62
2-15	Perched Groundwater Preliminary Remediation Levels (Perched Groundwater User)	2-65
2-16	Groundwater Preliminary Remediation Levels for the Great Miami Aquifer	2-67
2-17	Remedial Action Objectives for Operable Unit 5	2-69
2-18	Target Risk Cases Evaluated in the Feasibility Study	2-71
2-19	Estimate of Miscellaneous Soil Volumes to be Addressed by Operable Unit 5	2-84
2-20	Off-Property Soil Volumes Requiring Remediation	2-86
2-21	Operable Unit 5 Soil Volume Estimates	2-91
2-22	Characteristics of Collected Surface Water	2-105
2-23	Strategy of the Feasibility Study to Address Data Limitations of the Remedial Investigation	2-108
3-1	Initial Screening of Technologies and Process Options for Groundwater	3-6
3-2	Groundwater Technologies and Process Options Retained for Further Evaluation	3-11
3-3	Initial Screening of Technologies and Process Options for Soil and Sediment	3-12
3-4	Soil and Sediment Technologies and Process Options Retained for Further Evaluation	3-17
3-5	Summary of Evaluation of Technologies and Process Options for Groundwater	3-20

LIST OF TABLES
(Continued)

NUMBER	TITLE	PAGE
3-6	Summary of Retained Perched Groundwater Technologies and Process Options	3-29
3-7	Summary of Retained Great Miami Aquifer Groundwater Technologies and Process Options	3-30
3-8	Summary of Evaluation of Technologies and Process Options for Soil and Sediment	3-31
3-9	Summary of Retained Soil and Sediment Technologies and Process Options	3-38
4-1	Operable Unit 5 Feasibility Study Waste Acceptance Criteria	4-10
4-2	Source Areas for Soil Contaminants Regulated Under the Resource Conservation and Recovery Act	4-31
4-3	Hazardous Waste Management Units Containing Listed Waste to be Closed Under the Comprehensive Environmental Response, Compensation, and Liability Act	4-33
4-4	Hazardous Waste Management Units Containing Characteristic Waste to be Closed Under the Comprehensive Environmental Response, Compensation and Liability Act	4-34
4-5	Hazardous Waste Management Units Containing Listed and Characteristic Waste to be Closed Under the Comprehensive Environmental Response, Compensation and Liability Act	4-35
4-6	Suspect Areas Containing Resource Conservation and Recovery Act Characteristic Constituents	4-36
4-7	Summary of Soil Volumes Contaminated with Waste Regulated Under the Resource Conservation and Recovery Act	4-38
4-8	Summary of Operable Unit 5 Remedial Alternatives	4-48
4-9	Matrix of Operable Unit 5 Remedial Alternatives	4-52
4-10	Summary of Alternative 1	4-61
4-11	Summary of Alternative 2A	4-69
4-12	Summary of Alternative 3A	4-70
4-13	Summary of Alternative 4A	4-72
4-14	Summary of Alternative 2B	4-79
4-15	Summary of Alternative 3B	4-81
4-16	Summary of Alternative 4B	4-82
4-17	Summary of Alternative 2C	4-90
4-18	Summary of Alternative 3C	4-91
4-19	Summary of Alternative 4C	4-93
4-20	Summary of Remedial Alternatives Screening	4-115
5-1	Receptors and Alternatives Considered Under Each of the Four Land Use Objectives	5-4

7069

LIST OF TABLES
(Continued)

NUMBER	TITLE	PAGE
5-2	Key Elements for Remedial Action Alternatives	5-5
5-3	Matrix of Remedial Action Components Making Up the Seven Alternatives	5-7
5-4	Remedial Action Component Subelements	5-8
5-5	Target Receptors and Associated Risk Levels for Alternative 1	5-21
5-6	Remedial Action Alternative 1 Soil Volumes	5-23
5-7	Alternative 1 Costs	5-49
5-8	Target Receptors and Associated Risk Levels for Alternative 2A	5-53
5-9	Remedial Action Alternative 2A Soil Volumes	5-58
5-10	Alternative 2A Disposal Facility Dimensions	5-58
5-11	Alternative 2A Costs	5-76
5-12	Target Receptors and Associated Risk Levels for Alternative 2C	5-79
5-13	Remedial Action Alternative 2C Soil Volumes	5-83
5-14	Alternative 2C Consolidation Area Dimensions	5-84
5-15	Alternative 2C Costs	5-93
5-16	Target Receptors and Associated Risk Levels for Alternative 3A	5-97
5-17	Remedial Action Alternative 3A Soil Volumes	5-100
5-18	Alternative 3A Disposal Faciity Dimensions	5-101
5-19	Alternative 3A Costs	5-109
5-20	Target Receptors and Associated Risk Levels for Alternative 3C	5-115
5-21	Remedial Action Alternative 3C Soil Volumes	5-116
5-22	Alternative 3C Consolidation Area Dimensions	5-117
5-23	Alternative 3C Costs	5-125
5-24	Target Receptors and Associated Risk Levels for Alternative 4A	5-129
5-25	Remedial Action Alternative 4A Soil Volumes	5-130
5-26	Alternative 4A Disposal Facility Dimensions	5-131
5-27	Alternative 4A Costs	5-138
5-28	Target Receptors and Associated Risk Levels for Alternative 4C	5-142
5-29	Remedial Action Alternative 4C Soil Volumes	5-143
5-30	Alternative 4C Consolidation Area Dimensions	5-144
5-31	Alternative 4C Costs	5-152
5-32	Quantities of Resources Permanently Committed	5-155
6-1	Data Summary for Remedial Alternatives	6-9
6-2	Operable Unit 5 Comparative Analysis of Remedial Alternatives	6-10
6-3	Summary of Environmental Impacts for Remedial Alternatives	6-12
7-1	Projected Alternatives Comprising the Adopted Site-Wide Remedy	7-2
7-2	Projected Disposition of FEMP Waste Materials	7-4

000014

LIST OF TABLES
(Continued)

NUMBER	TITLE	PAGE
7-3	Material Assumed to Meet Waste Acceptance Criteria for On-Property Disposal	7-7
7-4	Waste Expected to be Shipped Off Property	7-8
7-5	Managing Uncertainties	7-13
7-6	Proposed Cleanup Levels for Soil in Operable Units 1, 2, 4, and 5	7-16
7-7	Comparison of Maximum Preremedial Risks to Site-Wide Postremedial Risks for Common Receptors	7-17

LIST OF FIGURES

NUMBER	TITLE	PAGE
1-1	FEMP Facility Location Map	1-2
1-2	Flow Diagram of FS Contents by Section	1-8
1-3	FEMP Environmental Restoration Process	1-13
2-1	Remediation Level Determination Process	2-4
2-2	Cross-Media Impacts for OU5 Soils	2-27
2-3	Process for Development of a Target Risk-Level Modified PRG for Soil Contaminated with Total Uranium for the On-Property Farmer	2-47
2-4	Schematic of the FEMP Solid Block Model	2-77
2-5	Areas Where the Soil Leaching Coefficient = 15	2-80
2-6	Extent of Required Off-Property Soil Remediation at 10^{-6} Risk	2-87
2-7	Extent of Required Off-Property Soil Remediation at 10^{-5} Risk	2-88
2-8	Areas of Potential Sediment Deposition	2-89
2-9	Soil Volume Estimates	2-92
2-10	On-Property Soil Excavation Footprint, Land Use Objectives 1 and 2, Case 1	2-93
2-11	On-Property Soil Excavation Footprint, Land Use Objectives 1 and 2, Case 2	2-94
2-12	On-Property Soil Excavation Footprint, Land Use Objective 3, Case 3	2-95
2-13	On-Property Soil Excavation Footprint, Land Use Objective 3, Case 4	2-96
2-14	On-Property Soil Excavation Footprint, Land Use Objective 3, Cases 5 and 6	2-97
2-15	On-Property Soil Excavation Footprint, Land Use Objective 3, Case 7	2-98
2-16	On-Property Soil Excavation Footprint, Land Use Objective 4, Cases 8 and 9	2-99
2-17	Perched Water Excavation Footprints	2-102
2-18	Target Areas for Great Miami Aquifer Restoration (3 ppb and 20 ppb Uranium)	2-104
2-19	Area of Controlled Storm Water Runoff	2-106
4-1	Development Logic for Preliminary Alternatives for Soil	4-4
4-2	Extent of Perched Zones Exceeding 1 Gallon per Minute Criteria	4-15
4-3	Target Areas for Great Miami Aquifer Restoration	4-20
4-4	Decision Logic for Identifying RCRA-Regulated Soil	4-40
4-5	Disposal and Treatment Requirements for RCRA-Regulated Soil	4-41
4-6	Alternative 1 Conceptual Flow Diagram	4-57
4-7	Alternative 2A, 3A, and 4A Conceptual Flow Diagram	4-63
4-8	Alternative 2B, 3B, and 4B Conceptual Flow Diagram	4-74
4-9	Alternative 2C, 3C, and 4C Conceptual Flow Diagram	4-85
5-1	Example Flow Diagram of the Remedial Action Process	5-2
5-2	Relationship of Screening Criteria to the Nine Evaluation Criteria	5-10
5-3	Site Plan Alternatives 1-1 and 2C-1	5-20
5-3a	Site Plan Alternatives 1-2	5-20a

LIST OF FIGURES
(Continued)

NUMBER	TITLE	PAGE
5-4	Estimated Uranium Discharge to the Great Miami River	5-25
5-5	Alternative 1 Costs by Component	5-51
5-6	Site Plan Alternative 2A-1	5-54
5-7	Site Plan Alternatives 2A-2 and 3A-3	5-55
5-8	Alternative 2A Costs by Component	5-77
5-9	Site Plan Alternatives 2C-2 and 3C-3	5-80
5-10	Alternative 2C Costs by Component	5-94
5-11	Site Plan Alternative 3A-4, 3A-5, 3A-6, 3A-7, 4A-8, and 4A-9	5-98
5-12	Alternative 3A Costs by Component	5-110
5-13	Site Plan Alternatives 3C-4, 3C-5, 3C-6, 3C-7, 4C-8, and 4C-9	5-113
5-14	Alternative 3C Costs by Component	5-126
5-15	Alternative 4A Costs by Component	5-139
5-16	Alternative 4C Costs by Component	5-151
6-1	Comparison of Affected Soil Volume for Various Uranium Soil Concentrations	6-8
6-2	Total Present Worth Costs by Alternative and Risk Case	6-26
7-1	Potentially Acceptable Location for Site-Wide On-Property Disposal Cell	7-6
7-2	Schedule For Adopted Site-Wide Remedy	7-10
7-3	On-Property Resident Farmer Projected Risk Reduction Between Preremedial and Postremedial Conditions	7-19
7-4	On-Property Resident Child Projected Risk Reduction Between Preremedial and Postremedial Conditions	7-20
7-5	Commercial/Industrial (Groundskeeper) Projected Risk Reduction Between Preremedial and Postremedial Conditions	7-21
7-6	Expanded Trespasser Projected Risk Reduction Between Preremedial and Postremedial Conditions	7-22
7-7	Undeveloped Park User Projected Risk Reduction Between Preremedial and Postremedial Conditions	7-23
7-8	Off-Property Resident Farmer Projected Risk Reduction Between Preremedial and Postremedial Conditions	7-24
7-9	Off-Property Resident Child Projected Risk Reduction Between Preremedial and Postremedial Conditions	7-25

LIST OF ACRONYMS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AIRFA	America Indian Religious Freedom Act
ALARA	as low as reasonably achievable
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
AWWT	advanced waste water treatment [facility]
BDAT	best demonstrated available technology
BMP	best management practices
BNL	Brookhaven National Laboratory
BSL	biodenitrification surge lagoon
BTV	benchmark toxicity value
BUSTR	Bureau of Underground Storage Tank Regulation
CAA	Clean Air Act
CAMU	corrective action management unit
CBC	circulating bed combuster
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CMSA	consolidated metropolitan statistical area
COC	constituent of concern
CPC	constituent of potential concern
CPRG	cross-media preliminary remediation goal
CRARE	comprehensive response action risk evaluation
D&D	decontamination & demolition
DCE	dichloroethene

DFO	director's finding and orders
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	environmental assessment
EE/CA	engineering evaluation/cost analysis
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FMPC	Feed Materials Production Center
FS	feasibility study
GRA	general response action
HDPE	high-density polyethylene
HEPA	high efficiency particulate air [filter]
HI	hazard index
HQ	hazard quotient
HRS	hazard ranking system
HSL	Hazardous Substance List
IAWWT	interim advanced wastewater treatment
HWMU	hazardous waste management unit
ILCR	incremental lifetime cancer risk
ISA	initial screening of alternatives
LDR	land disposal restriction
LRA	leading remedial alternative
MAWS	minimum additive waste stabilization
MCL	maximum contaminant level (Safe Drinking Water Act)
MCL	maximum concentration limit (Resource Conservation and Recovery Act)
MCLG	maximum contaminant level goal

NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAP	National Environmental Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NLO	National Lead of Ohio
NOI	notice of intent
NORM	naturally occurring radioactive material
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NRHP	National Registry of Historic Places
NTS	Nevada Test Site
O&M	operations and management
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
PAH	polycyclic aromatic hydrocarbon
PCA	polychloroethylane
PCB	polychlorinated biphenyl
PCE	polycholoroethylene
PEIS	programmatic environmental impact statement
PMF	probable maximum flood
PP	proposed plan
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million

PRG	preliminary remediation goal
PRL	preliminary remediation level
PRRS	Paddys Run Road Site
RA	remedial action
RAC	Radiological Assessments Corporation
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RI/FS	remedial investigation/feasibility study
RM	river mile
RME	reasonable maximum exposure
ROD	record of decision
SCQ	Sitewide CERCLA Quality Assurance Project Plan
SCS	Soil Conservation Service
SHPO	State Historic Preservation Office
SOWC	Southwestern Ohio Water Company
SPIT	South Plume interim treatment
SR	State Route
SSOD	storm sewer outfall ditch
STP	site treatment plan
SWIFT	Sandia Waste Isolation Flow and Transport [model]
SWMU	solid waste management unit
SWOAPCA	Southwestern Ohio Air Pollution Control Agency
SWRB	storm water retention basin
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
TI	technical impracticability
UMTRA	Uranium Mill Tailings Radiation Control Act

USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USID	uranium in soils integrated demonstration
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compound
WAC	waste acceptance criteria
WEMCO	Westinghouse Environmental Management Company of Ohio
WMCO	Westinghouse Materials Company of Ohio
WQC	water quality criteria

EXECUTIVE SUMMARY

The goal of the Fernald Environmental Management Project (FEMP) is the safe, least-cost and effective environmental restoration of a U.S. Department of Energy (DOE) former uranium processing facility located near the village of Fernald, Ohio. Widespread contamination of surface soil, sediment and groundwater exists both on and adjacent to the 1050-acre federal installation as a legacy of the 38-year production history of the facility. This environmental contamination is attributable to releases of radioactive and chemical substances during the facility's production mission, which yielded over 500 million pounds of high-purity uranium products to support U.S. defense initiatives. Formerly known as the Feed Materials Production Center during its years of production, the facility was renamed the FEMP shortly after production operations ceased in 1989 and DOE refocused site efforts on environmental restoration.

To formulate the plan for the permanent environmental cleanup of the site, the DOE is engaged in completing a remedial investigation/feasibility study (RI/FS), which is being conducted in accordance with the terms of a cooperative agreement with the U.S. Environmental Protection Agency (EPA). The Ohio Environmental Protection Agency (OEPA) is also participating in the review and oversight of the RI/FS and subsequent cleanup activities.

The objective of the RI/FS is to gather and evaluate technical information to support an informed decision as to the most prudent cleanup actions that DOE would undertake to permanently address environmental contamination at the site. The cleanup decisions at the FEMP are being made jointly by DOE and EPA, in concurrence with OEPA, following consideration of input from key stakeholders. These stakeholders include members of the public who reside near the facility.

The FEMP has been segmented into five operable units as a management approach to enable the more expedient initiation of cleanup actions. The term "operable unit" is used to identify a logical grouping of facilities or environmental media at the site. Separate documentation is being developed for each of the five operable units, including:

- The Remedial Investigation Report, which presents information on the nature and extent of contamination at the site and assesses the risks to human health and the environment from the existing conditions
- The Feasibility Study, which evaluates cleanup alternatives
- The Proposed Plan, which summarizes key information from the RI/FS reports and identifies the preferred remedial alternative for implementation at the site
- The Record of Decision (ROD) which documents how public comments to the Proposed Plan were addressed and identifies the cleanup decision for each operable unit.

This report presents the FS for Operable Unit 5, termed the environmental media operable unit and comprised of the following:

- Contaminated soil both on and off the FEMP property
- Contaminated sediment and surface water in FEMP drainage ditches, Paddys Run and the Great Miami River
- Contaminated groundwater both in the glacial overburden and the Great Miami Aquifer
- Potentially impacted flora and fauna.

The other operable units, Operable Units 1 through 4, address FEMP waste storage facilities and inventories and structures and equipment used for the former production mission. The existing contamination in the Operable Unit 5 environmental media is attributable to historical releases from the facilities and material inventories comprising Operable Units 1 through 4.

A companion document, the Operable Unit 5 RI Report, presents a compendium of information summarizing the nearly 10 years of studies and investigations of the environmental conditions at the FEMP site. The Report summarizes the nature and extent of soil, sediment and groundwater contamination at the FEMP site, and presents human health and ecological risk assessments of these environmental conditions. The RI Report concludes that the existing conditions at the FEMP present an unacceptable risk to human and environmental receptors, thereby warranting the implementation of remedial actions to address each of the environmental media. The data and analyses presented in the Operable Unit 5 RI Report have been used as the foundation for the development of this FS.

The Operable Unit 5 RI Report was approved by EPA in February, 1995. The primary objective of this FS is to develop and evaluate an appropriate range of remedial alternatives to address the environmental issues described in the RI Report. The results of this FS, when combined with input from support agencies, stakeholders and the general public on the preferred remedial alternative and the other remedial alternatives identified in the Proposed Plan, will form the basis for selecting the remedial action for Operable Unit 5. Input from the public and other stakeholders will be obtained through receipt of comments on the Proposed Plan. The Operable Unit 5 Proposed Plan will be made available for public review and comment during the Spring of 1995. The responses to comments on the Proposed Plan and the alternative(s) selected for implementation will be documented in the ROD for Operable Unit 5. A draft of this ROD is scheduled to be submitted to EPA and OEPA on July 3, 1995. Operable Unit 5 reports are available in the Administrative Record, located near the FEMP in the JAMTEK Building, 10845 Hamilton-Cleves Highway, Harrison, Ohio.

Scope of the Operable Unit 5 Remedial Decision

As previously discussed, Operable Unit 5 is focused on addressing the contamination in environmental media, including soil, sediment, and groundwater, both on and off the FEMP property. The final remedial decision for Operable Unit 5 will yield a remedy that provides a permanent cleanup solution for addressing these contaminated media. The expectations for the decision include:

- The establishment of final cleanup levels for soil, sediment, and groundwater
- A remedy which uses treatment to the extent practical to address the principal threats posed by the contaminated media
- The permanent disposition of removed contaminated materials or sludge generated through treatment in an appropriate on- or off-property disposal facility
- A remedy which applies institutional controls, as necessary, to complement engineering measures taken to address site contaminants
- A remedy which ensures the return of useable groundwater, including the Great Miami Aquifer, to its full beneficial uses within a reasonable time
- A remedy which ensures the short-term and long-term protection of the public and sensitive environmental receptors
- A remedy which is cost-effective and implementable and which accommodates the future application of new, more effective technologies which emerge during the conduct of remedial activities
- A remedy which accommodates the inherent uncertainties associated with the availability of future capacity at off-site licensed disposal facilities.

The cost of remedial actions, volumes of contaminated materials requiring action, and range of available remedial alternatives for Operable Unit 5 are sensitive factors in determining the final cleanup levels for the affected environmental media. These final cleanup levels will establish the concentration of a given contaminant which would be permitted to remain in site soil, sediment and groundwater following the implementation of remedial actions. The final cleanup levels also consider factors such as technical limitations on attaining the cleanup level (for example, attaining levels below natural background or analytical detection limits), cross-media impacts, potential impacts to sensitive ecological receptors, and cost. While the Operable Unit 5 ROD will not establish future land use for the FEMP, the possible future uses of the property and the costs of remedial actions necessary to accommodate those uses must be taken into consideration when determining the final cleanup levels for the operable unit. Projected future land uses which envision more extensive and continued exposure to site contaminants remaining after remedial actions, such as the creation of a family farm on the existing government property, would require lower cleanup levels to ensure the long-term

protection of such a future land user. Lower cleanup levels typically would require the removal, containment or treatment of larger quantities of contaminated site media, both on- and off-property, resulting in increased costs for a given remedial alternative.

In the winter of 1993, the DOE chartered the Fernald Citizens Task Force, representing key segments of the public or involved interest groups who have a stake in the final decision process for the FEMP, to make recommendations on the future land uses of the FEMP property and the final cleanup levels for the site. These key stakeholders include representatives from the public residing near the facility, local citizens groups, local government agencies, and site workers. This FS has been prepared to provide a technical information base from which the EPA, task force and public can make its recommendations to the final remedial decision makers for the site in addition to satisfying the regulatory requirements for such a document. The task force's recommendations will be instrumental in determining the direction of cleanup for the facility. DOE recognizes that the Fernald community's desired future use of the facility is critical to achieving a successful cleanup and is committed to giving these desires significant weight in cleanup decisions.

Conclusions of the Operable Unit 5 RI Report Relevant to the FS

While all conclusions of the Operable Unit 5 RI Report are relevant, the following summary provides the conceptual foundation from which viable remedial options were developed and evaluated:

- Extensive radiological and chemical contamination of surface and subsurface soils exists within the former production area, in the waste pit area (Operable Unit 1), and, to a lesser extent, adjacent to waste storage facilities (Operable Units 2 and 4). Subsurface uranium contamination in soil exceeds depths of 20 feet at locations aligned with facilities where large quantities of acids or other chemicals were used in the uranium purification process. Above-background concentrations of nonradioactive inorganic constituents in surface soil, and sporadically in subsurface soil, are present at various locations across these areas. Volatile and semivolatile organic constituents were found in surface and subsurface soils at certain locations in the vicinity of all the major former processing facilities.

- Subsurface soil exhibiting radiological constituents (up to five times above background) have been identified across the FEMP property outside the production area. Of particular note are elevated concentrations of uranium and other radiological contaminants that were identified adjacent to a retired incinerator located at the sewage treatment plant (east of the former production area). However, the soil exhibiting the most highly elevated concentrations of contaminants has been removed from affected areas both on and off FEMP property.

- Large areas (up to 11 square miles) of surface soil that exhibit above-background concentrations of uranium have been identified off the FEMP property. The concentrations typically occur at less than 10 parts per million (ppm) (natural background for uranium is approximately 4 ppm in regional soil).

- Above-background concentrations of uranium and certain other hazardous substances exist in sediment in on-property drainage ditches and at on- and off-property locations in Paddys Run. There is no discernable difference in concentrations of hazardous substances in sediment in the Great Miami River located upstream and downstream of the FEMP wastewater outfall line.

- Large areas of perched groundwater, located within the former production area and Operable Units 1, 2 and 4 waste storage areas, exhibit elevated levels of radiological constituents and other hazardous substances.

- Above-background concentrations of radiological constituents and certain other contaminants exist in the regional Great Miami Aquifer at locations beneath the FEMP and extending along Paddys Run from the FEMP to its confluence with the Great Miami River.

- A number of chemical contaminants have been detected in soil, sediment, and surface water in concentrations that exceed levels considered protective of flora and fauna. In general, radiological constituents were detected at low concentrations in select samples of aquatic and terrestrial vegetation.

Feasibility Study Process

Based on the findings of the Operable Unit 5 RI, remedial action objectives were developed for each of the contaminated environmental media. These objectives, which can be summarized as eliminating or reducing to acceptable levels the potential for human and ecological exposure to contaminated media, served as a foundation for the development of viable remedial action alternatives. Preliminary remediation levels (PRLs), considered preliminary cleanup levels for purposes of the FS, were established for each media on the basis of the reasonably maximally exposed (RME) human or environmental receptor projected to be potentially exposed to site contaminants. The preliminary site cleanup levels become final with the approval of the Operable Unit 5 ROD.

Potential health effects resulting from exposures to radioactive and chemical contaminants are a major consideration in the development of PRLs. Those potential health effects are divided into two categories: carcinogenic and noncarcinogenic. For carcinogens, EPA has identified a target range for incremental risks of 10^{-6} to 10^{-4}, or 1 in 1,000,000 to 1 in 10,000, to limit the possibility that an individual will develop cancer due to exposure to residual contaminants.

For noncarcinogens, EPA guidance provides that individuals be protected from health effects other than cancer by proposing that potential intakes or dermal exposures to a toxic chemical are maintained below the reference dose. The ratio of a chemical's actual or potential dose via one pathway to a reference dose set by EPA is referred to as its hazard quotient (HQ). The cumulative effects from all chemicals and all pathways is represented by the hazard index (HI), which is the sum of the HQs from all chemicals and pathways evaluated. Maintaining a receptor's HI below 1.0 is considered to provide an adequate level of protection.

For sites where the total estimated incremental lifetime cancer risk (ILCR) for each receptor is less than 10^{-4} and the HI is less than 1.0, remedial actions may not be warranted. The NCP targets an ILCR of 10^{-6} as the point of departure for establishing cleanup levels; however, the total incremental risk should be in the range of or less than 10^{-4} after remediation and have a total HI of less than 1.0 for the noncarcinogenic toxic effects.

In recognition of the PRLs and the need to provide supporting information to the Fernald Citizens Task Force, general public, and the final remedial decision makers, the development of remedial action alternatives for Operable Unit 5 was based upon a range of viable land uses that the FEMP property could evolve to in the future. This range was strategically defined to appropriately bracket the extensive array of potential future land use objectives viable for the property. The array of land use objectives considered ranged from unrestricted future use of the facility property to other uses that progressively introduced more reliance on continued institutional controls by the federal government coupled with increased restrictions on future land uses.

The prevailing land use of the region, residential farming, was used as the point of departure for establishing potential future land uses. For all off-property affected areas, unrestricted use of land and water was singularly considered as a requirement of the cleanup process. All preliminary cleanup levels were based on attaining this goal (off property) and on establishing family farms on the impacted private properties. From this point of departure, the following potential future land use objectives for the FEMP property were formulated:

- *Land Use Objective 1* examines the viability of returning the entire on-property area to full unrestricted use following cleanup. This objective considers the potential for establishing a hypothetical family farm on any portion of the existing FEMP property. For this, and all other land use objectives, affected off-property areas were examined only in context of the existing land use in the region, residential farming. The RME resident farmer was assumed as both the on-property and off-property receptor for development of the PRLs.

- *Land Use Objective 2* provides for the establishment of an on-property consolidated management area for contaminated soil, with unrestricted use of all remaining areas of the property. This land use objective considers the potential for establishing a hypothetical family farm, following cleanup, on any portion of the FEMP property outside the area where the contaminated materials are consolidated. The expanded trespasser was assumed as the maximally exposed receptor within the FEMP consolidation area. Outside the consolidation area, the RME resident farmer was assumed as both the on-property and off-property receptor for calculation of PRLs.

- *Land Use Objective 3* also provides for the consolidation of contaminated soil in a central area, but restricts the potential uses of the remaining areas of the property through the application of institutional controls. This objective considers the potential for establishing recreational, commercial/industrial, or undeveloped open space (i.e., green space) on any portion of the FEMP property outside the area where the contaminated materials are consolidated. The

expanded trespasser was assumed as the maximally exposed receptor within the FEMP consolidation area. Outside the consolidation area, derivation of PRLs considered multiple on-property receptors including an industrial user and a recreational user of an undeveloped park. The RME resident farmer was assumed as the off-property receptor for derivation of PRLs.

- *Land Use Objective 4* provides for minimum consolidation of contaminated soil with access and future use of the FEMP property restricted. This land use objective contemplates the FEMP property being maintained as a waste management area. A trespasser scenario is used as the potential receptor for development of risk-based PRGs for the FEMP property. For off-property locations, land use is expected to remain agricultural in the future and this was assumed in developing PRLs for these locations.

By using the land use objectives approach to formulate remedial action alternatives, decision makers are provided with a comprehensive but manageable array of alternatives. From this array, decision makers have the information with which to evaluate technical site constraints, required administrative controls, and the overall cost implications of moving from totally restrictive to progressively less restricted land use possibilities.

Considering this range of potential future land uses for the FEMP, viable technologies and process options were arrayed to produce remedial action alternatives for each land use objective which could attain the remedial action objectives. These remedial action alternatives each considered comprehensive solutions for addressing soil, sediment, perched groundwater, and the regional groundwater aquifer. The range of remedial alternatives was initially defined very broadly, encompassing almost 2000 potentially viable remedial options. This list of initial alternatives was then progressively refined based on practicality and other technical considerations. From this process, 10 viable remedial alternatives were developed for further consideration in the FS. Each of these alternatives was subjected to an initial screening process in which the alternative was evaluated against cost, implementability, and effectiveness considerations. Three alternatives were screened from further consideration based on the results of these initial evaluations. The remaining seven alternatives were then subjected to a comprehensive detailed analysis process.

The detailed process employed seven evaluation criteria, consistent with regulatory requirements. Assessments against two of these criteria relate directly to an evaluation against regulatory requirements, and are categorized as threshold criteria. An alternative must satisfy these threshold criteria to be considered further:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements.

The following five criteria are grouped together because they represent the primary balancing criteria upon which the detailed analysis is based:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

Two other criteria will be evaluated following the receipt of public and OEPA comments on the Proposed Plan and will be addressed in the ROD. These criteria are termed modifying criteria and are:

- State acceptance
- Community acceptance.

Remedial Action Alternatives Summary

Each of the seven remedial action alternatives retained for detailed analysis, along with the requisite no-action alternative, is listed below with its associated land use objective category.

No-Action Alternative

Under this alternative, no remedial actions would be taken for Operable Unit 5 contaminated media. This alternative is retained to provide a baseline for comparison in accordance with regulatory requirements.

Land Use Objective 1: Full Unrestricted Use

Alternative 1 - Excavation and Off-Site Shipment - Under this alternative, contaminated soil and sediment exceeding remediation levels would be excavated and shipped to an off-site licensed disposal facility. Shipping is assumed to take place in covered gondola rail cars. Excavated areas would be regraded with existing site soil so as to reach a predetermined final surface grade. The use of clean, imported fill would be required, but kept to a minimum. Contaminated perched groundwater zones, deemed to represent unacceptable risks to potential human receptors or the underlying Great Miami Aquifer, would also be excavated and disposed of at an off-site disposal facility.

Within this alternative, two differing projected cleanup levels were examined. The first set of cleanup levels (i.e., remediation levels) examined had as an objective the protection of the projected future receptors (i.e., in this case a hypothetical on- and off-property farmer) at an ILCR of 10^{-6}. The second case was designed to provide protection to these same receptors at a 10^{-5} level.

To achieve these goals, remediation levels for soil had to be adjusted (i.e., lowered) in select areas to take into consideration the potential for continued leaching of contaminants into the aquifer at concentrations which potentially exceeded groundwater cleanup levels. These adjustments were

contaminant specific and took into consideration the geologic conditions of the site and the solubility of the contaminant.

Target risk levels for the cleanup of existing contamination in the Great Miami Aquifer were established. For uranium, the two groundwater restoration cases examined were to restore the aquifer to levels of 3 parts per billion (ppb) (i.e., 10^{-6} ILCR) and 20 ppb (i.e., the proposed federal maximum contaminant level [MCL] for drinking water). For both cases a series of groundwater extraction wells would be installed to flush the contaminants from the aquifer and attain the desired cleanup levels.

An administrative boundary was established at the southern extent of groundwater capture created by the South Plume Removal Action wells, which began operating in 1993. The South Plume Removal Action was initiated before selection of the final remedy to prevent the additional migration of contaminants offsite. Monitoring would continue south of the administrative boundary until such time as the need for action is established and implemented.

Modeling performed for the FS was used to estimate the pumping rates required from the recovery wells to restore the aquifer to the target cleanup levels. This modeling effort yielded an estimated maximum pumping rate of 7500 gallons per minute (gpm) for the 10^{-6} ILCR and 4000 gpm for the MCL targets. The pumping rate would be expected to vary during the period of aquifer restoration with gradual cessation of pumping once the attainment of cleanup goals was certified. The modeling further estimated the time to restore the aquifer for the 10^{-6} ILCR-based recovery system to be approximately 75 years, while the MCL-based system was estimated at approximately 27 years of pumping. More detailed modeling would be conducted following remedy selection to refine these flow rates and restoration timeframes in support of the remedial design process.

Groundwater restoration systems, similar to the recovery well network contemplated at the FEMP, have been applied by industry for the last 10 to 15 years under Superfund and other environmental cleanup programs. In general, the industry experience has highlighted the inherent difficulties in successfully applying the technology to fully restoring aquifer systems in a reasonable timeframe. This industry experience has identified the importance of treating groundwater restoration as an iterative process requiring continued process evaluation, monitoring, and (if needed) modifications to optimize system performance. The need for this continued performance evaluation is attributable to the high uncertainty typically found in using mathematical models to predict the process of recovering contaminants from aquifer systems. Consistent with industry experience, the FEMP would continue to evaluate the performance of the recovery well system and explore opportunities for applying design changes or new technologies to enhance the aquifer restoration process.

During the time of active aquifer restoration, alternate water would be provided to all groundwater users in areas exhibiting concentrations above the remediation levels. The DOE has provided funding to the Hamilton County Department of Public Works to help support the installation of a public water supply to the surrounding area. The system is expected to be operational in the fall of 1995.

An expansion of the FEMP's advanced wastewater treatment (AWWT) facility would be designed to treat all major contaminants in the recovered groundwater. The projected treatment would reduce the concentration of uranium, the primary contaminant, to below 20 ppb before discharge to the Great Miami River.

The specific treatment configuration, size and capacity of the required expansion to the AWWT facility would be finalized during the remedial design process. An important focus of the design process would be establishing the final capacity of the facility considering the previously discussed uncertainties in the effectiveness and time frame of the aquifer restoration process.

Contaminated storm water runoff from the surface of the former production area and the Operable Unit 1 and 4 areas is currently being collected in retention basins. Collection of this water will continue until those areas are remediated. The collected storm water would be treated before discharge to the Great Miami River.

The estimated time required to complete the required remedial actions involving soil and sediment is similar for each of the alternatives: approximately 22 years. This time frame is directly related to gaining access to contaminated soil underlying the structures of the former production area; demolition of these facilities is estimated to take at least 16 years. It is estimated that approximately 75 years of groundwater extraction would be required to complete the restoration of the Great Miami Aquifer to the 10^{-6} ILCR with treatment of groundwater for up to 30 years. For the case examining attainment of existing and proposed MCLs in the aquifer, it is estimated that groundwater pumping would continue for up to 27 years with treatment for up to 20 years.

SUMMARY OF ALTERNATIVE 1 - EXCAVATION AND OFF-SITE SHIPMENT

	Risk Range	
On-Property Receptor	Resident Farmer	Resident Farmer
On-Property Risk Level	10^{-6}	10^{-5}
On-Property Uranium Cleanup Level (ppm)	5	15
Off-Property Receptor	Resident Farmer	Resident Farmer
Off-Property Risk Level	10^{-6}	10^{-5}
Off-Property Uranium Cleanup Level (ppm)	5	15
Volume Requiring Excavation		
- On-Property (cubic yards)[a]	4,450,000	2,340,000
- Off-Property (cubic yards)	5,200,000	400,000
- Total (cubic yards)[b]	9,650,000	2,740,000
Off-Site Disposal		
- Volume (cubic yards)[c]	9,350,000	2,400,000
- Rail Cars	165,000	42,240
On-Site Disposal (cubic yards)	0	0
Present Worth Cost[d]	$4330M	$1240M
Total Project Cost[d]	$13870M	$3020M

[a] Includes 175,000 cubic yards of gravel from production area.
[b] Includes volume of clean soil (to be used as backfill) excavated to reach contaminated soil at depth.
[c] Volume does not include excavation of soil below cleanup level to gain access to deeper contamination.
[d] All costs (M = million) are estimated and include the recovery/collection and treatment of site surface water, wastewater, and groundwater.

Land Use Objective 2: Establishment of a Consolidated Waste Management Area with Unrestricted Use of the Remaining Areas of the Property

Alternative 2A - Engineered Disposal Facility - Under this alternative, contaminated soil exceeding remediation levels would be excavated and placed in an engineered above-grade disposal facility. The facility would be situated on an area displaying the best available geologic conditions. An investigation of the property is presently underway to establish the most suitable location for such a facility in the event it is deemed appropriate.

The contaminated perched water extraction and aquifer recovery and treatment component of the alternative are the same as those associated with Alternative 1. The footprint of the disposal facility would be fenced and would remain under the continued ownership of the federal government, with restrictions placed in the property deed and permanent markers installed to reduce the potential for human intrusion into the consolidation area. Additionally, a long-term environmental monitoring

program would be implemented with reviews of performance of the disposal facility conducted by EPA at least once every five years.

SUMMARY OF ALTERNATIVE 2A - ENGINEERED DISPOSAL FACILITY

	Risk Range	
On-Property Receptor	Resident Farmer	Resident Farmer
On-Property Risk Level	10^{-6}	10^{-5}
On-Property Uranium Cleanup Level (ppm)	5	15
Off-Property Receptor	Resident Farmer	Resident Farmer
Off-Property Risk Level	10^{-6}	10^{-5}
Off-Property Uranium Cleanup Level (ppm)	5	15
Volume Requiring Excavation		
- On-Property (cubic yards)[a]	4,450,000	2,340,000
- Off-Property (cubic yards)	5,200,000	400,000
- Total (cubic yards)[b]	9,650,000	2,740,000
Off-Site Disposal		
- Volume (cubic yards)	50,000	25,000
- Rail Cars[c]	880	440
On-Site Disposal Facility (cubic yards)[d]	9,300,000	2,375,000
Present Worth Cost[e]	$2290M	$720M
Total Project Cost[e]	$12030M	$2580M

[a] Includes 175,000 cubic yards of gravel from production area.
[b] Includes volume of clean soil (to be used as backfill) excavated to reach contaminated soil at depth.
[c] For off-site disposal volumes of 50,000 yd^3 or less, shipment may be made by truck rather than rail.
[d] Volume does not include excavation of soil below cleanup level to gain access to deeper contamination.
[e] All costs (M = million) are estimated and include the recovery/collection and treatment of site surface water, wastewater, and groundwater.

Alternative 2C--Consolidation With Off-Site Shipment - Under this alternative, contaminated soil exceeding remediation levels would be excavated and, depending on contaminant concentration levels, dispositioned either in an on-property earthen-covered consolidation area or at an off-site licensed disposal facility. Two risk and cleanup levels, consistent with Alternative 2A, were evaluated for this alternative.

Soil exhibiting low concentrations of contaminants (e.g., less than 45 ppm of insoluble uranium) would be consolidated under an earthen cover. The earthen cover would include at least 12 inches of clean fill and a vegetative cover. The area of consolidation would be maintained under the continued

ownership of the federal government, with restrictions placed in the property deed and permanent markers installed to reduce the potential for human intrusion into the consolidation area.

The perched groundwater and Great Miami Aquifer remedial strategies would be consistent with those described for Alternative 2A.

SUMMARY OF ALTERNATIVE 2C - CONSOLIDATION WITH OFF-SITE SHIPMENT

	Risk Range	
On-Property Receptor	Resident Farmer	Resident Farmer
On-Property Risk Level	10^{-6}	10^{-5}
On-Property Uranium Cleanup Level (ppm)	5	15
Off-Property Receptor	Resident Farmer	Resident Farmer
Off-Property Risk Level	10^{-6}	10^{-5}
Off-Property Uranium Cleanup Level (ppm)	5	15
Volume Requiring Excavation		
- On-Property (cubic yards)[a]	4,450,000	2,340,000
- Off-Property (cubic yards)	5,200,000	400,000
- Total (cubic yards)[b]	9,650,000	2,740,000
Off-Site Disposal		
- Volume (cubic yards)	9,350,000	1,160,000
- Rail Cars	165,000	20,400
On-Site Disposal (cubic yards)[c]	0	1,240,000
Present Worth Cost[d]	$4330M	$910M
Total Project Cost[d]	$13870M	$2780M

[a] Includes 175,000 cubic yards of gravel from production area.
[b] Includes volume of clean soil (to be used as backfill) excavated to reach contaminated soil at depth.
[c] Volume does not include excavation of soil below cleanup level to gain access to deeper contamination.
[d] All costs (M = million) are estimated and include the recovery/collection and treatment of site surface water, wastewater, and groundwater.

Land Use Objective 3: Establishment of a Consolidated Waste Management Area with Restricted Use of the Remaining Areas of the Property

Alternative 3A–Engineered Disposal Facility - Under this alternative, contaminated soil exceeding remediation levels would be excavated and placed in an engineered disposal facility. The remedial strategy for soil, perched water and the Great Miami Aquifer is consistent with Alternative 2A. Perched water zones exhibiting concentrations of contaminants which threaten the water quality of the underlying aquifer to a level above the proposed or existing MCLs would also be excavated. This

alternative considered five different cases of restricted land use with corresponding remediation levels for on- and off-property soil. For all five cases evaluated, the remediation level of the Great Miami Aquifer was set at the existing and proposed federal drinking water standards (i.e., 20 ppb for uranium).

The disposal facility area would remain fenced and under the continued ownership of the federal government, with restrictions placed in the deed and permanent markers installed to reduce the potential for human intrusion into the facility. The remaining areas of the site would have institutional controls applied to ensure the adopted land use strategy is maintained. An environmental monitoring program would continue with reviews of the site performed by EPA at least once every five years.

SUMMARY OF ALTERNATIVE 3A - ENGINEERED DISPOSAL FACILITY

	Risk Range				
On-Property Receptor	Industrial User	Developed Park User	Undeveloped Park User	Undeveloped Park User	Undeveloped Park User
On-Property Risk Level	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
On-Property Uranium Cleanup Level (ppm)	15	40[a]	80[a]	80[a]	80[a] ppm with an ALARA goal of 50 ppm
Off-Property Receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Off-Property Risk Level	10^{-5}	10^{-5}	10^{-5}	HI=1 3.5×10^{-5}	HI=1 3.5×10^{-5}
Off-Property Uranium Cleanup Level (ppm)	15	15	15	50	50
Volume Requiring Excavation					
- On-Property (cubic yards)[b]	1,990,000	1,800,000	1,790,000	1,789,000	1,799,000
- Off-Property (cubic yards)	400,000	400,000	400,000	1000	1000
- Total (cubic yards)[c]	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Off-Site Disposal					
- Volume (cubic yards)	25,000	25,000	25,000	25,000	25,000
- Rail Cars[d]	440	440	440	440	440
On-Site Disposal[e] (cubic yards)	2,340,000	1,750,000	1,750,000	1,750,000	1,750,000
Present Worth Costs[f]	$690M	$630M	$610M	$580M	$580M
Total Project Cost[f]	$2510M	$2220M	$2180M	$2110M	$2110M

[a] Cleanup level of 20 ppm for uranium may be required in the production area to protect the aquifer.
[b] Includes 175,000 cubic yards of gravel from production area.
[c] Includes volume of clean soil (to be used as backfill) excavated to reach contaminated soil at depth.
[d] For off-site disposal volumes of 50,000 yd^3 or less, shipment may be made by truck rather than rail.
[e] Volume does not include excavation of soil below cleanup level to gain access to deeper contamination.
[f] All costs (M = million) are estimated and include the recovery/collection and treatment of site surface water, wastewater, and groundwater.

Alternative 3C - Consolidation With Off-Site Shipment - Under this alternative, contaminated soil exceeding remediation levels would be excavated, with the contaminated soil exhibiting levels greater than the consolidation area waste acceptance criteria shipped by rail to a licensed off-site disposal facility. The remedial strategy for soil, perched groundwater, and the Great Miami Aquifer is consistent with Alternative 2C and the remediation levels are consistent with those used for Alternative 3A.

SUMMARY OF ALTERNATIVE 3C - CONSOLIDATION WITH OFF-SITE SHIPMENT

	Risk Range				
On-Property Receptor	Industrial User	Developed Park User	Undeveloped Park User	Undeveloped Park User	Undeveloped Park User
On-Property Risk Level	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
On-Property Uranium Cleanup Level (ppm)	15	40[a]	80[a]	80[a]	80[a] ppm with an ALARA goal of 50 ppm
Off-Property Receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Off-Property Risk Level	10^{-5}	10^{-5}	10^{-5}	HI=1 3.5×10^{-5}	HI=1 3.5×10^{-5}
Off-Property Uranium Cleanup Level (ppm)	15	15	15	50	50
Volume Requiring Excavation					
- On-Property (cubic yards)[b]	1,990,000	1,800,000	1,790,000	1,789,000	1,799,000
- Off-Property (cubic yards)	400,000	400,000	400,000	1000	1000
- Total (cubic yards)[c]	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Off-Site Disposal					
- Volume (cubic yards)	1,150,000	1,130,000	1,120,000	1,120,000	1,120,000
- Rail Cars	20,200	19,900	19,700	19,700	19,700
On-Site Disposal[d] (cubic yards)	1,220,000	652,000	652,000	652,000	652,000
Present Worth Cost[e]	$880M	$820M	$800M	$770M	$770M
Total Project Cost[e]	$2690M	$2290M	$2240M	$2170M	$2170M

[a] Cleanup level of 20 ppm for uranium may be required in the production area to protect the aquifer.
[b] Includes 175,000 cubic yards of gravel from production area.
[c] Includes volume of clean soil (to be used as backfill) excavated to reach contaminated soil at depth.
[d] Volume does not include excavation of soil below cleanup level to gain access to deeper contamination.
[e] All costs (M = million) are estimated and include the recovery/collection and treatment of site surface water, wastewater, and groundwater.

Land Use Objective 4: Restricted Use of the Entire On-Property Area

Alternative 4A - Engineered Disposal Facility - Under this alternative, contaminated soil exceeding remediation levels would be excavated and placed into an engineered disposal facility. This alternative is similar to Alternatives 2A and 3A, except that the remediation level and minimum soil consolidation contemplates restricted access to the entire FEMP property.

SUMMARY OF ALTERNATIVE 4A - ENGINEERED DISPOSAL FACILITY

	Risk Range	
On-Property Receptor	Trespasser	Trespasser
On-Property Risk Level	10^{-6}	10^{-6}
On-Property Uranium Cleanup Level (ppm)[a]	100	100
Off-Property Receptor	Resident Farmer	Resident Farmer
Off-Property Risk Level	10^{-5}	HI=1
Off-Property Uranium Cleanup Level (ppm)	15	50
Volume Requiring Excavation		
- On-Property (cubic yards)[b]	1,790,000	1,789,000
- Off-Property (cubic yards)	400,000	1000
- Total (cubic yards)[c]	2,190,000	1,790,000
Off-Site Disposal		
- Volume (cubic yards)	25,000	25,000
- Rail Cars[d]	440	440
On-Site Disposal[e]	1,750,000	1,750,000
Present Worth Cost[f]	$610M	$580M
Total Project Cost[f]	$2180M	$2110M

[a] Cleanup level of 20 ppm for uranium may be required in the production area to protect the aquifer.
[b] Includes 175,000 cubic yards of gravel from production area.
[c] Includes volume of clean soil (to be used as backfill) excavated to reach contaminated soil at depth.
[d] For off-site disposal volumes of 50,000 yd^3 or less, shipment may be made by truck rather than rail.
[e] Volume does not include excavation of soil below cleanup level to gain access to deeper contamination.
[f] All costs (M = million) are estimated and include the recovery/collection and treatment of site surface water, wastewater, and groundwater.

Alternative 4C - Consolidation With Off-Site Shipment - Under this alternative, contaminated soil exceeding remediation levels would be excavated, and dispositioned either on property in an earthen-covered consolidation area or off site at a licensed disposal facility. This alternative is similar to Alternatives 2C and 3C, except that the remediation levels contemplate restricted access to the entire FEMP.

SUMMARY OF ALTERNATIVE 4C - CONSOLIDATION WITH OFF-SITE SHIPMENT

	Risk Range	
On-Property Receptor	Trespasser	Trespasser
On-Property Risk Level	10^{-6}	10^{-6}
On-Property Uranium Cleanup Level (ppm)[a]	100	100
Off-Property Receptor	Resident Farmer	Resident Farmer
Off-Property Risk Level	10^{-5}	HI=1
Off-Property Uranium Cleanup Level (ppm)	15	50
Volume Requiring Excavation		
- On-Property (cubic yards)[b]	1,790,000	1,789,000
- Off-Property (cubic yards)	400,000	1000
- Total (cubic yards)[c]	2,190,000	1,790,000
Off-Site Disposal		
- Volume (cubic yards)	1,120,000	1,120,000
- Rail Cars	19,700	19,700
On-Site Disposal[d]	652,000	652,000
Present Worth Cost[e]	$800M	$780M
Total Project Cost[e]	$2240M	$2170M

[a] Cleanup level of 20 ppm for uranium may be required in the production area to protect the aquifer.
[b] Includes 175,000 cubic yards of gravel from production area.
[c] Includes volume of clean soil (to be used as backfill) excavated to reach contaminated soil at depth.
[d] Volume does not include excavation of soil below cleanup level to gain access to deeper contamination.
[e] All costs (M = million) are estimated and include the recovery/collection and treatment of site surface water, wastewater, and groundwater.

Evaluation of Alternatives

The seven alternatives were subjected to a detailed comparative evaluation process to identify the relative advantages and disadvantages of each alternative. The detailed evaluation was conducted employing the defined criteria as the framework for identifying technical and administrative differences between the alternatives.

Overall Protection of Human Health and the Environment

All of the action alternatives would provide permanent solutions and adequately protect human health and the environment. The no-action alternative would allow for continued migration of site

contaminants and would not provide for the protection of human health and the environment. Alternative 1 ranks the highest in terms of the degree of protectiveness, as measured by reduced uncertainty and long-term effectiveness. Alternative 1 involves the removal of contaminated soil and sediment from the site to a permitted off-site disposal facility. This alternative provides a high level of certainty for continued long-term protectiveness and requires no provisions for perpetual institutional controls or five-year CERCLA reviews. Future uncertainties on the availability of off-site disposal capacity could affect the implementability of this alternative, potentially causing delays in the attainment of the remedial objectives.

Alternatives contemplating the off-site shipment of the more heavily contaminated soil with consolidation of less contaminated soil, provide the highest level of certainty for maintaining protectiveness over time, for land uses contemplating on-property disposal. For alternatives relying on an engineered disposal facility, conservative design assumptions and the adoption of concentration-based waste acceptance criteria will be used to supplement existing site geology to ensure the long-term performance of the disposal system. Modeling runs completed for the FS on the performance of the disposal facility demonstrate a reasonable certainty (> 80 percent) that concentrations in the aquifer underlying the on-property disposal facility will not exceed concentrations specified as existing or proposed federal drinking water standards (at the time the ROD is signed) for 1000 years.

Alternatives relying on on-property disposal typically presented the lowest overall short-term risk to remediation workers and off-property residents. Short-term risks are those occurring during implementation of the remedial action and include mechanical hazards, transportation-related injuries/fatalities, and impacts due to releases (i.e., fugitive dust, etc.,) during construction activities. For the on-property disposal alternatives, short-term risks were directly related to the quantity of material excavated (i.e., the remediation levels) and placed in the disposal facility. The larger the quantity excavated, the higher the associated short-term risks.

Alternatives employing on-property disposal would adequately protect flora and fauna, including aquatic life in Paddys Run and the Great Miami Aquifer. For select remediation levels (i.e., 10^{-6} ILCR to the resident farmer), significant acreage of forested wetlands and woodlands both on and off the FEMP property would be excavated. For alternatives not contemplating a residential farming land use at the FEMP, no areas of forested wetlands on or off the FEMP property would be disturbed.

Compliance With Applicable or Relevant and Appropriate Requirements (ARARs)
Alternative 1 would comply with ARARs. All other action alternatives that include an on-property disposal facility or consolidation area would comply with ARARs if a CERCLA waiver is granted by EPA for the State of Ohio solid waste disposal facility siting requirements. In general, to be granted the waiver, the FEMP would need to adopt an engineering design for the facility which would, when

coupled with existing site geologic conditions, attain a standard of performance equivalent to that required under the State of Ohio siting requirements. Input received from representatives of OEPA indicates that the consolidation area with earthen cover, contemplated under Alternatives 2C, 3C and 4C, would probably not fulfill waiver requirements.

Each of the alternatives (except the no-action alternative) includes an aggressive aquifer pump and treat component aimed at restoring the Great Miami Aquifer to its full beneficial use within a reasonable time frame. This groundwater recovery component would reduce the existing concentration of uranium to below proposed drinking water standards at all points within the aquifer in about 27 years and these alternatives would be in compliance with ARARs.

Each of the alternatives relying on on-property disposal (i.e., capping systems or disposal facilities) would employ design considerations found in the federal Uranium Mill Tailings Radiation Control Act standards and Resource Conservation and Recovery Act to ensure the long-term performance of the disposal system. These standards would require the use of multilayered capping and lining systems, the development of contaminant-specific waste acceptance criteria, and use of a design which ensures protectiveness for 200 to 1000 years. Long-term monitoring would be provided for all alternatives involving on-property disposal, as required to demonstrate the continued performance of the disposal system.

Long-Term Effectiveness and Permanence

Long-term effectiveness is evaluated through two criteria: the magnitude of the residual risk remaining at the site after the cleanup, and the adequacy and reliability of any required engineering or institutional controls. Remedial alternatives employing off-site disposal as the principal means for addressing the contaminated soil and sediment would require the least amount of contaminated materials to remain at the site. Alternative 1 would include the removal of all contaminated material from the site with no long-term requirements for continued institutional controls, surveillance, or maintenance activities at the facility.

Each of the alternatives would ensure the attainment of the remediation levels through the implementation of a verification sampling program before remediation and the completion of a certification sampling program following completion of remediation activities. All alternatives would employ excavation to remove perched groundwater zones presenting unacceptable risks to future receptors or the underlying aquifer. Each alternative also employs pump and treat technologies to attain health-protective levels in the Great Miami Aquifer.

Each of the alternatives employing a disposal facility or central consolidation area relies on engineering measures and institutional controls to ensure the long-term performance of the remedy and maintain the protection of human health and the environment over time. The highest level of

certainty is associated with the consolidation area with engineering controls and with more heavily contaminated soil being shipped off site for disposal. The remaining material would exhibit low concentrations of contaminants which present lower overall risks to potential intruders in the event the planned institutional controls were to fail in the future.

Long-term environmental impacts associated with the construction of the on-property disposal facility or consolidation area would permanently commit up to 301 acres of land, including up to 57 acres of terrestrial habitat in the form of woodlands and pine plantation habitat. Between 9 and 36 acres of wetlands could be lost depending on the cleanup level selected. The 100- and 500-year floodplains of Paddys Run and the Great Miami River would not be permanently altered as a result of backfilling and regrading activities. No significant long-term impacts are expected for water quality and hydrology, air quality, socioeconomics, or cultural resources. Mitigation for wetlands impacts will be determined using the Section 404(b)(1) guidelines of the Clean Water Act, in consultation with the Corps of Engineers, EPA and OEPA.

Reduction of Toxicity, Mobility, or Volume Through Treatment

All of the alternatives rely upon treatment to address contaminated storm water and recovered groundwater before discharge to the Great Miami River. In general, two other treatment options were considered for application to Operable Unit 5 contaminated media. The first is soil washing, which involves the use of physical and chemical processes to reduce contaminant levels in soil. The second is the use of cement stabilization to address site soil, which involves mixing the soil with cement to generate a solid monolithic product. Soil washing is a promising technology for addressing contaminated soil; however, the technology is limited in its application due to physical constraints at the site. Soil washing cannot sufficiently lower contaminant concentration levels to be protective of the Great Miami Aquifer over the long term. With further development, soil washing could have application as a support technology at the FEMP when used in conjunction with a disposal technology, such as an on-property disposal facility. Cement stabilization was not adopted as a major component of any of the alternatives because of the significant cost of applying the technology and the increased volumes due to the addition of cement additives.

It should be recognized that each of the proposed alternatives will require from 20 to 22 years to complete soil cleanup activities and potentially 27 years to complete groundwater restoration. Additionally, for those alternatives relying on the availability of off-site disposal capacity, there is significant uncertainty in the continued availability of this capacity over the 22-year soil cleanup. During this period, the FEMP will continue to evaluate emerging technologies, such as physical separation, phosphate amendment of soil, and soil compaction to potentially apply to the selected remedy to promote cost effectiveness, waste minimization and to reduce potential vulnerabilities to completing remedial action due to unavailability of off-site disposal capacity.

Short-Term Effectiveness

The evaluation of the alternatives under this criterion addresses effects during the construction and implementation phase of remedial actions. Short-term effectiveness evaluates the potential impacts to workers, the public and the environment associated with performing a remedial alternative. Critical considerations in the assessment of the Operable Unit 5 alternatives are: the projected amount of workhours to accomplish a given alternative, the quantity of soil excavation, the estimated fugitive dust generated by material movements, and the haul time to the off-site disposal facility.

By definition, the no-action alternative presents the least short-term impacts. All the action alternatives involve remedial activities such as earthmoving, construction and operation of treatment facilities, and material transport. All action alternatives would create an impact and pose some risk to the environment, workers and the public. These impacts can be effectively controlled through the application of mitigative measures such as dust suppression techniques and rigorous worker health and safety programs.

In general, those alternatives relying upon off-site disposal as the principal means for material disposition present the highest overall short-term risk. The most significant element of short-term risk for these alternatives is due to the projected injuries and fatalities estimated to result as a consequence of transporting such large quantities of material.

Alternatives relying on disposal in an on-property facility would present lower overall risks. The most significant element of short-term risk associated with this set of remedial alternatives is attributable to projected worker injuries related to mechanical hazards. Such injuries would be minimized at DOE facilities, such as the FEMP, through the adoption of strict health and safety program requirements during the implementation of remedial actions.

As part of the short-term risk assessment, estimates were completed for each alternative of the projected risks to individuals neighboring the FEMP due to the conduct of remedial activities. These risks were estimated on the basis of modeling projections of the potential releases of dust during excavation, soil transport, and disposal activity. For alternatives considered in the FS, the highest calculated risk to the maximally exposed individual over the 22-year soil cleanup process would not be expected to exceed a 10^{-6} ILCR.

Short-term impacts associated with remedial action alternatives would include temporary on-property disruption of up to approximately 42 acres of land from construction of support facilities and 930 acres from soil excavation. Off-property soil excavation would temporarily disturb up to 6446 acres of land (i.e., assumes cleanup at the 10^{-6} level). Appropriate engineering controls would minimize fugitive dust emissions during excavation activities.

Implementability

This evaluation criterion addresses the technical and administrative feasibility of implementing the remedial alternatives. Alternatives involving the on-property disposal of contaminated soil and sediment are considered readily implementable through the use of existing technologies and construction methods.

The availability of off-site disposal capacity over the duration of the remedial actions presents considerable uncertainty. Discussions with personnel associated with a representative off-site disposal facility indicate that the disposal site could be expanded to accommodate a greater volume of low-level radioactive or mixed wastes. The availability of this expanded capacity or alternate capacity at some future (yet to be constructed) site is unclear and is compounded by the up to 22-year duration of remedial actions to address contaminated soil and sediment. For these reasons, alternatives relying on off-site disposal are considered less implementable than the on-site alternatives, and may offer delays to accommodate administrative or capacity issues.

The aquifer restoration component of the alternatives are considered implementable through reliance on available groundwater extraction and treatment technologies. There is considerable uncertainty in the time required to attain remediation levels for the aquifer for uranium and several other contaminants. This uncertainty is due to the limited ability to predict the rate at which the silt, sand and gravel making up the aquifer will release contaminants to the groundwater for extraction. The FEMP will continue to investigate other technologies, such as reinjection, to enhance contaminant recovery, and reduce the time to restore the aquifer. Reinjection would potentially involve the pumping of treated groundwater back into the aquifer to increase the rate of flow and the flushing effect so as to speed contaminant removal.

Cost

Cost estimates are used in the FS process to provide a basis for comparison among alternatives; estimates are typically provided to an accuracy range of +50 percent (real cost would be 50 percent higher than the estimate) to -30 percent (real cost would be 30 percent lower than the estimate) because of the uncertainties in the information available to develop them. To provide a fair basis of comparison for alternatives, cost estimates for alternatives are presented in present worth costs. Present worth costs reflect the quantity of money which would need to be placed in a bank today at a set interest rate, termed the discount rate, to pay for the remedial action over the life of the project.

The tables previously presented summarizing each of the remedial alternatives provided the present worth costs of each of the alternatives considered for Operable Unit 5. As identified in these summary tables, the cost estimates for each alternative reflect the costs to attain differing levels of protection against residual ILCR attributable to the site following the implementation of the

alternative. As the incremental risk levels become progressively more stringent, there is a corresponding increase in the contaminated soil volume that requires attention.

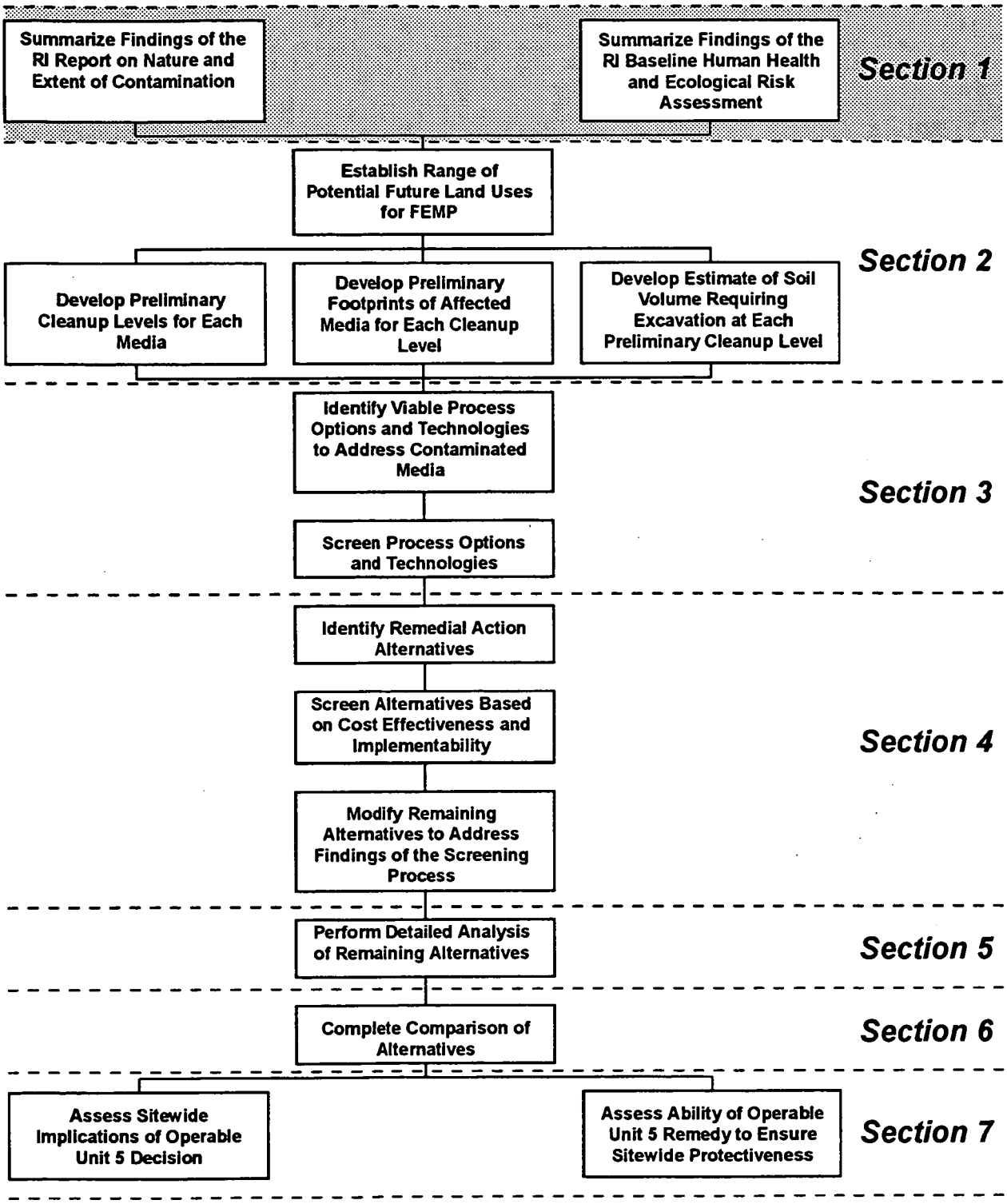
In general, for alternatives pursuing restoration to a 10^{-6} ILCR to the resident farmer (Alternatives 1, 2A, and 2C), in excess of 80 percent of the projected cost is associated with addressing the cleanup of contaminated soil with the remaining 20 percent attributed to the recovery and treatment of contaminated groundwater. For all other alternatives, approximately 60 to 75 percent of the projected costs would be associated with soil cleanup and the remaining 25 to 40 percent attributed to groundwater recovery and treatment. For the groundwater recovery and treatment cost component, in excess of 80 percent of the projected costs are attributed to the operation, maintenance and final dismantlement of the advanced wastewater treatment facility.

Analysis of Site-Wide Implications of the Operable Unit 5 Remedy Decision

An analysis of the site-wide implications of the Operable Unit 5 remedy decision is presented in Section 7. This analysis addresses the current status of decision making for each of the five operable units to provide a perspective for the projected remediation of the entire FEMP site and surrounding contaminated properties. The Operable Unit 5 representative alternative in conjunction with an adopted site-wide remedy portrays a balanced approach for the safe, acceptable, cost-effective, and timely disposition of both principal and secondary threat materials present at the site to ensure the long-term protection of human health and the environment.

The major elements of the analysis include: major assumptions associated with the implementation of the adopted site-wide remedy; identification of waste types and their estimated volumes; applicable treatment technologies; on/off-property disposal; long-term custodial care; and key uncertainties. From the standpoint of residual risks, the adopted site-wide remedy is not projected to leave residual contaminant concentrations which would result in unacceptable health hazards or incremental lifetime cancer risks to the three target receptors selected and evaluated to represent the most likely future land use at the FEMP.

The eventual determination of the remedial actions to be taken at the FEMP will be established by the ROD for each operable unit. The representative alternative for Operable Unit 5 coupled with the adopted site-wide remedy provides the opportunity for transforming significant portions of the FEMP property into land available for beneficial use by the community.


Summarize Findings of the RI Report on Nature and Extent of Contamination
Summarize Findings of the RI Baseline Human Health and Ecological Risk Assessment
Section 1
Establish Range of Potential Future Land Uses for FEMP
Develop Preliminary Cleanup Levels for Each Media
Develop Preliminary Footprints of Affected Media for Each Cleanup Level
Develop Estimate of Soil Volume Requiring Excavation at Each Preliminary Cleanup Level
Section 2
Identify Viable Process Options and Technologies to Address Contaminated Media
Screen Process Options and Technologies
Section 3
Identify Remedial Action Alternatives
Screen Alternatives Based on Cost Effectiveness and Implementability
Modify Remaining Alternatives to Address Findings of the Screening Process
Section 4
Perform Detailed Analysis of Remaining Alternatives
Section 5
Complete Comparison of Alternatives
Section 6
Assess Sitewide Implications of Operable Unit 5 Decision
Assess Ability of Operable Unit 5 Remedy to Ensure Sitewide Protectiveness
Section 7

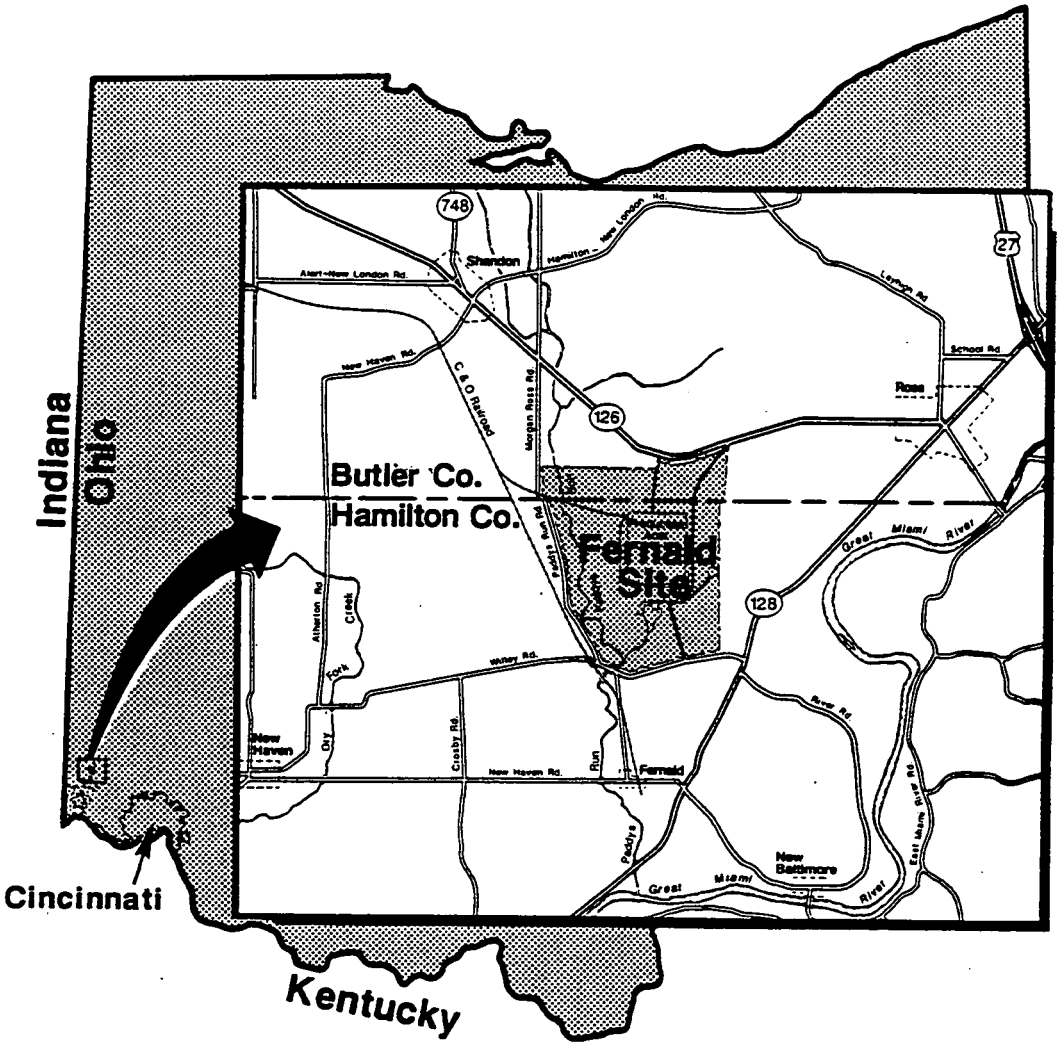
1.0 INTRODUCTION

This report documents the Feasibility Study (FS) phase of the Remedial Investigation/Feasibility Study (RI/FS) for Operable Unit 5 at the U.S. Department of Energy's (DOE) Fernald Environmental Management Project (FEMP). The FEMP is located in southwestern Ohio approximately 18 miles northwest of the city of Cincinnati (see Figure 1-1). Formerly known as the Feed Materials Production Center (FMPC), the FEMP operated from 1952 until 1989 providing high purity uranium metal products in support of U.S. defense programs. Production operations were halted in 1989 because of reduced needs, nationwide, for the uranium products produced by the FEMP.

The RI/FS is being conducted pursuant to the terms of a Consent Agreement entered into in 1990, and amended in 1991, by the DOE and the U.S. Environmental Protection Agency (EPA). The purpose of the RI/FS is to identify and evaluate the array of plausible remedial action alternatives to be considered at the FEMP to address environmental concerns identified through the remedial investigation and engineering treatability studies. The concerns include the potential impacts on human health and the environment from past releases of hazardous materials from the FEMP to the air, water, and the surrounding soil; continuing releases of hazardous materials from the facility; and the on-property accumulation of a large inventory of uranium process materials and low-level radioactive and hazardous wastes. On the basis of these concerns and an evaluation of existing environmental sampling data, EPA placed the FEMP on the National Priorities List (NPL) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in November 1989. The FEMP site includes all areas within the boundary of the FEMP and any off-property areas that received released hazardous substances, pollutants, contaminants, or hazardous constituents from the FEMP. Inclusion on the NPL reflects the importance placed by the federal government on completion of cleanup actions at the FEMP site. The NPL process is explained in more detail in Section 1.3.1.

To promote a more structured and expeditious cleanup, the facility and associated environmental issues are being managed as five operable units. An operable unit is a term employed under federal environmental regulation to represent a logical grouping of environmental issues at a cleanup site. Separate RI/FS documentation is being issued for each of the five operable units at the FEMP. The five operable units for which RI/FS documents are being compiled are defined within the Amended Consent Agreement as:

- Operable Unit 1: Waste Pits 1 through 6, the Clearwell, burn pit, berms, liners, and soil to a determined depth (estimated to be approximately 3 feet) beneath the waste pits



FINAL

000048

FIGURE 1-1. FEMP FACILITY LOCATION MAP

- Operable Unit 2: Other waste units including the flyash piles, other South Field disposal areas, lime sludge ponds, solid waste landfill, berms, liners, and soil within the operable unit boundary

- Operable Unit 3: Former production area and production-associated facilities and equipment (includes all above- and below-grade improvements) including, but not limited to, all structures, equipment, utilities, drums, tanks, solid waste, waste, product, thorium, effluent lines, a portion of the K-65 transfer line, wastewater treatment facilities, fire training facilities, scrap metal piles, feedstocks, and the coal pile

- Operable Unit 4: Silos 1, 2, 3, and 4, berms, and decant sump tank system

- Operable Unit 5: Environmental media including groundwater (both perched and the Great Miami Aquifer), surface water, soil not included in the definitions of Operable Units 1 through 4, sediment, flora, and fauna.

The goal of the RI phase is to compile existing environmental data at the site and undertake the necessary field investigations to develop a detailed understanding of the nature and extent of environmental media contamination and the risk the contaminants pose to human and environmental receptors. This detailed understanding is developed to the degree necessary to support the decision on whether remedial action is warranted and to support the evaluation of available remedial action alternatives in the FS. The final RI Report for Operable Unit 5 is available in the Administrative Record.

The purpose of this Operable Unit 5 FS is to evaluate the range of available cleanup alternatives to address contaminated environmental media. The FS has been formatted to provide the appropriate type and level of information required for key stakeholders and decision makers to come to informed decisions. The FS is prepared in accordance with EPA guidance (1988a) and provides a conceptual level of detail on each of the alternatives evaluated.

A separate document, the Proposed Plan (PP), summarizes the results of the FS and identifies a preferred alternative for potential implementation. The PP provides the reader with a summary of RI results and FS information. Following consideration of agency and public comments, a Record of Decision (ROD) is issued documenting the selected alternative. Following selection of the remedy in the ROD, remedial design (RD) and remedial action (RA) work plans are written describing the detailed engineering design and implementation phases and the schedules of the remedial action.

For sites undergoing investigations and cleanup under CERCLA, it is DOE policy to integrate the National Environmental Policy Act (NEPA) values into the procedural and documentation requirements of the RI/FS, wherever practical. On May 15, 1990, a Notice of Intent (NOI) was published in the Federal Register indicating DOE's plans to prepare an integrated FS and

environmental impact statement (EIS), consistent with NEPA, to evaluate the environmental impacts associated with the implementation of cleanup actions for each of the five operable units. Consistent with the NOI, an integrated FS-EIS was issued for Operable Unit 4. The Operable Unit 4 FS-EIS has been finalized and the ROD has been signed.

As of June 13, 1994, DOE revised its policy for sites undergoing CERCLA investigations to eliminate the administrative requirement of preparing a NEPA document. The revised policy, "Secretarial Policy Statement of National Environmental Policy Act," identified that only the values of NEPA need to be evaluated in the development of CERCLA RI/FS documentation. Although it is not the intent of DOE to make a determination about the applicability of NEPA to CERCLA, DOE has supplemented the evaluations contemplated by RI/FS guidance to accommodate the evaluation of NEPA values in the preparation of this FS. This information is also summarized in the Operable Unit 5 PP. Additional details on this integration process for addressing NEPA values in the RI/FS process can be found in Section 1.4 of this document.

The Amended Consent Agreement, signed in September 1991, expanded the scope of Operable Unit 5 by the addition of soil and perched groundwater inside the former production area. Further, in order to ensure the development of an integrated site-wide strategy for the management and cleanup of contaminated soil, the demarcation between Operable Unit 5 and the other operable units has been altered for purposes of this FS. The definition of Operable Unit 5 has been expanded to encompass all soil containing residual concentrations of contaminants currently within the boundaries of the other operable units which are not envisioned to be excavated as part of the selected or preferred remedy for those units. The Operable Unit 5 FS is revisiting these residuals for purposes of establishing final cleanup levels supportive of a site-wide future land use strategy. This expansion is assumed to include the following:

- Soil from 3 feet beneath and adjacent to the Operable Unit 1 waste pits
- Soil within the boundary of Operable Unit 2 but not excavated as part of the currently identified preferred remedy
- Soil surrounding and underlying Operable Unit 4 structures, with the exception of the soil determined to have high contaminant concentrations such that it will be treated with Operable Unit 4 source materials
- All soil presently stored in piles or drums at the site.

Extensive field investigations have been conducted at the site to define the horizontal and vertical extent of contaminated environmental media. Generally, these investigations have identified the following:

- Extensive radiological and chemical contamination of surface and subsurface soils within the former production area and (to a lesser extent) the waste pit area
- Large areas of surface soil exhibiting concentrations of radiological constituents (up to five times above background) on the FEMP property outside the production area, and on private property adjacent to the facility (just east of the Sewage Treatment Plant)
- Localized areas of concentrations above five times background concentrations at select on-property locations (outside the production area) and limited off-property locations
- Large areas of perched groundwater, contained in the glacial overburden above the underlying regional aquifer, located within the former production area and the waste storage area, exhibiting elevated levels (five times background concentrations) of radiological constituents and other hazardous substances
- Above-background concentrations of radiological constituents and other hazardous substances in the regional groundwater aquifer beneath the FEMP and extending along and beneath Paddys Run from the FEMP to its confluence with the Great Miami River (the affected area of the aquifer south of the FEMP has been termed the South Plume)
- Above-background concentrations of uranium in off-property soil within an approximate 2-mile radius from FEMP property.

1.1 PURPOSE AND NEED FOR DECISION

Facilities and environmental media at the FEMP site contain radioactive and chemical constituents at levels that exceed certain federal and state standards and guidelines for protecting human health and the environment. Currently, DOE maintains custody of the property and restricts access with fences and security forces, precluding a member of the public from being exposed to the more heavily contaminated areas on the site. A formalized risk assessment process has been established by the EPA to determine whether a given waste site warrants the implementation of cleanup actions. Under this process, several hypothetical scenarios that could expose members of the public to site contamination are examined. One of these scenarios assumes site access is not controlled (unrestricted) and a member of the public could be exposed to the more heavily contaminated areas. Results of the risk assessment performed for this hypothetical unrestricted access scenario indicate that if an individual established a residence within the heavily contaminated portions of the Operable Unit 5 study area under existing conditions, that individual would be subjected to an increased risk of incurring an adverse health effect. Risk assessment calculations performed for Operable Unit 5 indicate the projected level of increased risk exceeds established federal regulatory guidelines. On the basis of the results of the baseline risk assessment, the DOE concluded in the Operable Unit 5 RI

Report that existing site conditions warrant remedial action. Additional information on risk assessment can be found in Section 1.5.3 and the Operable Unit 5 RI Report (DOE 1995e).

The purpose of DOE's environmental restoration program is to preclude the potential for impact on human populations now and in the future by implementing long-term cleanup solutions. DOE is addressing long-term management of the FEMP site through the previously identified integrated environmental decision-making process.

The RI/FS site characterization and routine environmental monitoring programs provide information on the nature and extent of contamination, including information for areas off the FEMP property to which contaminants have migrated or could migrate in the future. The environmental monitoring program focuses on estimating the reasonable maximum exposure (RME) that current neighboring residents could potentially receive as a result of FEMP operational activities. The environmental monitoring program provides data that can be examined over long periods of time (i.e., months, years, and decades) to provide an early indication of any adverse change in environmental conditions. The FEMP environmental monitoring program will continue throughout the RI/FS decision process and during the period of remedy implementation to ensure the continued protection of the neighboring public.

1.2 ORGANIZATION OF THE REPORT

This report evaluates viable methods for removing the contaminated media through the application of excavation and extraction technologies, treating or disposing of removed media, and permanently dispositioning the affected media or treatment residuals at on-property or off-site locations. This report has been prepared consistent with the requirements of the Amended Consent Agreement, applicable project documentation, and available EPA guidance. Consistent with EPA guidance (1988a), the FS examines an appropriate range of potential remedial alternatives, from response actions considering only limited containment activities to remedial activities considering full contamination removal and reestablishment of near natural background conditions.

Each of the alternatives has been developed to the extent necessary to facilitate the fair comparison of these alternatives against established regulatory-based evaluation criteria. To establish a basis for the development of alternatives, the FS relies upon the data compiled for the RI Report. The best available assumptions, tending on the conservative side, have been employed in the FS to define the vertical and lateral extent of media affected by individual constituents of concern. Following selection of any of the remedial action alternatives presented in this report, additional characterization activities will be performed, as necessary, to verify the assumptions employed to establish the boundaries of contamination (i.e., remedial footprints) in this FS. Thus, the intent of this FS is not to determine whether or not action will be taken at a given location but to make the most supportable

decisions, on the basis of available data, to determine the boundaries of required action. It will be necessary to adjust these boundaries of remedial action during remedial design and remedial action implementation. Adjustment of these boundaries for the selected alternative will be completed on the basis of the progressive analysis of data collected during remedy design and implementation.

The NCP requires that nine criteria be met to develop the remedial alternatives to the extent necessary to support the fair comparison of these alternatives against established criteria in the FS. These criteria include the long-term effectiveness, reliability, implementability, and cost of any remedial system. These nine criteria help in evaluating the alternatives against each other to select the preferred alternative. This comparison is also summarized in the Operable Unit 5 PP. For evaluating cost, remedial alternatives are typically developed to the extent necessary to produce cost estimates for each alternative to a range of accuracy of +50 percent to -30 percent. The conceptual design level of information presented in this FS will be refined for the selected alternative following closer examination during the remedial design process.

Figure 1-2 presents a summary level flow diagram of the contents of the FS by section. This figure will be used throughout the report to remind the reader of where they are in the document and what issues are addressed by a given section.

The Operable Unit 5 FS, as identified in Figure 1-2, is organized in the following manner:

- The remainder of Section 1.0 presents a brief summary description of the history, scope and role of Operable Unit 5, integration with other operable units, and a general summary of the Operable Unit 5 RI Report. This section has been written to provide an overview for informed readers. Those readers requiring additional detail are directed to Appendix A of this report or to the Operable Unit 5 RI Report which is available in the Administrative Record.

- Section 2.0 discusses the development of preliminary cleanup levels, volumes, and footprints of affected media for use throughout the remainder of the report. Section 2.0 first discusses the derivation of risk-based and regulatory-based [applicable or relevant and appropriate requirements (ARARs) based] preliminary remediation goals (PRGs). Appendices B and C present a summary of the ARARs and the derivation of the risk-based PRGs, respectively. Section 2.0 summarizes the consideration of cross-media impacts (e.g., concentrations allowable in soil to be protective of perched groundwater) to modify the PRGs and the influences of natural background and analytical sensitivities to derive preliminary remediation levels (PRLs). Appendix F (Fate and Transport Modeling) provides supporting detail on the development of cross-media impact PRGs. The PRLs will be used throughout the report as the goals of cleanup for the remedial alternatives. On the basis of the PRLs, the areas termed footprints and the volumes of media affected at each preliminary cleanup level have been estimated. These footprints and volumes are used as the foundation for the cost and technical evaluation of remedial alternatives.

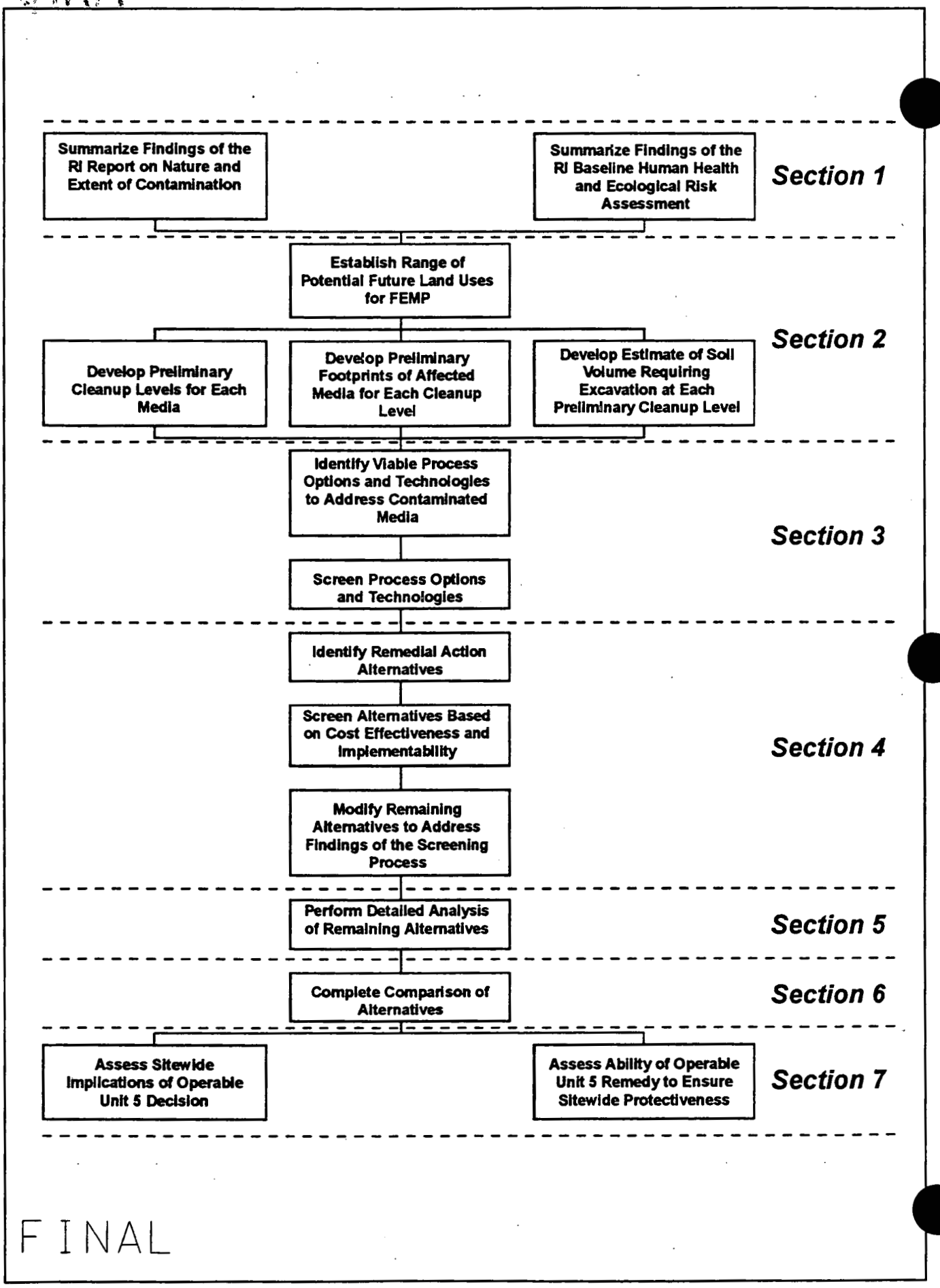


FIGURE 1-2. Flow Diagram of FS Contents by Section

- Section 3.0 discusses the results of identifying and screening technologies and process options. Additional details on the identification and screening process are available in Appendix M. Appendix E discusses the waste acceptance criteria (WAC), available off-property disposal facilities, and the results of Operable Unit 5 treatability studies.

- Section 4.0 explains the development and screening of alternatives and any modifications to the remedial alternatives following initial screening. For each remedial alternative, Section 4.0 summarizes the WAC for each constituent of concern (COC). The derivation of the WAC is provided in Appendix F. Additionally, Appendix F provides further detail on perched groundwater and groundwater remediation strategies.

- Section 5.0 provides an overview of alternatives, a more detailed description of the alternatives being considered, and performs an evaluation of the overall protectiveness of human health and the environment, compliance of each alternative with ARARs, long-and short-term effectiveness of the alternatives, reduction of mobility, toxicity, and volume through treatment, implementability, and cost for each individual alternative retained. Appendix B supports Section 5.0 by providing a detailed discussion of potential ARARs for each alternative. Appendix G provides a short-term risk assessment of the remedial alternatives discussed in Section 5.0. Appendices I and J assess NEPA cumulative impacts and potential wetlands/floodplain impacts, respectively, of Operable Unit 5 remedial activities for each alternative. Brief descriptions of cost estimates are given in Section 5; Appendix K contains a more detailed discussion of these estimates. Although sufficient detail is provided in Section 5.0 to familiarize the reader with each remedial alternative, a more detailed discussion of each alternative is provided in Appendix L.

- Section 6.0 presents a comparative analysis of the land use objectives, the residual risk level considerations, and the remedial alternatives with the nine criteria specified under CERCLA and NCP guidance.

- Section 7.0 discusses integration with other operable units (primarily the interaction of the Operable Unit 5 remedy decision with the Operable Unit 2 and Operable Unit 3 remedy selections) and the long-term residual risk implications of a site-wide remedy [Comprehensive Response Action Risk Evaluation (CRARE)]. Appendix H presents the CRARE for Operable Unit 5.

Because the English system is the traditional standard for geologic and geographic information at the FEMP, Operable Unit 5 RI/FS documents will use inches, feet, and miles throughout text, tables, and figures. The metric system is used by the laboratories testing and analytical reports for FEMP site samples. These data are entered in the database in metric units; therefore, all concentration units will be reported and discussed in metric units in the Operable Unit 5 FS. Also, because historical uranium production data was reported in metric units (kilograms and metric tons), this convention will be maintained.

A list of the most often used terms in this FS is provided in Section 2.0.

1.3 SCOPE AND ROLE OF OPERABLE UNIT 5

This section discusses the scope and role of Operable Unit 5 as it pertains to the FEMP RI/FS process, the RD/RA process, and the removal action process.

1.3.1 History of the FEMP as an NPL Site and Basis for Listing

The FEMP was placed on the NPL on November 21, 1989. The NPL is found in Appendix B of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. CERCLA requires the NCP include a list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and that the list be revised at least annually. The NPL, originally promulgated on September 8, 1983 (48 FR 40658), constitutes this list.

The Hazard Ranking System (HRS) is one of three mechanisms for listing sites on the NPL. The other two methods include state designation on the Master's Site List and EPA designation. The HRS serves as an objective screening device to evaluate the relative potential of uncontrolled hazardous substances to cause human health or safety problems, or ecological and environmental damage. The HRS score represents an estimate of the relative probability and magnitude of harm to the human population or sensitive environment from exposure to hazardous substances as a result of the contamination of groundwater, surface water, or air. Sites that score 28.50 or greater on the HRS are eligible for the NPL. HRS scores are not sufficient to determine either the extent of contamination or the appropriate response for a particular site.

The HRS for the FEMP exceeded the 28.50 score primarily because the FEMP is located above a Class I aquifer (the Great Miami Aquifer). The definition of a Class I aquifer states that the aquifer is an irreplaceable, irrevocable source of drinking water and allows zero degradation to this sole-source potable water supply. The Great Miami Aquifer is also a federally designated sole-source aquifer which means it provides the only drinking water for the entire watershed.

Under CERCLA, each state may designate a single site as its top priority, regardless of the HRS score. EPA may also list sites if all of the following occur: the Agency for Toxic Substances and Disease Registry (ATSDR) recommends dissociation of individuals from the release; if EPA determines that the release poses a significant public health threat; and if EPA anticipates that it would be more cost effective to use remedial rather than removal authorities for cleanup.

The identification of a site for the NPL assists EPA in determining which sites warrant further investigation to assess the nature and extent of the public health and environmental risks associated with the site and to determine what CERCLA-financed remedial action(s), if any, may be appropriate. The NPL also serves to notify the public of sites that EPA believes warrant further investigation.

1.3.2 Scope of Operable Unit 5

Operable Unit 5 can be described as the environmental media operable unit, as distinguished from the other operable units which are considered to be sources of contamination. Operable Unit 5 addresses environmental media, both on and off FEMP property, which has been contaminated as a result of releases from operational activities associated with the FEMP. The site, as defined by the Amended Consent Agreement, includes all areas within the property boundary of the FEMP and any other areas that received or potentially received releases of hazardous substances, pollutants, contaminants, or hazardous constituents.

The Operable Unit 5 RI Report contains an ecological risk assessment (Appendix B) that examines the potential baseline risks to ecological receptors across the FEMP site, including the Great Miami River. The conclusions of this assessment have been factored into the derivation of PRLs for each of the remedial alternatives considered in this FS.

The Operable Unit 5 RI was performed to characterize the extent and concentrations of contaminants in environmental media, the mechanisms for transport of these contaminants through the environment, and the viable pathways of exposure to human or environmental receptors. The media or pathways addressed by the Operable Unit 5 site investigations included:

- Surface and subsurface soils on and off the FEMP property
- Surface water and sediment in on- and off-property drainage ditches, Paddys Run, and the Great Miami River
- Water quality and flow characteristics of the perched groundwater system on the FEMP property
- Regional groundwater quality and flow characteristics in the Great Miami Aquifer under and off the FEMP property
- Air quality on and off the FEMP property
- Direct radiation fields on, and immediately adjacent to, the FEMP property
- Surface water infiltration to the Great Miami Aquifer and to on-property perched groundwater zones
- Terrestrial ecology on the FEMP property and adjacent areas
- Aquatic ecology in Paddys Run, the Great Miami River, and wetlands on FEMP property.

In general, releases to air and water historically occurred from a variety of sources including production-related stacks and equipment, underground piping, waste storage containers, and pits on the FEMP property. Cessation of production and the implementation of mitigative measures at the facility have significantly reduced ongoing releases from these sources. Final cleanup of these sources is being addressed as part of Operable Units 1 through 4. These releases have resulted in contamination of environmental media surrounding each of these sources. This existing contamination in the media can also be considered a secondary source in that the contaminants present continue to move through the environment, confined only by the limits imposed by the forces of nature. Contaminants residing on surface soil are available for resuspension and transport by wind as dust particles, movement to surface water channels by contact with rainfall, or vertical transport through the soil column to underlying groundwater systems. In each of the environmental media on site, viable mechanisms for transport through the environment, and exposure pathways to receptors are the focus of the Operable Unit 5 RI/FS process.

1.3.3 Role of Operable Unit 5 Within the FEMP RI/FS Process (Integration of Operable Unit 5 With Other Operable Units)

A diagram providing an overview of the RI/FS process as it is being implemented at the FEMP site is presented in Figure 1-3. While the operable unit concept provides a management strategy to expedite the cleanup process at a site, the concept does not negate the statutory requirement to ensure protection of human health and the environment from a site-wide perspective. To ensure site-wide protectiveness, the Amended Consent Agreement provides for a CRARE within each operable unit FS. The intent of the CRARE process is to provide information regarding the residual risk projected to remain at the site following implementation of remedial actions at the four other operable units, in conjunction with the contribution of residual risk attributable to Operable Unit 5 alternatives. The intent of this process is to provide decision makers with a perspective of the potential for a given remedial alternative, when coupled with projected actions for the other operable units, to effectively contribute to the protection of human health and the environment on a site-wide basis.

To complete the CRARE (Appendix H), the preferred alternatives identified in the draft or final PPs for Operable Units 1, 2, and 4 and the leading remedial alternative (LRA) for Operable Unit 3 were used in conjunction with a representative alternative selected from the array evaluated for Operable Unit 5. The LRA for Operable Unit 3, previously identified in the Site-Wide Characterization Report (DOE 1993e), represents the remedial option which, on the basis of available data, is the most likely to be implemented. The CRARE process and the use of the preferred alternatives for Operable Units 1, 2, and 4, a representative alternative for Operable Unit 5, and the LRA for Operable Unit 3 should not be considered a preselection of alternatives for implementation in advance of the formal RI/FS decision-making process. All necessary site investigations have been completed for Operable Unit 5 and the final RI Report was issued in March, 1995.

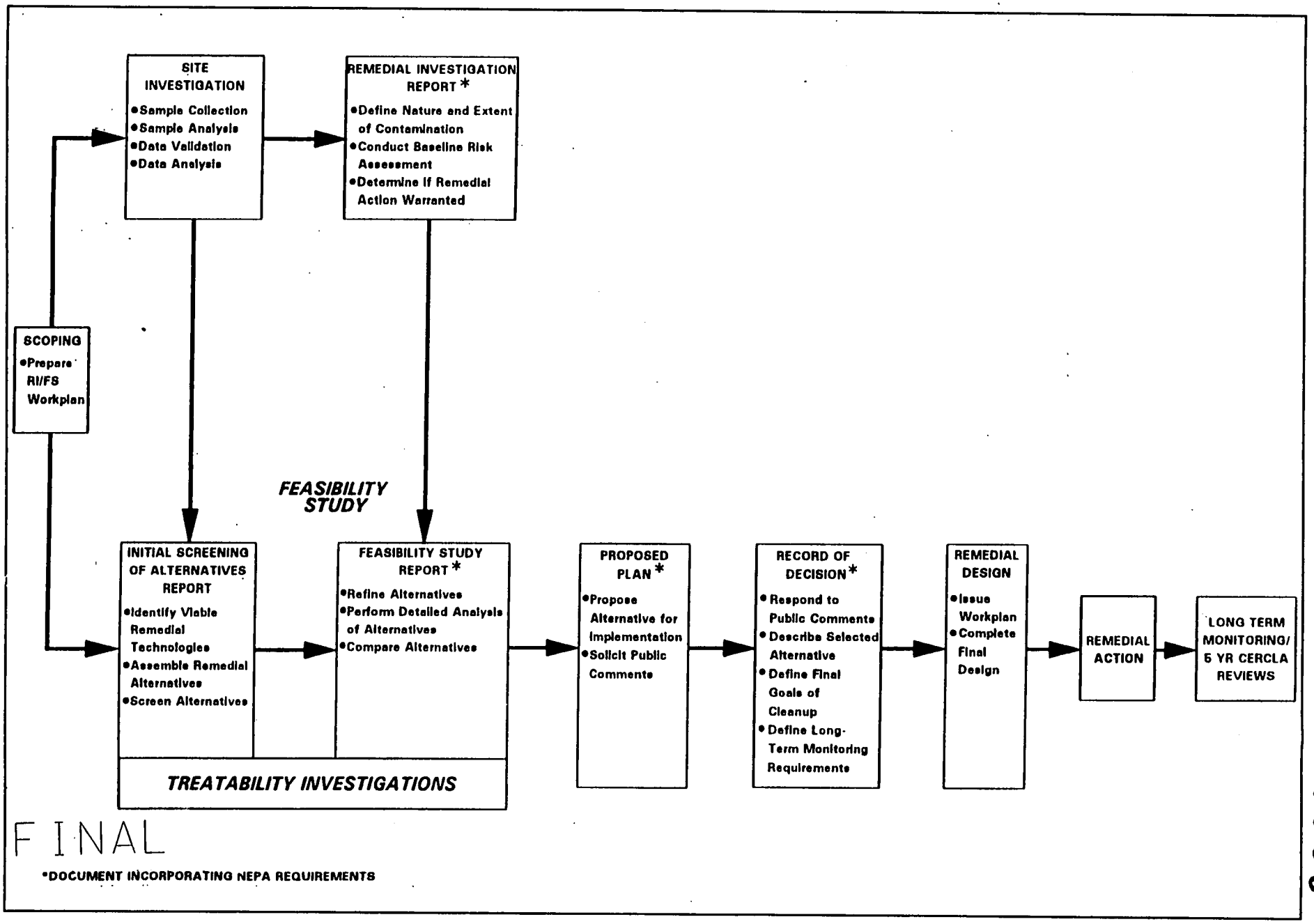


FIGURE 1-3. FEMP ENVIRONMENTAL RESTORATION PROCESS

000059

7069

Discrete data points were collected as part of these investigations to characterize the nature and extent of contamination in environmental media at the site; the results of the data analyses are summarized in Sections 1.5.2.2 and Appendix A. In November 1992, the Treatability Study Work Plan for Operable Unit 5: Soil Washing (DOE 1992b) was issued describing planned bench- and pilot-scale testing to assess treatment technologies pertinent to addressing contaminated soil. A summary of the results of soil treatability studies performed for Operable Unit 5 is presented in Appendix D.

In March 1993, the Operable Unit 5 Initial Screening of Alternatives (ISA) Report (DOE 1993d) was submitted to DOE and EPA. The ISA report summarizes viable remedial technologies potentially applicable to Operable Unit 5. Viable technologies were assembled into remedial alternatives and screened to remove inappropriate alternatives. The approved ISA Report was used as the foundation for the development of Sections 3.0 and 4.0 of this FS.

All soil at the FEMP not contemplated to be exhumed as part of a remedy for Operable Units 1 through 4 are considered within the scope of this FS. Soil considered include soil under and adjacent to the waste pits, burn pit, and Clearwell (Operable Unit 1); soil within Operable Unit 2 but outside the proposed on-property disposal facility; soil underlying and adjacent to the K-65 silos including the earthen berms (Operable Unit 4); and soil presently stored in piles and containers in or near the former production area (Operable Unit 3). This approach has been adopted to allow the examination of soil on a site-wide basis such that comprehensive remedial alternatives can be formulated and evaluated and is consistent with presentations in the FS reports for Operable Units 1, 2, and 4. The RODs for Operable Units 1 and 4 and the PP for Operable Unit 2 establish operable unit-specific soil remediation levels that are being revisited by Operable Unit 5; they will be revised to adopt final remediation levels identified in the Operable Unit 5 ROD in the event these levels are more restrictive.

The Operable Unit 5 RI/FS process has examined perched groundwater on a site-wide basis. It should be noted, however, that the Amended Consent Agreement provides that each operable unit address perched groundwater envisioned to be encountered as a consequence of conducting remedial action. An example of such an incidence is the collection of perched groundwater in deep excavations completed to remove underground tank systems (K-65 decant sump), pits, or foundations. This collected water will be directed to Operable Unit 5 wastewater treatment systems. All soil not considered for remediation by other operable units will be managed by Operable Unit 5.

Process wastewaters generated by remedial actions conducted by all operable units will be directed to Operable Unit 5 treatment systems. Operable Unit 5 will establish pretreatment requirements to ensure that available treatment capabilities will not be exceeded by incoming wastewater streams. These projected process wastewater streams have been factored into each of the Operable Unit 5

remedial alternatives presented in this report. Additionally, the Operable Unit 5 remedial alternatives consider the handling and treatment, if required, of site-wide storm water. Pretreatment requirements will be established during remedial design.

1.3.4 Remedial Design/Remedial Action Process (RD/RA)

The RI/FS process is focused on developing technical data associated with remedial alternatives to the extent necessary to support a fair and unbiased evaluation of each of the alternatives against criteria established by federal guidelines. The alternative development process is typically completed at a conceptual level. While developing alternatives to this extent in the FS is sufficient to support remedy selection, a significant level of additional detail is required for the field implementation of the selected alternative. The process to provide this additional detail on the selected alternative is termed remedial design (RD). The purpose of RD is to complete the necessary engineering designs, specifications, and bid packages to enable the safe and cost-effective implementation of the selected alternative.

The Amended Consent Agreement specifies that a RD work plan be submitted by the DOE 60 days after finalization of the ROD for each of the operable units. The work plan is to contain a schedule for completion of RD and establish the interrelationship among DOE, EPA, and Ohio EPA regarding the design review and approval process. The RD process will revisit the conceptual plans outlined in the FS for the selected alternative and make the necessary refinements and improvements to increase the level of technical detail to enable the implementation of the alternative. Such refinements will include reanalyzing the proposed process flow diagrams, material balances, and fundamental technical assumptions underlying the selected alternative, without jeopardizing its goal of protecting human health and complying with established regulations.

The Amended Consent Agreement also requires the DOE to submit to EPA for approval the remedial action (RA) work plan. The schedule for submittal of the RA work plan is to be established through the approved RD work plan. The RA work plan will include, but not be limited to, the following: a sampling and analysis plan which includes a quality assurance plan and a field sampling plan; a health and safety/contingency plan; a plan for satisfaction of permitting requirements, if any; a groundwater monitoring plan; and an operations and maintenance plan. This work plan will also define the interrelationship among the DOE, the EPA, and the OEPA regarding the review and oversight of remedy implementation. Under CERCLA, remediation activities are required to begin within 15 months after approval of the ROD and progress continuously from that time.

1.3.5 Removal Action Process

Removal actions, as discussed in Part 40 CFR 300.415, are primarily intended to abate, minimize, stabilize, mitigate, or eliminate a release of hazardous substances, pollutants, or contaminants before

implementing a final remedial action. These actions are typically initiated during the RI/FS before the issuance of a ROD to accelerate cleanup actions to address releases of hazardous substances. Under the terms of the Amended Consent Agreement and in accordance with authorities granted to DOE under Section 106 of CERCLA by Executive Order 12580, a number of removal actions and other abatement measures have been completed, or are underway, at the FEMP to reduce discharges of hazardous substances to Paddys Run and the Great Miami River. These actions have been (or are being) implemented as best management practice initiatives or to achieve compliance with DOE Orders or state discharge limits.

The following paragraphs briefly describe several of these removal and abatement actions. Additional detail of the projects may be obtained from the Operable Unit 5 RI Report and the Administrative Record.

Contaminated Water Beneath FMPC Buildings (Removal Action No. 1). This removal action was initiated to minimize the potential for uranium-contaminated groundwater to continue to infiltrate the underlying aquifer from perched groundwater located beneath selected former production facilities (Plants 2/3, 6, 8, and 9). A series of recovery wells were installed in and around these plants to extract the perched groundwater for treatment of volatile organic compounds through the Plant 8 granular activated carbon treatment system. The water is then processed through the FEMP's existing water treatment system for uranium removal and eventually discharged to the Great Miami River. Treatment of perched groundwater will continue in this manner until the advanced waste water treatment (AWWT) system is operational and replaces this function in 1995.

Waste Pit Area Runoff Control (Removal Action No. 2). This removal action involved the installation of a runoff control system to collect storm water runoff from the waste pit area (approximately 26 acres, including the Operable Unit 4 study area) and direct the runoff through treatment systems at the FEMP site before discharge to the Great Miami River. Storm water sampling initiated in the late 1980s indicated that significant concentrations of radionuclides were flowing to Paddys Run in storm water runoff from areas surrounding the waste pits that did not flow to the Clearwell.

The removal action consisted of a series of trench drains, curbs, gutters and storm sewers that direct the storm water runoff from the waste pit perimeter areas to a central collection sump. From the sump, the runoff is pumped to a lagoon for treatment and discharge. This removal action was completed in the summer of 1992.

South Groundwater Contamination Plume (Removal Action No. 3). An engineering evaluation/cost analysis (EE/CA) was prepared by the FEMP to support the identification of the most feasible

alternative to prevent or minimize the further migration of contamination within the South Plume. On the basis of the EE/CA results, the following actions were taken:

- Part 1 - An alternate water source was completed to supply potable and process water to an industry affected by the South Plume

- Part 2 - A groundwater recovery well system was completed to extract and pump groundwater from the South Plume through a force-main pipeline back to the FEMP for monitoring and subsequent discharge to the Great Miami River. The groundwater recovery well system became operational on August 27, 1993. A new effluent outfall line was also installed under Part 2. The new pipeline parallels the original outfall line to the Great Miami River. Other Part 2 work included increasing the effluent capacity at the storm water retention basin (SWRB) to reduce the potential for future overflow of the basin. The operation of the new outfall line and recovery well system have been taken into consideration in the configuration of all remedial action alternatives.

- Part 3 - An interim advanced wastewater treatment (IAWWT) system was constructed to remove additional uranium from site wastewater streams and thereby reduce the amount of uranium discharged to the Great Miami River. This treatment capacity compensates for the additional discharges of uranium from the South Plume and other removal actions. This system became operational in July 1992.

- Part 4 - Groundwater monitoring and institutional controls were put in place to prevent use of contaminated groundwater. This activity continues to be implemented through the FEMP's groundwater monitoring program, including frequent monitoring of private wells located near areas of known contamination.

- Part 5 - Additional groundwater investigations were completed in the vicinity of the South Plume to identify the location and extent (the leading edge of the plume) of any remaining contamination attributable to the FEMP in the groundwater downgradient (south) of the recovery wells installed under Part 2 of this removal action. The information gained as part of this investigation has been incorporated into the RI Report and has been condensed in this FS.

Collect Uncontrolled Production Area Runoff (Removal Action No. 16). This removal action included the installation of drainage control structures and regrading to control storm water runoff from the production area perimeter. Storm water from these areas was redirected to the existing storm water system and the SWRB. This removal action was completed in August 1993.

South Plume Interim Treatment. As part of an agreement with DOE to conduct a supplemental environmental project to reduce uranium discharges from the FEMP to the Great Miami River, one additional IAWWT unit was installed at the FEMP site to treat 200 gallons per minute (gpm) of water of South Plume discharge. The operating life of the original IAWWT at the SWRB will be extended and converted to treat additional South Plume water instead of storm water which will be treated at

the AWWT facility beginning in January 1995. Treatment capacities and additional details of the project are discussed in the Operable Unit 5 RI Report.

Advanced Wastewater Treatment System. Construction of the AWWT plant was initiated to achieve compliance with DOE Order 5400.5. The plant consists of two treatment trains, each unit consisting of clarification with flocculation, filtration, carbon filtration, and ion exchange. The AWWT will treat approximately 1200 gpm of storm water, wastewater, future remediation wastewater flow, and South Plume groundwater. The AWWT became operational in January 1995.

Storm Water Retention Basin. Consistent with the terms of the Ohio Directors Finding and Orders (DFOs), the FEMP constructed a SWRB to provide retention for production area and parking lot runoff of a 10-year, 24-hour duration storm event. The system consists of a two-chamber basin with a total retention capacity of 10 million gallons. The west chamber of the basin was operational in December 1986 and the second chamber in December 1988. Storm water is pumped to the IAWWT facility prior to monitoring and subsequent discharge to the Great Miami River through the FEMP outfall line. Beginning in 1995, the storm water collected in the SWRB will be treated at the AWWT.

Surface Water Control of the Plant 1 Pad. Prior to the initiation of this project in 1988, the majority of storm water runoff in the Plant 1 Pad area flowed west through the waste storage area and into Paddys Run. The Plant 1 Pad was modified to include a curb around its periphery; additionally, flow in drainage ditches in the vicinity was reversed or blocked and several new connections to the existing storm sewer system were installed. Collected storm water is directed to the SWRB.

Pilot Plant Warehouse Sump. Historically, storm water discharges from the southwest corner of the former production area (the area surrounding the pilot plant) were discharged to a drainage ditch directly west of the pilot plant and subsequently to Paddys Run. It is assumed this was done because the topography would not allow gravity flow to the storm sewer system which discharged to the storm sewer outfall ditch (SSOD). In 1962, the runoff in this drainage ditch was found to contain elevated levels of radionuclides. Actions were taken to collect this flow and pump it to the general sump for treatment.

It was noted several times the pumping system was not operating. In 1989, actions were taken to investigate the flows discharging to the sump. In October 1991, the sump overflow was plugged but the pump was not operational. It is suspected that water accumulating in the sump and in the saturated ground surrounding the sump continued to migrate to the overflow line by seeping around the plug or by flowing directly into the line downstream of the plug. In May 1994 the pump was repaired and tested and began operating by late Summer.

A more thorough discussion of the existing and planned configuration of the FEMP wastewater treatment system can be found in Appendix L in the groundwater treatment component description.

1.4 INTEGRATION OF OPERABLE UNIT 5 WITH OTHER REGULATORY/DECISION PROCESSES

Planned actions at the FEMP site involve many complex technical and regulatory issues. To facilitate the preparation of this document and support an efficient and cost-effective remedial action program, the CERCLA response action process for Operable Unit 5 has been integrated with several other regulatory processes, as well as specific aspects of the response actions for other operable units. The regulatory processes include interface with State of Ohio programs for the management of hazardous waste and underground storage tanks. Coordination with the response actions for the other operable units includes the approach to manage contaminated soil, perched groundwater, storm water, and remediation process wastewater in an integrated manner. Details of Operable Unit 5 integration activities are provided in Section 7.0.

1.4.1 Integration of the Operable Unit 5 RI/FS with NEPA

As previously stated, it is DOE policy to integrate NEPA requirements into the procedural and documentation requirements of CERCLA, wherever practicable. This policy is embodied within DOE Order 5400.4 defining the roles and responsibilities of the Department regarding compliance with CERCLA and the integration of the remedial process with NEPA. It is not DOE's intent to make a determination about the applicability of NEPA to CERCLA. In accordance with this policy, a Notice of Intent (NOI) was published on May 15, 1990, in the Federal Register (55 FR 20183) indicating the intent on the part of the DOE to prepare an EIS to evaluate the environmental impacts associated with planned cleanup activities at the site. Two scoping meetings were held in potentially affected communities located near the FEMP on June 12 and 13, 1990.

Consistent with the NOI, the FS for the lead operable unit (Operable Unit 4) has been issued as a Feasibility Study/Proposed Plan (FS/PP) written to incorporate NEPA values at the level of an EIS, resulting in an integrated FS/PP-EIS. The Operable Unit 4 RI Report and the Site-Wide Characterization Report have been incorporated into the FS/PP-EIS by reference. These documents support both the description of the affected environment and the impact analysis of the site-wide no-action alternative required in an EIS. As identified in the NOI, the RI/FS documents for the remaining operable units (Operable Units 1, 2, 3, and 5) have been written to include the NEPA values and tier from the Operable Unit 4 FS/PP-EIS. This approach is consistent with the Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act, as codified by 40 CFR 1502.20.

The CERCLA/NEPA integration strategy is outlined in the Implementation Plan for the NEPA/CERCLA integration activities at the FEMP which was finalized in January 1993, and placed in the Administrative Record and the Information Repository at the FEMP Public Environmental Information Center. The purpose of the Implementation Plan is to record the results of the scoping process and to provide guidance to DOE for the preparation of the lead FS/PP-EIS for Operable Unit 4 and the CERCLA/NEPA documents for the remaining operable units.

Subsequent to the issuance of the Implementation Plan, DOE issued revised guidance regarding its policy for sites undergoing CERCLA investigations to eliminate the administrative requirement of preparing NEPA documentation. The revised policy, "Secretarial Policy Statement of National Environmental Policy Act," identified that only the values of NEPA need to be evaluated in the development of CERCLA RI/FS documentation. The new policy allows DOE to rely on the CERCLA process to satisfy the procedural aspects of NEPA. Therefore, DOE has supplemented the evaluations contemplated by RI/FS guidance to accommodate the evaluation of NEPA values in the preparation of this FS.

The RI Report for Operable Unit 5 contains specific characterization data for environmental media that supports the description of the affected environment for NEPA purposes. In addition, the RI Report contains a baseline risk assessment addressing the impact on human health that would be associated with the no-action alternative for Operable Unit 5. The preliminary baseline ecological risk assessment contained in the Site-Wide Characterization Report addresses the entire FEMP and is based on data collected in each operable unit before December 1991. Since then, new ecological data have been collected and a revised site-wide ecological risk assessment was included in the Operable Unit 5 RI Report.

This FS Report contains the NEPA environmental impact analysis as part of the detailed analysis of each remedial alternative. The evaluation of environmental impacts will include a discussion of the impacts to biotic resources, socioeconomics, cultural resources, wetlands, and floodplains. The NEPA impact analysis is factored into the Detailed and Comparative Analysis of Alternatives presented in Sections 5.0 and 6.0 of the FS Report and the identification of the preferred alternative in the PP.

A baseline Cumulative Environmental Impact Analysis was included in the Operable Unit 4 FS/PP-EIS for the purpose of assessing the potential cumulative impacts associated with the implementation of remedial actions at all of the operable units. This analysis employed representative remedial alternatives for each of the operable units because the evaluation preceded the CERCLA decision process for these units. A revised representative remedial alternative was identified from the array of alternatives considered in this FS report for purposes of updating this cumulative

environmental impact analysis. This FS Report has been supplemented to incorporate this updated cumulative environmental impact analysis (Appendix I). A list of the agencies consulted and contributors to the document can also be found in Appendix I. In addition, a floodplain/wetland assessment completed pursuant to the requirements of 10 CFR Part 1022 has been prepared and attached to this report as Appendix J.

1.4.2 Interaction of the Operable Unit 5 RI/FS with Other Regulatory Processes and Requirements

The Operable Unit 5 FS must integrate other regulatory processes and requirements into the document. These processes include integration with the Federal Facility Compliance Act, the State of Ohio Hazardous Waste Management Program, the Ohio Underground Storage Tank Program, and the Fernald Citizens Task Force. The following paragraphs discuss Operable Unit 5 interaction with these processes.

1.4.2.1 Integration of Operable Unit 5 with the Federal Facility Compliance Act

To fully evaluate the alternatives proposed in the Operable Unit 5 FS, consideration of the Federal Facility Compliance Act must also be taken into account. The DOE is required by the Resource Conservation and Recovery Act [RCRA (Section 3021 (6))], as amended by the Federal Facility Compliance Act (the Act), to prepare the plans describing the development of treatment capacities and technologies for treating mixed waste. The Act requires site treatment plans (STPs) to be developed for each site at which DOE generates or stores mixed waste. These STPs are then submitted to the state or EPA for approval. The FEMP conceptual STP is the preliminary version of the proposed plan required by the Act and has been submitted to the State of Ohio, EPA, and others for review.

The Act, signed on October 6, 1992, grants no sovereign immunity for fines and penalties for RCRA violations at federal facilities. However, a provision waives the effective date for three years from the enactment of the statute for mixed waste land disposal restriction (LDR) violations at DOE sites and requires DOE to prepare plans for developing the required treatment capacity for mixed waste. The Act further provides that DOE will not be subject to fines and penalties for LDR violations for mixed waste as long as it is in compliance with an approved plan and order.

The STPs must address all mixed waste at the site, regardless of the time of generation. The plan must provide a schedule and milestones for constructing the necessary treatment capacity, for which identified treatment technologies exist. For mixed waste without an identified existing treatment technology, the plan must include a schedule for identifying and developing technologies.

Two additional reporting activities are also required under the Act: the Mixed Waste Inventory Report and a schedule for submitting plans for treatment of mixed wastes generated/stored at each site. The Mixed Waste Inventory Report provides an inventory of mixed waste streams stored, generated, or

expected to be generated over the next five years and treatment capacities and technologies. The schedule for submitting plans was published April 6, 1993 (58 FR 17875) and specifies that DOE sites will provide STPs in three phases: conceptual (October 1993), draft (August 1994), and final proposed (February 1995). The conceptual STP identifies treatment needs, capabilities, and options for treating the site's mixed waste. The draft STP identifies DOE's preferred option for treating mixed wastes, as well as providing proposed schedules for constructing treatment capacity. The final proposed STP will be submitted to the state and/or EPA for review and approval.

Contaminated soil and sediment or treatment residuals exhibiting characteristics of hazardous waste, containing a listed hazardous waste, or exceeding PRG concentration levels are anticipated to be encountered or generated during remedial actions associated with Operable Unit 5. This FS discusses treatment plans and technologies to address these materials to render it acceptable for on- or off-property disposal. In the event appropriate alternate treatment capabilities are developed in response to the Act at the FEMP and are available in a timeframe supportive of the Operable Unit 5 remedial activities, the DOE proposes to preferentially use these capabilities to address the affected Operable Unit 5 media volumes.

1.4.2.2 Integration With Natural Resource Trustee Activities

Under CERCLA and the NCP, DOE is required to act as a Trustee for natural resources at its federal facilities. These same documents also appoint other departments, such as the U.S. Department of the Interior (DOI) and state representatives, as Trustees for natural resources. The Trustees' role is to act as guardian for natural resources at or near the site.

The DOE has contacted and met with trustee representatives from the U.S. Fish and Wildlife Service (on behalf of DOI) and the OEPA. The Trustees are working together to plan future efforts to avoid or mitigate impacts to natural resources at the Fernald site. The Trustees will be examining each of the operable units' preferred remedial alternatives and RODs for potential avenues of resource protection.

1.4.2.3 RCRA/CERCLA Integration With State of Ohio Hazardous Waste Management Program

A statutory framework for the treatment, storage, and disposal of hazardous waste was established by RCRA. The State of Ohio, through its designated agency the OEPA, has authorization by EPA to enforce most provisions of RCRA regulations for facilities within Ohio, including the FEMP. The FEMP continues to store inventories of hazardous waste which also contain above-background concentrations of radiological constituents (termed mixed waste). These mixed-waste inventories remain due to limited or nonexistent treatment and disposal capacity nationwide. Pursuant to the terms of federal rulemaking, the hazardous waste component of mixed waste is to be managed under RCRA. As a result of this rulemaking and the lack of disposal alternatives, the FEMP continues to

seek the issuance of a Part B permit from the State of Ohio as interim status facilities for the storage of these mixed wastes under the terms of Ohio's hazardous waste regulations.

The OEPA has RCRA authority for the operation and closure of hazardous waste treatment, storage, and disposal units [termed hazardous waste management units (HWMUs)] at the FEMP. The term HWMU is defined in 40 CFR 260.10 as "a contiguous area of land on/in which hazardous waste is placed, or the largest area in which there is significant likelihood of mixing hazardous waste constituents in the same area." A similar definition of HWMUs is contained in the Ohio Administrative Code (OAC 3745-51).

A Part B permit application for the FEMP was submitted to the State of Ohio in 1989; this permit identified 53 HWMUs at the FEMP. In March 1993 the FEMP submitted a revised Part B permit application to the State of Ohio for the storage of hazardous waste and for the operation and closure of 7 HWMUs at the FEMP (Table 1-1; the 54th unit, Tank T-2, was added as a HWMU in September, 1994). This permit application identified that 46 of the HWMUs are not actively being used. Following the submittal of the Part B permit application, seven HWMUs were reclassified as solid waste management units (SWMUs) in 1993. In addition, the Hilco oil recovery, primary calciner, and wheelabrator are pending reclassification from HWMUs to SWMUs based on reevaluation of information associated with the units and OEPA concurrence. The experimental treatment facility, and Waste Pit 5 are currently pending reclassification upon analysis of the contents of these units and concurrence with the State of Ohio for reclassification.

Twenty of the remaining 43 units are proposed to be closed concurrently with the CERCLA remediation process pursuant to a Director's Findings and Orders (DFO) which is currently in negotiation. The DFO reflects an integrated process, coupling OEPA hazardous waste regulations with the CERCLA response action process. The DFO would be signed by the Director of the OEPA and the DOE. The DFO is also expected to address the approach to attain final clean closure of the 20 HWMUs discussed above and document the intent to no longer seek a permit of the 7 remaining active HWMUs at the FEMP. In addition, this integrated process will be achieved in conjunction with the conduct of remedial action for both Operable Units 3 and 5. If successful, the HWMUs described in the DFO will be closed based on two reasons: a HWMU is not capable of being removed without decommissioning larger areas of the facility first, and limited or extensive environmental media contamination may be the result of releases from a HWMU. Five of the 20 remaining HWMUs will be delayed for closure until remediation under CERCLA due to the physical limitations described above. The remaining 15 units are proposed for reevaluation under the CERCLA process due to possible association with media contamination. Table 1-1 identifies each

TABLE 1-1
FEMP HAZARDOUS WASTE MANAGEMENT UNITS

No.	Unit Description	Type of Unit	Hazardous Wastes Managed in Unit [a]	Approximate Dimensions	Operational Status	Closure Status	Closure Strategy [b]	Basis for Adopted Closure Strategy
1	Fire training facility	Disposal	Listed (F002, F003)	105 ft x 134 ft; 85 ft x 68 ft	Inactive	RAWP/CPID submitted 06-Aug-93	Attain closure through CERCLA response	Potential media contamination
2	Parts cleaner in Welding Shop (Building 12)	Reclassified to SWMU	N/A	4 ft x 6 ft x 6 ft	Inactive	N/A	N/A	N/A
3	Waste oil storage at garage	Storage	Listed (F001)	10 ft x 10 ft	Inactive	CPID resubmitted 16-Feb-95	Clean close under RCRA	Limited or no potential for media contamination
4 [a]	Drum storage area near loading dock (lab)	Storage	Various	76 ft x 22-40 ft	Inactive	Revised CPID submitted 02-Mar-94	Clean close under RCRA	Limited or no potential for media contamination
5 [a]	Drum storage area south of W-26 (lab)	Storage	Various	32 ft x 41 ft	Inactive	CPID submitted 08-Oct-92; requested closure under CERCLA via letter 17-Feb-1995	Propose to attain closure through CERCLA response	Potential media contamination
6 [a]	Drummed HF residue storage area inside Plant 4	Storage	Listed (U134)	4 ft x 17 ft	Inactive	Closure work completed; Closure Certification submitted 24-Jan-94	Clean close under RCRA	Limited or no potential for media contamination
7	Drummed HF residue storage area NW of Plant 4	Storage	Listed (U134)	25 ft x 30 ft	Inactive	CPID withdrawn 2-May-94; to be replaced with Administrative closure	Clean close under RCRA	Limited or no potential for media contamination
8	Drummed HF residue storage south of cooling tower	Storage	Listed (U134)	14 ft x 40 ft x 15 ft	Inactive	CPID withdrawn 2-May-94; to be replaced with Administrative closure	Clean close under RCRA	Limited or no potential for media contamination

000020

TABLE 1-1 (Continued)

No.	Unit Description	Type of Unit	Hazardous Wastes Managed in Unit [a]	Approximate Dimensions	Operational Status	Closure Status	Closure Strategy [b]	Basis for Adopted Closure Strategy
9 [a]	Nitric acid rail car and area	Storage	Characteristic (D002)	10 ft wide x 40 ft long x 15 ft high	Inactive	Closure work completed; closure certification submitted 31-Oct-94	Clean close under RCRA	Limited or no potential for media contamination
10 [a]	NAR system components	Storage	Characteristic (D002/D007)	13,262 ft^2	Inactive	CPID submitted 30-Jun-93	Attain closure through CERCLA response	Potential media contamination
11	Tank farm sump	Treatment	Characteristic (D002)	165 ft x 135 ft	Inactive	TBD	Attain closure through CERCLA response	Potential media contamination
12	Wheelabrator (Building 66) [c]	Storage	Characteristic (D006)	24 ft x 20 ft	Inactive	TBD	Attain closure through CERCLA response	Unit removal better addressed in conjunction with CERCLA response
13	Wheelabrator dust collector	Storage	Characteristic (D006)	30 ft x 17 ft	Inactive	CPID submitted 18-Jul-94	Clean close under RCRA	Limited or no potential for significant media contamination
14	Box furnace	Treatment	Characteristic (D005/D007/ D008/D011); listed (F001/F002)	18 ft x 14 ft	Inactive	TBD	Attain closure through CERCLA response	Potential media contamination
15	Oxidation furnace #1	Treatment	Characteristic (D005/D008); Listed (F001)	85 ft^2	Inactive	TBD	Attain closure through CERCLA response	Unit removal better addressed in conjunction with CERCLA response
16	Primary calciner [c]	Treatment	Listed (F001/F002)	13.5 ft diam. x 40 ft high	Inactive	TBD	Attain closure through CERCLA response	Unit removal better addressed in conjunction with CERCLA response
17 [a]	Plant 8 east pad	Storage	Various	18,300 ft^2	Inactive	TBD	Attain closure through CERCLA response	Potential media contamination

TABLE 1-1 (Continued)

No.	Unit Description	Type of Unit	Hazardous Wastes Managed in Unit [a]	Approximate Dimensions	Operational Status	Closure Status	Closure Strategy [b]	Basis for Adopted Closure Strategy
18 [a]	Plant 8 west pad	Storage	Various	4,500 ft^3	Inactive	TBD	Attain closure through CERCLA response	Potential media contamination
19 [a]	CP storage warehouse	Storage	Various	50 ft x 180 ft	Active	In Section I of Part B 29-Mar-93	Attain closure through CERCLA response	Unit will be used during CERCLA response action
20 [a]	Plant 1 storage pad	Storage	Listed (F002, F003) Characteristic (D005, D008)	480,000 ft^2	Active	In Section I of Part B 29-Mar-93	Attain closure through CERCLA response	Unit will be used during CERCLA response action
21	Hilco oil recovery [c]	Storage	Characteristic (D001)	272 ft^2	Inactive	TBD	Clean close under RCRA	Limited or no potential for media contamination
22	Abandoned sump west of Pilot Plant	Storage	Characteristic (D008); listed (F001/F002/ F003)	2 ft diam. x 14 ft deep	Inactive	TBD; Sump removed as reported in Removal Action final report approved by USEPA 14-Jan-94	Attain closure through CERCLA response	Potential media contamination
23 [a]	Well drilling storage area	Reclassified to SWMU	N/A	29 ft x 56 ft	Inactive	N/A	N/A	N/A
24 [a]	Equipment storage area	Reclassified to SWMU	N/A	45 ft x 145 ft	Inactive	N/A	N/A	N/A
25 [a]	Plant 1 storage building	Storage	Characteristic	40 ft x 100 ft	Inactive	TBD	Attain closure through CERCLA response	Potential media contamination
26	Detrex still	Storage	Listed (F001/F002)	1 ft x 2 ft x 8 ft	Inactive	Revised CPID submitted 02-Mar-94	Clean close under RCRA	Limited or no potential for media contamination
27	Waste Pit 4	Disposal	Characteristic (D005)	Surface dimensions: 170 ft x 400 ft x 320 ft; 24 ft deep	Inactive	Certification of Interim Closure submitted 15-Sep-89	Attain closure through CERCLA response	Closure tied to CERCLA decision

000072

TABLE 1-1 (Continued)

No.	Unit Description	Type of Unit	Hazardous Wastes Managed in Unit [a]	Approximate Dimensions	Operational Status	Closure Status	Closure Strategy [b]	Basis for Adopted Closure Strategy
28	Trane incinerator	Treatment	Characteristic (D008); listed (F002)	50 ft x 52 ft	Inactive	Revision 3 to be submitted; date TBD	Attain closure through CERCLA response	Potential media contamination
29 [a]	Plant 8 warehouse	Storage	Various	60 ft x 170 ft	Active	In Section I of Part B 29-Mar-93	Attain closure through CERCLA response	Unit will be used during CERCLA response action
30	Barium chloride salt treatment facility	Treatment	Characteristic (D005)	75 ft x 50 ft	Inactive	Closure work completed; Closure Certification submitted 19-Apr-90	Clean close under RCRA	Limited or no potential for media contamination
31	Tank T-5	Storage	Listed (F001)	15 ft tall x 10 ft diam.	Inactive	CPID submitted 18-Nov-93; closure work has been initiated	Clean close under RCRA	Limited or no potential for media contamination
32	Tank T-6	Storage	Listed (F001)	15 ft tall x 10 ft diam.	Inactive	CPID submitted 18-Nov-93; closure work has been initiated	Clean close under RCRA	Limited or no potential for media contamination
33 [a]	Pilot plant warehouse	Storage	Various	69 ft x 7 ft	Active	In Section I of Part B 29-Mar-93	Attain closure through CERCLA response	Unit will be used during CERCLA response action
34 [a]	KC-2 warehouse	Storage	Various	346 ft x 82 ft	Active	In Section I of Part B 29-Mar-93	Attain closure through CERCLA response	Unit will be used during CERCLA response action
35 [a]	Plant 9 warehouse	Storage	Various	80 ft x 100 ft	Active	In Section I of Part B 29-Mar-93	Attain closure through CERCLA response	Unit will be used during CERCLA response action
36	Storage pad north of Plant 6	Storage	Characteristic (D008); listed (F001/F002)	8 ft x 40 ft	Inactive	CPID submitted 30-Dec-93; closure work has been initiated	Clean close through RCRA	Limited or no potential for media contamination
37 [a]	Plant 6 warehouse	Storage	Various	100 ft x 170 ft	Active	In Section I of Part B 29-Mar-93	Attain closure through CERCLA response	Unit will be used during CERCLA response action

TABLE 1-1 (Continued)

No.	Unit Description	Type of Unit	Hazardous Wastes Managed in Unit [a]	Approximate Dimensions	Operational Status	Closure Status	Closure Strategy [b]	Basis for Adopted Closure Strategy
38 [a]	HF tank car	Storage	Characteristic (D002)	10 ft wide x 34 ft long x 15 ft high	Inactive	CPID approved 14-Feb-95; closure work has been initiated	Clean close under RCRA	Potential media contamination
39	Clearwell	Reclassified to SWMU	N/A	Surface area: 30,600 ft^2 Depth: 25 ft Capacity: 4 million gal.	N/A	N/A	N/A	N/A
40	Bio-surge lagoon	Reclassified to SWMU	N/A	Surface area: 160,000 ft^2 Depth: 9 ft	Inactive	N/A	N/A	N/A
41	Sludge drying beds	Treatment	Listed (F002)	79 ft x 92 ft	Inactive	TBD	Attain closure through CERCLA response	Potential media contamination
42	Waste Pit 5	Treatment	Characteristic [d]	4.2 acres/ 184,000 ft^3	Inactive	CPID submitted 26-Sep-91	Attain closure through CERCLA response	Closure tied to CERCLA decision
43	Lime sludge ponds	Reclassified to SWMU	N/A	100 ft x 200 ft each	Inactive	N/A	N/A	N/A
44	Coal pile runoff basin	Reclassified to SWMU	N/A	107 ft x 54 ft Depth: 11 ft	Inactive	N/A	N/A	N/A
45	UST No. 5	Reclassified to SWMU	N/A	3 ft diam. x 6 ft long	Inactive	N/A	N/A	N/A
46	UNH tanks - NFS storage area	Storage	Characteristic (D002/D005/ D007)	61 ft x 52 ft	Inactive	CPID submitted 22-Jun-93	Attain closure through CERCLA response	Potential media contamination
47	UNH tanks - north of Plant 2	Storage	Characteristic (D002/D005/ D007)	63 ft x 40 ft	Inactive	CPID submitted 22-Jun-93	Attain closure through CERCLA response	Potential media contamination
48	UNH tanks - southeast of Plant 2	Storage	Characteristic (D002/D005/ D007)	Tank: 25,000 gal. Containment area: 55 ft x 45 ft	Inactive	CPID submitted 22-Jun-93	Attain closure through CERCLA response	Potential media contamination

TABLE 1-1 (Continued)

No.	Unit Description	Type of Unit	Hazardous Wastes Managed in Unit [a]	Approximate Dimensions	Operational Status	Closure Status	Closure Strategy [b]	Basis for Adopted Closure Strategy
49	UNH tanks - digestion area (2 locations)	Storage	Characteristic (D002/D005/ D007)	Each location: 20 x 127 ft	Inactive	CPID submitted 22-Jun-93	Attain closure through CERCLA response	Potential media contamination
50	UNH Tanks - raffinate building (2 locations)	Storage	Characteristic (D002/D005/ D007)	14 ft x 50 ft; 15 ft x 30 ft	Inactive	CPID submitted 22-Jun-93	Attain closure through CERCLA response	Potential media contamination
51	Experimental treatment facility (ETF) [c]	Treatment	Listed (F001/F002)	20 ft x 48 ft 2400 ft^2 capacity	Inactive	TBD	Attain closure through CERCLA response	Potential media contamination
52	North and south solvent tanks	Storage	Characteristic (D001)	6.5 ft diam. each	Inactive	Response to comments on CPID submitted 05-Jan-95; closure work has been initiated	Clean close under RCRA	Limited or no potential for media contamination
53	Safe geometry digestion sump	Storage	Characteristic (D008)	1 ft long x 8 in. diam.	Inactive	Closure work completed; letter of closure completion submitted 13-Feb-95	Clean close under RCRA	Limited or no potential for media contamination
54	Thorium nitrate Tank T-2	Storage	Characteristic (D002/D006/ D007) [e]	10 ft diameter	Inactive	CPID to be submitted 15-Nov-95	Clean close under RCRA	Limited or no potential for media contamination

[a] Although unit types vary, most units were designated as HWMUs because they held hazardous wastes for more than 90 days.
[b] Closure strategy for each HWMU is based on the information currently available and negotiation/discussions with OEPA. The final strategy will be driven by the Director's Findings and Orders (when signed).
[c] HWMU determinations on several units are being reevaluated. The units may, with OEPA approval, be reclassified as SWMUs.
[d] Specific hazardous waste characteristics will be determined during the OU1 CERCLA response.
[e] D006 and D007 (toxicity characteristic for cadmium and chromium, respectively) will be reevaluated because of possible uranium and thorium interferences in the lab analyses.

HWMU, the basis for listing, the closure status, and the closure strategy. A detailed discussion of remedial actions to be performed by Operable Unit 5 for environmental media contaminated by hazardous constituents is provided in Section 4.1.2.

The cleanup and disposition of any affected environmental media associated with these 20 HWMUs will be considered within the remedy selection (Operable Unit 5 PP) and the design and implementation process (Operable Unit 3 and Operable Unit 5 RD/RA Work Plans). An interim ROD (DOE 1994c) establishing the intent on the part of DOE to decontaminate and dismantle all former FEMP processing buildings and facilities was issued by EPA on July 22, 1994. As the decontamination and dismantling activities involve the structural components of HWMUs, OEPA hazardous waste closure requirements will be considered during the design and implementation of the proposed response action. In addition, integration of Operable Unit 3 and Operable Unit 5 remedial actions will be established through the RD and RA Work Plans for surface level and subsurface level structures, such as building floors, pads, and subsurface piping to be managed during Operable Unit 5 remedial actions. The purpose of this integration process is to mitigate the potential for unnecessary releases to the environment, or to generate unnecessary waste by using clean backfill materials in areas that would otherwise be excavated by Operable Unit 3. Final closure for the HWMUs to be remediated under CERCLA will be performed as part of remedial actions to demonstrate attainment of remedial objectives established through the CERCLA process.

1.4.2.4 Interaction of Operable Unit 5 with the State of Ohio Underground Storage Tank Program

Underground storage tanks (USTs) containing petroleum products were used throughout the history of the FEMP to support facility operations, including storing gasoline for site vehicles and machining oils for process equipment. A total of 14 USTs were identified at 5 locations within the former production area. Table 1-2 presents a summary of the location and status of the FEMP USTs. These tanks are subject to regulation under the Ohio Administrative Code (OAC) pursuant to authorities delegated to them through RCRA Subtitle I. The State of Ohio administers the program through the State Fire Marshall's Bureau of Underground Storage Tank Regulations (BUSTR).

Ten of the USTs at the FEMP, their associated piping, and surrounding contaminated soil have been excavated and removed. One tank, which is located beneath the Plant 6 machining area, could not be removed without significantly damaging the Plant 6 structure. As a result, this tank (Tank 14) was emptied and closed in place pending final disposition of Plant 6 under CERCLA. Closure reports covering the remaining tanks were submitted to BUSTR consistent with the OAC. The DOE was subsequently notified by BUSTR that these three tanks were considered closed. All remaining tanks at the FEMP will be closed in conjunction with Operable Unit 5 CERCLA actions; estimates of the volume of media potentially affected by the remaining USTs have been included within the scope of Operable Unit 5.

TABLE 1-2
STATUS OF FEMP UNDERGROUND STORAGE TANKS

Tank No.	Regulated Under OAC[a]	Location	Status
1	Yes	Building 31, garage	Removed and closed
2	Yes	Building 31, garage	Removed and closed
8	Yes	Building 31, garage	Removed and closed
9	Yes	Building 31, garage	Removed and closed
10	Yes	Building 31, garage	Removed and closed
11	Yes	Truck dock	Removed and closed
12	Yes	Truck dock	Removed and closed
13	Yes	Truck dock	Removed and closed
14	Yes	Under Plant 6	Abandoned in place
5	No	East of Bldg. 31A	To be removed under CERCLA
7	No	North of Bldg. 9A	To be removed under CERCLA
17	No	North of Bldg. 46	To be removed under CERCLA.
3	Yes	Building 24A	Removed and closed
6	Yes	Building 12	Removed and closed

[a] Ohio Administrative Code 1301:7-a-12(L)

1.4.3 Interaction of Operable Unit 5 with the Fernald Citizens Task Force

In October 1993 the DOE, following consultation with OEPA and EPA, chartered the Fernald Citizens Task Force. The Task Force is comprised of local citizens involved in or affected by the FEMP cleanup plans, local community leaders, scientists, and other professionals.

The Fernald Citizens Task Force has been requested by DOE to make recommendations regarding the future use, waste disposal plans, and cleanup priorities for the FEMP property. These recommendations will be instrumental in determining the direction of cleanup for the facility. The DOE recognizes the future uses desired by the Fernald community are critical to achieving a successful cleanup and is committed to giving these desires significant weight in cleanup decisions. The Task Force's recommendations, in particular, will be taken into consideration throughout the decision-making process.

Preliminary recommendations of the Task Force were presented in the Fernald Citizens Task Force Interim Report, November 1994. These recommendations included the following:

- Past impacts of the Fernald site on the Great Miami Aquifer must be remediated and any future impacts controlled so that groundwater quality meets the standards of the Safe Drinking Water Act.

- The excess risk of contracting cancer posed by exposure to Fernald contamination under any use of land on and off the Fernald property shall never exceed one in ten thousand (1×10^{-4}). Additionally, the Task Force recommends limiting land use even in cases where the concentrations achieved in the soil would allow for less restrictive uses, to provide for an additional margin of safety.

- All contaminated soil and other waste sources both on and off the Fernald property must be reduced to levels that will provide safety from noncancer toxilogical effects at a level equivalent to a Hazard Index (HI) of 1.

- All contaminated soil and other waste sources both on and off the Fernald property must be reduced to levels that will prevent contaminants from reaching the aquifer at levels that would result in groundwater concentrations exceeding Safe Drinking Water Act levels.

- For the purpose of evaluating risks all off-property land is to be considered at the resident farmer scenario to provide for the most stringent cleanup levels.

- The best use of the land on the Fernald property itself does not necessarily include agricultural or residential uses.

- There should be no new agricultural or residential uses on the Fernald property following remediation.

A final report discussing the Task Force's recommendations is expected to be completed in July 1995.

This FS has been written to take these resolutions into consideration in the formation and evaluation of alternatives.

1.5 BACKGROUND INFORMATION

This section provides a brief summary description and history of Operable Unit 5 and affected media. This summary was derived from the Operable Unit 5 RI Report and the Site-Wide Characterization Report. The Operable Unit 5 RI Report and baseline risk assessment and the Site-Wide Characterization Report are incorporated herein by reference and should be consulted for more detailed discussions of topics summarized here. These documents are available in the FEMP Public Environmental Information Center at 10845 Hamilton-Cleves Highway, Harrison, Ohio. Additional detailed information regarding site description and history, nature and extent of contamination, and baseline risk assessment results are included as Appendix A of this document.

1.5.1 Site Description and History

The FEMP is a 1050-acre facility located in southwestern Ohio, approximately 18 miles northwest of downtown Cincinnati. The facility is located just north of the small rural community of Fernald, and lies on the boundary between Hamilton and Butler counties (see Figure 1-1). Of the total FEMP property, 850 acres are in Crosby Township of Hamilton County and 200 acres are in Ross Township of Butler County.

Operations at the FEMP site were limited to a fenced, 136-acre tract of land known as the former production area, located near the center of the site. Large quantities of liquid and solid wastes were generated consequential to production operations. Before 1984, solid and slurried wastes from FEMP processes were stored or disposed of in the on-site waste storage area, located west of the former production area. The remaining FEMP property consists of forest and pasturelands, a portion of which is leased to nearby dairy farmers to graze livestock. The land adjacent to the FEMP is primarily devoted to open land use such as agriculture and recreation. Commercial activity is generally restricted to the village of Venice (Ross), approximately 3 miles northeast of the facility, and along State Route (SR) 128 just south of Ross. Industrial use is concentrated in the areas south of the FEMP site, along Paddys Run Road, in Fernald, and in a small industrial park on SR 128 between Willey and New Haven roads. Residential units are situated immediately north of the FEMP site, in Ross, and directly east in a trailer park adjacent to the intersection of Willey Road and SR 128. Other residences located around the site are generally associated with farmsteads. Because the area had been intensively used for agricultural purposes before the establishment of the FEMP, there is no land on or in the vicinity of the FEMP site where a predevelopment natural environment remains intact.

In general, the site is situated on glacial till underlain by sand and gravel deposits which comprise the Great Miami Aquifer, designated as a sole-source aquifer under the provisions of the Safe Drinking Water Act. The Great Miami Aquifer is a high-yield aquifer (wells completed in some areas yield greater than 500 gallons of water per minute) and supplies a significant amount of potable and industrial water to people located in Butler and Hamilton counties.

Sand and sand/gravel deposits have been encountered within the glacial till at the FEMP and surrounding area. These deposits act as reservoirs for available water because the deposits are more permeable than the surrounding less permeable glacial till (clay). These pockets of water are known as "perched groundwater" because they are perched above the aquifer.

1.5.2 Nature and Extent of Contamination

The nature and extent of contamination for Operable Unit 5 is discussed in two parts in this section: a brief discussion on historical FEMP environmental releases and discharges and a summarization of the Operable Unit 5 RI Report findings.

1.5.2.1 Historical Releases

Contamination of environmental media at the FEMP and its surroundings has multiple sources that can be described under two major categories: process operations and waste management practices. Process operations include all those elements of the FEMP production cycle that resulted in releases of contaminants to the environment over the 38-year operating history of the plant. Waste management practices include all those actions associated with the storage and disposal of waste streams from process operations and subsequent interim remedial action efforts.

A variety of primary release mechanisms including air, wastewater discharge, spills, leaks, and land disposal provided the vehicle for transport of contaminants to environmental media and, subsequently, to potential human and ecological receptors. Secondary releases, such as air resuspension of contaminated soil, contributed to further migration and transport to other media. The cessation of production reduced or eliminated many of the primary sources of contaminant release to environmental media; the remaining primary sources of contamination attributable to the former production area are being addressed under Operable Unit 3 response actions. The following paragraphs briefly discuss airborne, water, and nonroutine releases.

Airborne Releases

Dust collector stack discharges were the principal sources of airborne emissions during FEMP operations from 1951 to 1989. A total of 94,950 kilograms (kg) of uranium was released from plant stacks (95 percent of which were oxides and green salt). Stack discharges from Plants 4 and 5 comprise 63 percent of the total stack discharges.

Discharges from Plant 2/3 and 8 account for 52 percent (88,549 kg of uranium) of total discharges; Plant 7 discharged 14 percent of the FEMP total in three years of operation (1954-1956).

Secondary releases from nonproduction sources (incinerators, storage, and exhausts) were also a source of airborne emissions. Uranium releases from incineration are estimated to be 3087 kg [most likely as uranium oxide (U_3O_8)]; fugitive uranium emissions at the waste pits are estimated at 1371 kg through 1984. Uranium releases from building exhausts and lab emissions are estimated to be 379 kg and 68 kg, respectively, through 1984.

In 1992, airborne uranium emissions were measured and estimated at 0.51 pound (FERMCO, 1993), a 20 percent decrease from the 1991 air emissions. Airborne emissions are expected to remain at these low levels for several years. However, as remediation of the site occurs, an increase in emissions is possible as contaminated materials are moved for final disposition.

Waterborne Releases

Waterborne releases to the environment have occurred through wastewater, leaking lines, discharge into Paddys Run and the Great Miami River, and storm water runoff.

Approximately 961 pounds of uranium were discharged to the Great Miami River during 1992 (as measured at Manhole 175). This was a reduction of more than 30 percent as compared to 1991 uranium discharges to the Great Miami River.

An estimate of uranium in uncontrolled storm water runoff into Paddys Run is reported annually to the EPA. Before November 1992, a general estimate of 10 pounds of uranium for every inch of rain was used to develop calculations; after November 1992, this estimate was reduced to 6.3 pounds. The estimate was decreased because the Waste Pit Area Runoff Control Removal Action eliminated that source of contamination to Paddys Run. For 1992, the estimate of uranium in storm water runoff to Paddys Run was reported as 350 pounds.

Nonroutine Releases

Due to the nature of activities historically conducted at the FEMP, spills, leaks, and nonprocess discharges to the air, storm sewers, and soil have occurred (nonroutine releases). Nonroutine releases may also be designated as "significant or unusual events."

Although several specific nonroutine releases have been documented, not all releases were reported. It is, therefore, difficult to determine the amount of uranium released to the environment through

nonroutine releases. Several documented releases to the atmosphere and the associated amount of uranium discharged are listed below.

- February 14, 1966: 1195 kg of uranium as uranium hexafluoride (UF_6)
- January 19, 1986: 21.6 pounds of UF_6 gas
- November 11, 1986: 230 pounds of uranium trioxide [UO3 (containing 26 ppb plutonium)]
- August 18, 1987: 200 pounds of uranium oxide
- September 29, 1987: 270 pounds of anhydrous hydrogen fluoride
- January 18, 1988: 40 pounds of uranium as uranyl nitrate
- July 1988: 145 pounds of uranium as exhaust gases
- Spring 1989: 0.004 pounds of uranium from fly ash spill
- June 1, 1989: 0.84 pounds of uranium from a storage pad fire.

1.5.2.2 Summary of Operable Unit 5 RI Report Findings

This section summarizes the nature and extent of contamination as defined in the Operable Unit 5 RI Report. To aid in determination of site-related contamination, constituent concentrations in various media were compared to background concentrations. These background data provide points of comparison that aid in understanding the significance of data collected during the RI.

The primary Operable Unit 5 radiological constituents, based on process knowledge and the findings of the source operable units (Operable Units 1 through 4), are uranium isotopes (uranium-238, uranium-234, uranium-235) and their progeny (radium-226, and thorium-230). Thorium-232 and its more stable progeny (radium-228, thorium-228, and radium-224) are also expected to be present in lesser amounts. Several fission and uranium activation products such as technetium (Tc-99), strontium-90, cesium-127, and plutonium-238, 239, and 240 are also anticipated at low levels, since the FEMP processed recycled uranium from other DOE facilities.

Chemical constituents likely to be encountered in Operable Unit 5, based upon process knowledge and findings of other operable units, include tributyl phosphate (a reagent used in the extraction of uranium); polychlorinated biphenyls (PCBs); polynuclear aromatic hydrocarbons (PAHs) from flyash, incinerator ash, and fuel oils; chlorinated phenoxy acid herbicides that were used for weed control; common solvents such as acetone and benzene; chlorinated solvents that were used as degreasers or paint solvents; various oils that were used as lubricants and coolants; and various inorganic species such as calcium, magnesium, fluoride, and heavy metals.

The following sections discuss the nature and extent of contamination in various media within and outside the FEMP boundaries.

1.5.2.2.1 Surface Soil and Subsurface Soil

Extensive sampling of surface and subsurface soils has been conducted within the boundaries of the FEMP and at nearby locations outside the FEMP property. For the purposes of this report, surface soil is defined as the top 18 inches of soil below ground surface (0 to 18 inches); subsurface soil is defined as the soil below 18 inches from ground surface. The sampling was conducted as part of the RI site investigation and other programs. These investigations were designed to characterize the nature and extent of soil contamination resulting from past FEMP activities and to permit quantification of baseline risks associated with the contamination. The nature and extent of soil contamination has been sufficiently characterized to perform a baseline risk assessment for Operable Unit 5 and to evaluate and select remedial alternative(s).

Radiological Parameters

It has been estimated that during the 38-year production life of the FEMP, more than 179,000 kg of uranium and nearly 6500 kg of thorium were released to the atmosphere from the production facilities. Generally, the depths and concentrations of radiological contaminants can be characterized as more significant in the former production area, trending toward lower concentrations and more limited depths outside the former production area and off the FEMP property.

The highest concentrations of uranium in the surface soil (greater than 10,000 mg/kg) were found in the Plant 1, Plant 6, laboratory, and former scrap metal pile areas. Total uranium concentrations in surface soil within the FEMP boundary typically ranged from 10 to 100 mg/kg, with concentrations outside the former production area and waste storage area averaging from 10 to 20 mg/kg. Increased concentrations exist in surface soil adjacent to a retired solid waste incinerator located at the FEMP sewage treatment plant; much of this soil contamination was excavated as part of a removal action. Total uranium contamination in the subsurface soil can be characterized as isolated occurrences beneath former process facilities and waste storage areas. The areas of highest subsurface uranium contamination, those with concentrations greater than 100 mg/kg, were found localized near former processing facilities and in-ground sumps where acid solutions of uranium and liquid wastes were handled in large volumes.

Total uranium concentrations were observed at levels slightly above background on the property surrounding the FEMP. On the basis of available data, uranium concentrations in surface soil off the FEMP property exceeds background concentrations in areas of up to 11 square miles. Uranium detections were generally from 5 to 6 mg/kg in these areas. The probable source of these elevated levels of uranium is airborne releases from areas within the FEMP. Although the levels of uranium and its isotopes do exceed background, the exceedance is minor and may be attributable to the routine errors associated with the method of analytical measurement, or variation in natural background. Total uranium contamination in soil identified by RI sampling (see Tables 4-17 and 4-18 of the

Operable Unit 5 RI, DOE 1995e), was detected off property along the outfall line and at the eastern FEMP boundary adjacent to the sewage treatment plant. Concentrations of total uranium at the outfall line ranged from 3.0 mg/kg (1.0-1.5 foot depth) to 54.0 mg/kg (0.5-1.5 foot depth); total uranium concentrations at the sewage treatment plant (at the eastern FEMP boundary) ranged from 2.7 mg/kg (1.5-3.0 foot depth) to 7572.0 mg/kg (0.0-0.5 foot depth).

Radium-226 contamination is believed to be limited to former processing areas and waste storage areas where elevated levels were expected. Analyzed areas adjacent to the Plant 1 pad and former scrap metal pile exhibit radium-226 activity greater than 1000 pCi/g. Radium-226 contamination in the subsurface soil identified by the RI sampling (see Tables 4-19 and 4-20 of the RI Report, DOE 1995e) was located west of the K-65 silos. Concentrations ranged from nondetectable (10.0-15.0 foot depth) to 137.0 pCi/g (3.0-5.0 foot depth). The source of this contamination is likely the K-65 decant tank or spills associated with the filling of the silos.

Elevated levels of thorium and its decay products were generally found in localized areas near former processing and thorium storage locations. The highest concentrations of thorium (exceeding 1000 mg/kg) were located within the scrap metal pile and laboratory areas. Thorium contamination was detected primarily in the surface soil and available data suggest it is limited to a depth of less than 10.0 feet in the subsurface soil.

Fission and uranium activation products present are associated with recycled uranium that was processed at the FEMP (uranium that has been irradiated in a nuclear reactor for the production of energy, weapons material, or synthetic radionuclides). Irradiated uranium was chemically processed to remove fission and activation products prior to its shipment to the FEMP, but some residual levels remained. These fission and activation products are found sporadically above the RI detection limits within the FEMP. In general, detectable concentrations of fission and activation products were coincidentally located with elevated concentrations of uranium in soils.

Inorganic and Organic Parameters

The majority of inorganic contamination is located in the surface soil. The primary inorganic contaminants detected at the FEMP in above-background concentrations were magnesium, manganese, beryllium and cadmium. Magnesium was a constituent present in airborne emissions from several points in the former production process, including Plants 1, 5, 8, and 9. The only known source of cadmium is as an impurity in the uranium ore feed material, while the primary source of beryllium is not known. Silver was detected sporadically in both the surface and subsurface soil at low levels across the site. Selenium was found in low concentrations in the subsurface soil; no background level is available for selenium.

Lead concentrations above 200 mg/kg are present in the following areas (ss Table 4-29 and 4-30 in the Operable Unit 5 RI Report):

- Plant 2/3 (440.0 mg/kg at 0.5-1.0 foot depth)
- Plant 6 (226.0 mg/kg at 0.0-0.5 foot depth)
- Sewage treatment plant (570.0 mg/kg at 0.0-0.5 foot depth)
- Electrical substation (543.0 mg/kg at 0.0-0.5 foot depth)
- Maintenance building (334.0 mg/kg at 0.0-0.5 foot depth)
- Scrap metal pile (569.0 mg/kg at 0.0-0.5 foot depth)
- KC-2 warehouse (569.0 mg/kg at 0.0-0.5 foot depth)
- Trap range (2180.0 mg/kg at 0.0-0.5 foot depth)
- K-65/Clearwell line west (240.0 mg/kg at 0.0-0.5 foot depth).

Volatile and semivolatile organic compounds and PCBs were detected in select samples in the vicinity of all major processing and support facilities. With few exceptions, the organic detections were located within the uranium envelope. From data review, it appears that the areas of total uranium contamination encompass other areas of site-related contamination. This boundary of uranium contamination is referred to as the "uranium envelope." Therefore, all parameters are discussed relative to uranium contamination or the uranium envelope.

1.5.2.2.2 Groundwater

Two types of groundwater are discussed in this section: perched and Great Miami Aquifer groundwater. The nature and extent of contamination in these two groundwater types is described in the following two subsections.

Perched Groundwater

Seven broad areas where uranium and other contaminants are present at above-background concentrations in the perched groundwater have been identified as follows:

- Area I plume
- Area II plume
- Area III plume
- Area IV plume
- Area V plume
- Area VI plume
- Area VII plume.

As part of the area-wide Operable Unit 5 RI studies, perched groundwater was sampled from 336 Type 1 groundwater monitoring locations situated throughout the FEMP. The period of record for sampling activities extends from 1988 to 1993, during which time more than 2000 samples were collected. Uranium is the principal groundwater contaminant and contamination by other radionuclide, inorganic, organic, and general chemistry parameters falls within the extent of uranium

contamination as defined by the 5 μg/L contour line of total uranium based on unfiltered samples. Based on the 5 μg/L total (unfiltered) uranium contour, the land area occupied by the seven broadly contaminated areas is approximately 525 acres, which is approximately one-half of the on-property glacial overburden area.

Each of the seven groundwater contamination areas contains multiple contaminants in addition to uranium. The total number of constituents and constituent groups detected above background within each area is as follows:

Area I Plume: Production Area: 48 constituents and constituent groups

- 16 radionuclides
- 25 inorganics
- volatile organic compounds
- semivolatile organic compounds
- 5 general chemistry parameters

Area II Plume: Sewage Treatment Plant Area: 24 constituents and constituent groups

- 11 radionuclides
- 8 inorganics
- volatile organic compounds
- semivolatile organic compounds
- 3 general chemistry parameters

Area III Plume: South Field/Flyash Pile Area: 22 constituents and constituent groups

- 12 radionuclides
- 8 inorganics
- volatile organic compounds
- semivolatile organic compounds
- 2 general chemistry parameters

Area IV Plume: K-65 Silos Area: 29 constituents and constituent groups

- 7 radionuclides
- 17 inorganics
- volatile organic compounds
- semivolatile organic compounds
- 3 general chemistry parameters

Area V Plume: Waste Pits and Solid Waste Landfill Areas: 43 constituents and constituent groups

- 12 radionuclides
- 24 inorganics
- volatile organic compounds
- semivolatile organic compounds
- 5 general chemistry parameters

Area VI Plume: Fire Training Area: 23 constituents and constituent groups

- 15 radionuclides
- 7 inorganics
- volatile organic compounds
- semivolatile organic compounds

Area VII Plume: Lime Sludge Ponds Area: 18 constituents and constituent groups

- 16 radionuclides
- 4 inorganics
- semivolatile organic compounds
- 2 general chemistry parameters.

Uranium contamination exists outside the seven areas primarily as a result of plant air emissions resulting in uranium deposition on surface soil both on- and off-property. The surface soil contamination has (and continues to be) leached by infiltrating rainwater, resulting in slightly elevated concentrations of uranium in perched groundwater. Outside the seven areas and within the bounds of the FEMP property, perched groundwater has a total uranium concentration greater than background (1.3 μg/L), but generally less than 20 μg/L. The uppermost saturated horizon in this area potentially has elevated concentrations of total uranium resulting from leaching from contaminated surface soil. However, total uranium concentrations are predicted to be less than 5 μg/L (relative to a background concentration of 1.3 μg/L) based on trends seen in on-property glacial overburden monitoring wells.

The greatest number of constituents and the highest reported concentrations above background occur in perched groundwater beneath the production area. The least number of constituents and the lowest reported concentrations occur in perched groundwater near the lime sludge ponds. The results of RI characterization of perched groundwater provide sufficient information to characterize risk and to determine appropriate response actions in the FS.

Great Miami Aquifer

Uranium is the principal site-introduced groundwater contaminant in the Great Miami Aquifer. The extent of every other contaminant, except sulfate, falls within the limits of uranium contamination as defined by the 5 μg/L contour line of total uranium based on unfiltered samples. Contamination of the Great Miami Aquifer is largely confined to the uppermost portion of the aquifer.

The nature and extent of contamination in the Great Miami Aquifer was determined using groundwater analytical data from 323 wells. The period of record for Operable Unit 5 sampling activities extends from 1988 to 1994, and the Operable Unit 5 database compiled for this report consists of more than 2900 groundwater samples collected between 1988 and 1994. The comprehensive data set was culled to select a set of data confined to one distinct period. The

selection process focused on data collected in 1993 because 1993 was the year during which the most wells were sampled in the shortest period. This data set, referred to as the 1993 data set, was used to analyze the extent of contaminant occurrence.

Uranium is the principal groundwater contaminant and contamination by virtually every other radionuclide, inorganic, organic, and general chemistry parameter falls within the extent of uranium contamination as defined by the 5 μg/L contour line of total uranium based on unfiltered samples. One general chemistry parameter, sulfate, has a plume which extends farther than the maximum extent of uranium contamination defined by the 5 μg/L isoconcentration contour.

The majority of contamination observed in the Great Miami Aquifer is attributed to six point or line sources. Each source has resulted in a distinct plume:

- The waste storage area A plume is a result of leaks from the Operable Unit 1 waste pits
- The waste storage area B plume is a result of surface water infiltration along the northern stretch of Paddys Run
- The Plant 6 plume is a result of leaks through the glacial overburden where the overburden has been thinned beneath Plant 6 and the sewage lift station
- South Plume A is a result of leachate and surface water that infiltrates in the vicinity of the Operable Unit 2 inactive flyash pile, active flyash pile and South Field
- South Plume B is a result of surface water infiltration along the Storm sewer outfall ditch and Paddys Run
- South Plume C which is a result of surface water infiltration along the southern stretch of Paddys Run south of New Haven Road.

Two of the six FEMP plumes, South Plumes A and B, are commingled with contaminant plumes that originate from an independent industrial facility located south of the FEMP, the Paddys Run Road Site.

Contamination of the Great Miami Aquifer is largely confined to the uppermost portion of the aquifer. Based on the 5 μg/L total uranium contour identified for Type 2 wells, the areal extent of uranium contamination at the top of the Great Miami Aquifer is 340 acres. Similarly, the areal extent of uranium contamination at the Type 3 well depth is 120 acres. Uranium contamination occurs as isolated above-background detection at the bottom of the aquifer, in Type 4 wells.

Low levels of uranium contamination exist outside of the six FEMP plumes primarily as a result of deposition of airborne emissions on surface soils both on- and off-property. The surface soil

contamination has (and continues to be) leached by infiltrating rainwater, resulting in slightly elevated uranium concentrations in both perched groundwater and the uppermost horizon of the Great Miami Aquifer. However, total uranium concentrations are estimated to be less than 10 μg/L (relative to a background concentration of 1.2 μg/L), based on trends seen in the groundwater samples from the existing monitoring well network.

Low levels of uranium contamination also exist in groundwater along the west bank of the Great Miami River, south of the confluence of Paddys Run; the contamination was identified through sampling of private wells. The contamination is believed to have resulted from infiltration of Great Miami River water into the bank of the river. The maximum concentration observed in the area was 9.9 μg/L (relative to a background concentration of 1.2 μg/L).

The 1993 data set used to describe nature and extent of contamination shows that there are isolated low-level above-background detections of radionuclides and inorganics outside the maximum extent of uranium contamination as defined by the 5 μg/L contour line for total uranium based on unfiltered samples.

Surface Water

The primary surface water drainageways on the FEMP are the SSOD, the pilot plant drainage ditch, Paddys Run, and the Great Miami River.

Currently, the SSOD carries all surface water flow from the open areas east and south of the production area. However, from the beginning of production at the FEMP through 1986, when the SWRB was installed, the SSOD served as the primary receptor of storm water runoff from the production area storm sewer collection system. The SSOD drains to Paddys Run on FEMP property. This drainage rarely runs except when the SWRB overflows during a storm event that exceeds the capacity. The SWRB was designed to contain runoff from a 10-year, 24-hour rainfall event; the runoff is generated from the former production and parking lot areas.

As part of the RI program, surface water samples were collected from the SSOD in 1988, 1989, and 1993. Total uranium was detected in all samples with concentrations ranging from 2 to 51.8 μg/L. One sample also exhibited above-background concentrations of magnesium and sodium. The only other notable constituent present was the semivolatile bis(2-ethylhexyl)phthalate with concentrations ranging from 16 to 58 μg/L.

Paddys Run is an intermittent stream that flows south along the western edge of the FEMP to its confluence with the Great Miami River. Historically, Paddys Run received both uncontrolled FEMP sheet runoff and runoff from drainage ditches within the FEMP boundaries. Numerous storm water

runoff control projects and removal actions in the waste storage area and production area have nearly eliminated the primary sources of contamination to Paddys Run. Currently, all uncontrolled drainages except the northeast drainage ditch (which flows to the Great Miami River) discharge into Paddys Run or one of its tributaries. These uncontrolled drainage ditches continue to be pathways for contaminants to reach Paddys Run, the Great Miami River, and the Great Miami Aquifer.

For surface water samples collected from the on-property portion of Paddys Run during the period 1988 to 1993, constituents exceeded background concentrations for uranium-238, uranium-234, and strontium-90. In addition, the average on-property uranium concentration, 15.5 μg/L, exceeded average Paddys Run background values by an order of magnitude. The average on-property concentrations of aluminum and silicon in Paddys Run were also determined to be above average surface water background concentrations in Paddys Run.

Surface water samples collected from off-property locations in Paddys Run to the south of the FEMP contained concentrations slightly above the Paddys Run background levels for thorium-230, uranium-234, uranium-238, and total uranium. The maximum detected concentrations for each of these constituents occurred at different locations. The filtered concentrations for calcium, manganese, and silicon also slightly exceeded the Paddys Run background concentrations for these constituents.

The Great Miami River is the ultimate receptor for groundwater in the vicinity of, and surface water discharged from, the FEMP. The three principal pathways for FEMP discharges to enter the river are effluent from the outfall line, surface water flow from Paddys Run, and surface water runoff from the eastern portions of the FEMP property.

Using results from the FEMP Environmental Monitoring Program, the Great Miami River surface water sampling data show that during the period from 1986 to 1993, the highest annual average concentrations of uranium was 2.1 μg/L, detected downstream of the confluence of Paddys Run with the Great Miami River. The data indicate that since 1991, annual concentrations at all sampling locations have been below 2 μg/L.

The RI/FS program consisted of data collected during 1988/1989 and 1993. This data is representative of conditions in the river before and after production activities were halted at the site. As part of the 1988/1989 RI/FS sampling program, total uranium was detected in Great Miami River surface water samples at concentrations ranging from 1 to 7 μg/L. The highest concentrations were detected in samples collected between the FEMP outfall line and the confluence of Paddys Run with the Great Miami River. Thorium-228 was detected at levels ranging from 1.5 to 2.6 picoCuries per Liter (pCi/L); thorium-230 was detected in one sample at 1.3 pCi/L at a location immediately downstream of the confluence of Paddys Run with the Great Miami River. Technetium-99 was

detected in 19 samples at concentrations ranging from 30 to 95.9 pCi/L. Radium-228 was detected in one sample at 5.1 pCi/L. Metals were detected at concentrations comparable to background and phenols were detected at concentrations ranging from 0.01 to 0.03 μg/L.

One round of surface water sampling was performed as part of 1993 RI/FS activities. All samples were analyzed for Hazardous Substance List (HSL) volatile, semivolatile, and inorganic parameters, total and isotopic uranium and thorium, and isotopic radium. Total uranium was detected in all surface water samples from the Great Miami River at concentrations ranging from 0.4 to 2.8 μg/L. The highest isotopic thorium activity detected was 0.7 pCi/L. Radium-226 was detected at activity levels ranging from 0.6 to 2.8 pCi/L. One organic constituent (trichloroethane) was detected in one sample; two semivolatiles [bis(2-ethylhexyl)phthalate and di-n-butyl phthalate] were also detected in the same sample.

Sediment

Sediment samples were collected from the SSOD, Paddys Run, and the Great Miami River. The analytical results are discussed below.

Sediment samples were collected from the SSOD under the FEMP Environmental Monitoring Program and the RI. Uranium and technetium-99 were the most abundant radionuclides. Uranium concentrations ranged from 3.3 to 12 mg/kg. Metals detected at above-background concentrations included beryllium, calcium, magnesium, sodium, and zinc. Methylene chloride (a volatile) was detected at 6 mg/kg; six semivolatiles were also detected at low concentrations.

Radium-226, thorium-230, and total uranium were detected in sediment from the on-property portion of Paddys Run at slightly above-background concentrations. The maximums for these radionuclides occurred downstream of the pilot plant drainage ditch and upstream of the flyash piles. Although thorium-230 was detected in one sample collected from Paddys Run, there is no background concentration available for comparison.

In addition to radionuclides, volatile organics, semivolatiles, and inorganics were detected in on-property Paddys Run sediment. During the 1993 RI/FS sediment sampling, several previously undetected volatile organics were identified: acetone, chloroform, carbon tetrachloride, methylene chloride, and toluene; all constituents were detected at on-property locations at a concentration at or below 3 μg/kg. Semivolatiles not previously detected were also identified; PAHs ranged from 100 to 350 μg/kg in the sediment taken from the last sampling location on Paddys Run (before the stream exits FEMP property). The following inorganic concentrations were detected at levels above-background concentrations: aluminum, barium, calcium, magnesium, manganese, nickel, potassium, vanadium, and zinc.

Off-property sediment locations in Paddys Run were sampled for inorganics and, although all metals were detected, only calcium, magnesium, manganese, and zinc exceeded the sediment background concentrations. One sediment sample was analyzed for HSL organics with only methylene chloride detected at a concentration of 6 μg/kg.

With regard to the Great Miami River sediment samples collected during the FEMP Environmental Monitoring Program, the data show no discernable difference between total uranium concentrations in sediment from locations upstream and downstream of the FEMP outfall line.

Sediment samples collected from the Great Miami River in 1988/1989 for the RI/FS sampling effort showed no discernable increase in levels of radionuclides downstream of the effluent line or downstream of Paddys Run. Total uranium was detected at concentrations ranging from 1 to 3 μg/kg. The average activity levels for the uranium isotopes was at or less than background concentrations. Radium-226 was detected at twice background concentrations and thorium-230 was detected at three times background concentrations at a location downstream of the confluence of Paddys Run with the Great Miami River.

One round of Great Miami River sediment samples was collected as part of the 1993 RI/FS activities. All samples were analyzed for HSL volatile, semivolatile, and inorganic parameters, total and isotopic uranium and thorium, and isotopic radium. Volatiles (chlorobenzene, carbon disulfide, and toluene) were detected in only one sample. Semivolatiles detected included acenapthene, chrysene, dibenzofuran, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenzo (a,h) anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, and benzoic acid. Inorganics detected at above-background concentrations included barium, beryllium, calcium, chromium, cobalt, copper, lead, magnesium, manganese, nickel, potassium, selenium, sodium, and zinc. Total uranium was detected at concentrations ranging from 2 to 11 μg/kg. Radium-226 activity levels ranged from 0.4 to 0.8 pCi/g.

Air and Direct Radiation

There are 21 on-property fence line locations for radon detection, two background locations, and nine other locations around the FEMP. Each location has either two, three, or six alpha-track-type radon detectors for measuring radon concentrations in the air. The detectors are changed each calendar quarter and sent to the supplier for analysis.

The average quarterly radon level at each location was computed from the results of all detectors at that location. The annual average radon level at each location was then calculated from the quarterly averages. The average annual radon level at the fence line for 1988 through 1993 ranged from

0.57 pCi/L (1992) to 1.16 pCi/L (1988). None of the observed levels exceeded either the DOE guideline of 3.3 pCi/L above background (DOE Order 5400.5) or 40 CFR 192 which specifies that the average annual increase of radon-222 in air or above any location outside the area should not exceed 0.5 pCi/L.

The maximum incremental annual dose from all sources to the person living closest to the K-65 silos was estimated to range from 10 to 19 millirem (mrem) prior to the K-65 removal action to approximately 1 mrem following the removal action. DOE's limit for exposure to all sources and all pathways is 100 mrem per year.

Biological Resources

Radiochemical analysis was performed on samples of aquatic and terrestrial vegetation, benthic macroinvertebrates, fish, and small mammals from on and off the FEMP property to examine potential bioaccumulation. Additionally, chemical analysis was performed on samples of grass leaves, roots, and two small mammals. The reader is referred to the results of the biota sampling program presented in the Operable Unit 5 RI Report. In general, isotopes of uranium were detected in select samples at low concentrations from all sample groups. Comparison of these values to background or statistical analysis of the results is not appropriate due to lack of control values and the small data set. The fission products examined (i.e., strontium-90 and cesium-137) were generally not detected above laboratory detection limits. Select samples of grass roots and a single cucumber sample did indicate cesium-137 levels above detection limits. Analysis of the significance of these occurrences cannot be completed due to lack of control samples.

Limited analysis of samples was completed for inorganics, including metals and sulfates, and organics. These constituents were detected in collected samples of grass roots and leaves and small mammals. Background values for these constituents have not been established.

1.5.3 Baseline Risk Assessment Results

This section summarizes the Operable Unit 5 baseline risk assessment. Exposure scenarios, constituents of potential concern (CPCs), risk characterization results, and uncertainties are discussed in the following paragraphs.

The chemical and radiological constituents present within the environmental media comprising Operable Unit 5 present certain risks to human and environmental receptors. The type and degree of this risk has been estimated for existing, or baseline, conditions using EPA risk assessment methods. A baseline risk assessment estimates the risks that could occur in and around the FEMP site in the event no further cleanup actions are taken. These risks are evaluated for the situation as it presently exists (measured) and for how it could exist from 200 to 1000 years in the future (maximum).

Federal regulations stipulate that risk from waste sites should generally not add greater than a 1×10^{-4} (one chance in 10,000) to 1×10^{-6} (one chance in 1,000,000) probability of acquiring cancer over the average lifetime of a potentially exposed human. CERCLA generally regards an ILCR from a waste site in the range of 1×10^{-4} to 1×10^{-6} to be acceptable and the ILCR of 1×10^{-6} as a point of departure (i.e., the waste site is unavailable for unrestricted use).

A hazard index (HI) was calculated for each receptor under each scenario to provide an indication of the risks due to the presence of noncarcinogenic constituents of concern. An HI of less than one for exposures to a given receptor from all noncarcinogenic constituents of concern is generally regarded as acceptable.

The Operable Unit 5 baseline risk assessment was completed for four land use scenarios: current land use with access controls, current land use without access controls, future land use with access controls, and future land use without access controls.

For the current land use with access controls scenario, the site is assumed to remain under federal ownership and access restrictions historically provided by the DOE are assumed to be maintained. No remedial actions have been taken and no members of the public have established residence in the Operable Unit 5 on-property area. The scenario further assumes DOE maintains a site-specific health and safety program to ensure nonremediation workers and visitors are properly protected. Hypothetical on-property receptors under this scenario include a trespassing youth, an on-site worker (groundskeeper), a visitor, and a consumer of milk and meat from cattle allowed to graze at specified on-property grazing areas. Hypothetical off-property receptors include an off-property resident farmer, an off-property resident child, and an off-property user of surface water from the Great Miami River.

For current land use with access control conditions, the highest calculated ILCR to human receptors due to the presence of radiological constituents at the FEMP site was 1.3×10^{-3} for an on-property groundskeeper in Area 2. The highest ILCR for chemical constituents under this scenario was 1.1×10^{-2} for an off-property farmer at the southern fence line; the calculations performed to obtain this value assumed the receptor to be ingesting contaminated groundwater from the South Plume containing the maximum detected concentrations of constituents at a rate of 2 liters per day for the farmer's entire assumed 70-year lifetime. The highest total carcinogenic risk (the sum of radiological risk and chemical risk) was 1.2×10^{-2} (unacceptable) for the off-property farmer at the southern fence line.

The HIs were calculated to provide an indication of the risks due to the presence of noncarcinogenic constituents of concern. An HI of less than one for exposures to a given receptor from all

constituents of concern is generally regarded as acceptable. The highest HI value for the current land use with access control conditions was 260 (unacceptable) for the hypothetical off-property child located along the eastern fence line.

For the current land use without access controls scenario, the FEMP is assumed to have been turned over to an industrial concern other than the DOE. Access restrictions currently provided by the DOE are assumed to be discontinued. In addition, no remedial actions are assumed to have been taken and it is assumed that no members of the public establish residence within the Operable Unit 5 on-property area. Potential on-property receptors under this scenario include a groundskeeper, a visitor, an on-property exploring youth, and a consumer of meat and milk from cattle allowed to graze in presently restricted on-property area. Hypothetical off-property receptors include an off-property resident farmer, an off-property resident child, and an off-property user of surface water from the Great Miami River.

Under the current land use without access control scenario, the highest calculated ILCR for radiological constituents was 1.3×10^{-3} for the groundskeeper in Area 2. For chemical carcinogens, the highest calculated ILCR associated with this land use scenario was 2.8×10^{-2} for the off-property farmer at the southern fence line. The highest total carcinogenic risk was 2.9×10^{-2} (unacceptable) for the off-property farmer at the southern fence line. The highest HI value for this scenario was 290 (unacceptable) for the hypothetical off-property child at the southern fence line.

Under the third scenario, future land use with access controls, the site is assumed to remain under federal ownership as a government reserve and access controls are assumed to remain in place. Contaminant concentrations at points of exposure, however, entail maximum values calculated from fate and transport modeling over a 200 to 1000-year time frame, rather than current-condition (measured) values. Potential on-property receptors for this scenario include an on-site worker (groundskeeper) and recreational receptors. Off-property hypothetical exposures for this scenario include an off-property resident child, an off-property farmer, and an off-property user of surface water from the Great Miami River. These receptors are the same as in the following scenario (future land use without access controls).

For the future land use with access controls scenario, the highest calculated ILCR for radiological constituents was 2.2×10^{-3} for the off-property farmer at the eastern fence line. For chemical carcinogens, the highest calculated ILCR was 9.5×10^{-5} for the off-property farmer at the farm northeast of the FEMP. The highest total carcinogenic risk was 2.3×10^{-3} (unacceptable) for the off-property farmer at the eastern fence line. The highest HI value for this scenario was 150 (unacceptable) for the off-property child at the eastern fence line.

The fourth land use scenario, future land use without access controls, includes exposure routes that require development time, such as establishing a home and a farm within the Operable Unit 5 on-property area. Access controls are assumed to be absent and no remedial actions are assumed to have been taken. In addition, members of the public are assumed to have established residence within the Operable Unit 5 on-property boundaries. Hypothetical on-property receptors under this scenario are an RME resident farmer, a central tendency (CT) resident farmer, a resident child, a RME farmer using perched groundwater, and a home builder. Hypothetical off-property receptors include an off-property resident child, an off-property farmer, and an off-property user of surface water from the Great Miami River. Maximum contaminant concentration values derived from fate and transport modeling are again used in this scenario.

Under the future land use without access controls scenario, the highest calculated ILCR for radiological constituents was 3.6×10^{-2} for the on-property RME farmer (perched groundwater use) in the former production area. The highest calculated ILCR for chemical carcinogens was 1.7×10^{-2} for the on-property farmer (use of perched water). The highest total carcinogenic risk was 5.3×10^{-2} (unacceptable) for the on-property farmer (use of perched water). The highest HI value for this scenario was 1500 (unacceptable) for the on-property RME farmer using perched groundwater in the former production area.

Ecological Risk Assessment

The Site-Wide Ecological Risk Assessment was performed as part of the Operable Unit 5 RI to determine if radiological and nonradiological contaminants associated with actions at the FEMP represent a current or future risk to ecological receptors inhabiting this facility and nearby off-property areas (including the Great Miami River). These receptors include all organisms, exclusive of humans and domestic animals, that may be potentially exposed to FEMP contaminants. The Site-Wide Ecological Risk Assessment focused on those on- and off-property areas not likely to be remediated based on human health concerns. The site was segmented into study areas to facilitate completion of the assessment.

The results of the Site-Wide Ecological Risk assessment indicate a number of contaminants are present in soil, surface water, and sediment in concentrations that may pose a risk to ecological receptors. The constituents exhibiting concentrations above benchmark toxicity values are listed below by media. All scenarios under the Drinking Water section assume receptors rely exclusively on the listed sources for drinking water.

- Soil
  - Aluminum
  - Antimony
  - Cadmium
  - Lead
  - Manganese
  - Molybdenum
  - Silver
  - Thorium
  - Uranium
  - Zinc
  - Benzo(a)anthracene
  - Benzo(g,h,i)perylene
  - Benzo(a)pyrene
  - Benzo(b)fluoranthene
  - Benzo(k)fluoranthene
  - Chyrsene
  - Dibenzo(a,h)anthracene
  - Indeno(1,2,3-cd)pyrene
- Sediment
  - Barium
  - Cyanide
  - Cadmium
  - Iron
  - Lead
  - Manganese
  - Phenanthrene
  - Uranium
  - Zinc
- Surface Water
  - Aluminum
  - Ammonia
  - Barium
  - Cadmium
  - Cyanide
  - Lead
  - Manganese
  - Mercury
  - Silver
  - Bis(2-ethylhexyl)phthalate
  - Di-n-octyl phthalate
- Drinking Water
  - Drainage ditches (terrestrial receptors)
    - Aluminum
    - Beryllium
    - Cadmium
    - Mercury
    - Uranium
    - Trichloroethylene
    - Tetrachloroethene
    - 1,2-dichloroethene
  - Paddys Run
    - Aluminum
    - Cadmium
    - Lead
    - Bis(2-ethylhexyl)phthalate
    - Di-n-octyl phthalate
  - Great Miami River
    - Aluminum
    - Beryllium
    - Mercury
    - Cadmium
    - Bis(2-ethylhexyl)phthalate

A more complete and detailed discussion of benchmark toxicity values is contained in Appendix B of the Operable Unit 5 RI Report.

1.5.4 Uncertainties Identified Through the Remedial Investigation

This section discusses potential limitations of the characterization identified in the Operable Unit 5 RI report and how these are addressed in the FS. The primary objective in characterizing the nature and

extent of contamination in the RI was to collect data sufficient to:

- Perform the baseline and ecological risk assessments
- Support the development and evaluation of remedial alternatives under the FS for Operable Unit 5.

Characterization activities performed under the Operable Unit 5 RI focused on obtaining the quality and quantity of data necessary to meet the stated RI objectives.

During the course of collecting and evaluating data for the Operable Unit 5 RI, the reduced quality or quantity of certain data sets imposed limits in meeting the stated RI objectives. Data limitations identified in the RI Report and the approach adopted in the FS to address each of these limitations are discussed further in Section 2.0.

A significant number of identified data limitations were resolved within the scope of the RI. Uncertainties requiring further definition will be addressed through post-FS confirmatory sampling and treatability studies. Refinements of Operable Unit 5 characterization data, exposure assessment models, and risk characterization information could further reduce uncertainties in the RI and in the baseline risk assessment methods. However, the projected baseline risk greatly exceeds acceptable regulatory thresholds for remedial action; therefore, no significant benefit would be gained in the baseline risk assessment from refinement of the data. While the RI data yielded concentrations in the horizontal and vertical distribution of contamination for various contaminants, the available data did provide an adequate basis for estimating volumes of affected media and evaluating remedial alternatives.

1.5.5 Postremediation Investigation Information

An additional investigation was conducted following the completion of the RI as a supplement to the fate and transport modeling performed as part of this FS. This investigation was conducted to provide additional information on the leachability of uranium in surface and subsurface soils outside the former production area that have been affected by air deposition. Further details of the investigation can be found in the Operable Unit 5 K_l Study Report (Draft).

Fate and transport modeling conducted for the FS examines the potential for cross-media impacts to the Great Miami Aquifer from the presence of surface and subsurface soil contaminants. Leachability of the soil (a key component of cross-media impact evaluation) is represented in the model by a source-loading term (K_l). The rate of movement of the leached contaminants (also a key component) is represented in the model through the soil-to-water partitioning coefficient (K_d). The percent of extractable contaminant (K_e) is also a major modelling component. The purpose of this investigation was to refine the K_l values for soil in low-concentration contaminated areas affected by air deposition.

Soil samples from six vertical intervals were collected at 15 locations within the FEMP property boundary, but outside the former production area. The locations of these samples were based on prevailing wind directions, source locations, and soil type. Sampling locations were biased toward areas of known or suspected surface soil contamination. Discrete soil samples were collected for dry bulk density analyses from intervals at 0 to 6 and 24 to 30 inches from an area adjacent (within a 3-foot radius) to each sampling location. Soil samples were collected from the 0- to 2-, 6- to 12-, 12- to 18-, 18- to 24-, and 24- to 30-inch intervals at each location. The 2- to 6-inch intervals within the vertical soil sample interval were not analyzed but were segregated and returned to the top of the excavated area during abandonment of the sampling site.

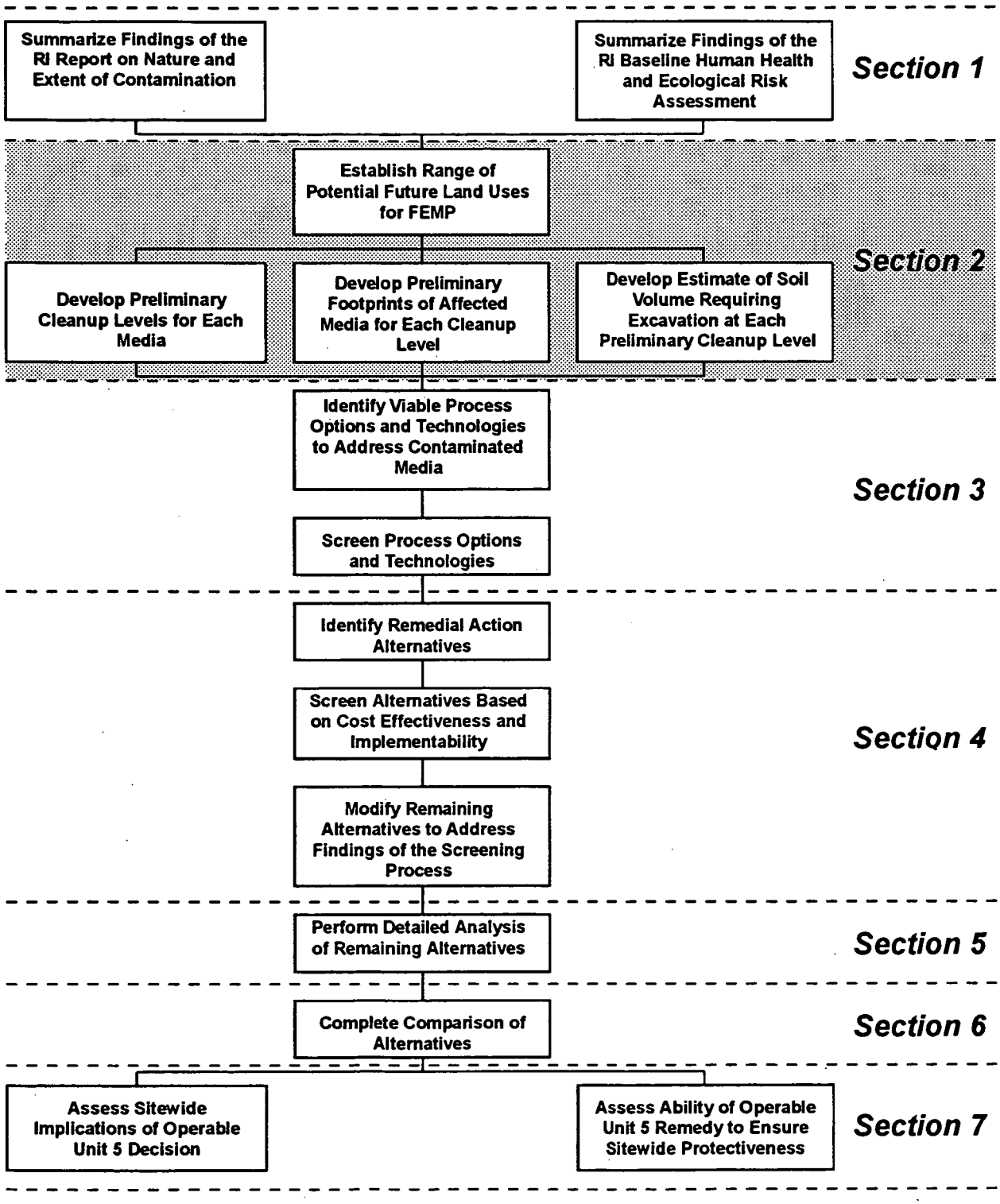
Soil sample analyses were conducted for the list of parameters contained in Table 3-1 of the Project-Specific Plan for Operable Unit 5 K_l Soil Sampling and Analysis, July 1994. The analytical results were expected to be used in risk assessment calculations; therefore, laboratory method detection limits and highest allowable minimum detectable concentrations were set at or as near as technically feasible to a level approximating a 1×10^{-6} ILCR for each contaminant for the RME farmer/child risk scenario. These levels for the RME farmer are presented in Section 2 and Appendix B.

The fate and transport modeling for the Operable Unit 5 FS has assigned a K_l and a K_e of 100 percent as modeling parameters. Conceptually, for a contaminated soil K_e will decrease with time and K_l based only on the extractable mass remains the same when extractable contaminant mass is dissolving. As a result, K_l based on the total mass will increase with time.

Soil samples collected for the K_l study exhibit a K_l ranging from 365 to 5060 for the 0- to 2-inch sampling interval and ranging from 628 to 37,991 for the 24- to 30-inch interval. Two locations at the 0- to 2-inch interval had K_l values of 74 and 125; these sampling locations are thought to be in a disturbed area and the resulting values are suspect.

In general, the soil exhibited high K_l values and low K_e values. This implies the overall uranium mass in FEMP soil does not readily leach and the extractable percentage of overall uranium mass is low. These field results agree with the parameters used for fate and transport modeling.

Section 2.0


Summarize Findings of the RI Report on Nature and Extent of Contamination
Summarize Findings of the RI Baseline Human Health and Ecological Risk Assessment
Section 1
Establish Range of Potential Future Land Uses for FEMP
Develop Preliminary Cleanup Levels for Each Media
Develop Preliminary Footprints of Affected Media for Each Cleanup Level
Develop Estimate of Soil Volume Requiring Excavation at Each Preliminary Cleanup Level
Section 2
Identify Viable Process Options and Technologies to Address Contaminated Media
Screen Process Options and Technologies
Section 3
Identify Remedial Action Alternatives
Screen Alternatives Based on Cost Effectiveness and Implementability
Modify Remaining Alternatives to Address Findings of the Screening Process
Section 4
Perform Detailed Analysis of Remaining Alternatives
Section 5
Complete Comparison of Alternatives
Section 6
Assess Sitewide Implications of Operable Unit 5 Decision
Assess Ability of Operable Unit 5 Remedy to Ensure Sitewide Protectiveness
Section 7

2.0 REMEDIAL ACTION OBJECTIVES AND ESTIMATES OF AFFECTED MEDIA

The purpose of this section is to develop remedial action objectives (RAOs) for the Operable Unit 5 Feasibility Study (FS) and to estimate the volumes of media requiring remediation in order to achieve those objectives. RAOs are site-specific, qualitative and, according to the National Contingency Plan (NCP), specify contaminants and media of concern, potential exposure pathways, and remediation goals. These objectives serve as the framework for the remainder of the FS and are used to develop and evaluate candidate remedial alternatives with respect to their ability to protect public health and the environment.

For purposes of this FS, the RAOs have adopted concentration-based preliminary remediation levels (PRLs) as the quantitative goals for the cleanup of the affected environmental media. PRLs have been developed for viable residual risk targets associated with a range of potential future land uses for the Fernald Environmental Management Project (FEMP) site. These future land uses are referred to as land use objectives. The range of land use objectives was strategically defined to bracket the combinations of potentially viable future uses for the FEMP property.

Estimates of the volumes and areas of media impacted (i.e., those media containing contaminants above the PRLs) were derived for a range of potential risk levels under each land use objective. These estimates, presented in Section 2.12, were developed using site characterization data from the Operable Unit 5 RI Report (DOE 1995e). The volumes and areas of affected media presented in this section serve as the foundation for development and evaluation of remedial action alternatives. They are used throughout the remainder of this report to judge the viability of technologies and process options (as presented in Section 3.0), as well as to size and estimate the cost for specific remedial alternatives (Sections 4.0 and 5.0).

The process described in this section produced estimates of media volumes and the areal extent of affected media which are of sufficient accuracy to support an unbiased comparison of remedial alternatives. Typically, there is significant uncertainty associated with such estimates, primarily attributable to the quantity and quality of available site characterization data. While the FEMP has conducted extensive sampling of the environmental media on and in the vicinity of the FEMP, uncertainty exists in the data set due to the large number of constituents considered and the relatively large area over which they are distributed. This uncertainty was acknowledged in Section 7.0 of the Operable Unit 5 RI Report (DOE 1995e). Section 2.14 of this FS addresses these uncertainties and the approach adopted within the FS to facilitate the fair comparison of alternatives. In all cases, conservative assumptions were consistently applied across all alternatives.

Verification sampling and real-time monitoring will be required as part of any selected remedy for Operable Unit 5 to verify the vertical and horizontal boundaries of impacted media before and during field implementation of remedial actions. Moreover, certification sampling will be performed following remedial actions to confirm that RAOs have been attained.

Potential risks associated with exposures related to contamination were assessed in detail in Section 6.0 and Appendix A of the Operable Unit 5 RI Report. The results of this baseline risk assessment identified the constituents of concern (COCs) in Operable Unit 5 media used to establish the RAOs. Contaminated media in Operable Unit 5 are as follows:

- Soil not associated with other operable units
- Discrete perched groundwater zones within the site property boundary
- Multiple groundwater plumes in the Great Miami Aquifer
- Limited volumes of contaminated sediment within Paddys Run and on-property drainage ditches
- Soil and concrete rubble adjacent to the FEMP outfall line to the Great Miami River.

A groundwater removal action is ongoing to remove and treat groundwater from the Great Miami Aquifer in an area south the FEMP. This removal action has been considered in the development and evaluation of remedial alternatives for Operable Unit 5.

The development of Operable Unit 5 RAOs is presented in Sections 2.1 through 2.12. Section 2.1 describes the technical approach employed to derive preliminary remediation goals (PRGs), PRLs, and finally RAOs. Section 2.2 describes the range of potential future land uses considered for the FEMP following remediation and defines the critical receptors who may be impacted by the residual risks remaining at the site following remedial actions. Section 2.3 identifies the COCs which must be considered when establishing PRGs. Section 2.4 summarizes the risk-based PRGs developed for the critical receptors to each of the environmental media. Section 2.5 summarizes the results of a screening process applied to the risk-based soil PRGs, designed to strategically reduce the number of cases examined in the development of remedial alternatives. Following screening, more detailed modeling was conducted to derive cross-media-based PRGs (termed CPRGs) for soil and perched water. These CPRGs are presented in Section 2.6.

Section 2.7 presents the chemical-specific applicable or relevant, and appropriate requirements (ARARs) and benchmark toxicity values (BTVs) for ecological receptors which must be considered for each COC in establishing the modified PRGs and the PRLs. Section 2.8 discusses the derivation of modified PRGs. Sections 2.9 and 2.10 discuss analytical detection limits and background

concentrations, respectively, which are key considerations in the derivation of PRLs. PRLs are presented in Section 2.11 for each media for the COCs for each critical receptor associated with the identified land use objectives. Finally, Section 2.12 presents RAOs for Operable Unit 5.

The RAOs, and more importantly the PRLs, are used to develop risk cases for each land use objective. These risk cases and target residual risk levels for each of the affected media are used throughout the remainder of the FS as the basis for development and evaluation of remedial action alternatives. Section 2.13 identifies the risk cases for the land use objectives and uses the associated PRLs to estimate the volume of media which must be addressed in order to achieve the RAOs. Finally, Section 2.14 describes the data limitations from the Operable Unit 5 RI Report and explains how those data limitations are being addressed to ensure that Operable Unit 5 RAOs will be met.

2.1 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

RAOs are site-specific and qualitative and specify contaminants and media of concern, potential exposure pathways, and remediation goals. Fundamental to the development of RAOs is the identification of media-specific remediation goals. These concentration-based remediation goals are derived for each COC in the affected media to ensure the protection of human health and the environment. The U.S. Department of Energy (DOE) used a multistep process, shown in Figure 2-1, to determine the cleanup levels for individual media that will meet this objective. The process was initiated with the development of risk-based PRGs and was finalized with the identification of PRLs, which are used to guide the development and evaluation of remedial alternatives. PRLs differ from PRGs in that PRLs consider the site-specific, naturally occurring background concentrations of the constituent in their derivation. PRLs also consider analytical limitations that affect the ability to detect the constituents in environmental media. These PRLs are then used as the contaminant-specific remediation goals to develop the RAOs.

The DOE has developed a range of alternatives presented in Section 4.0, which combine engineering controls with proprietary institutional controls to arrive at cost-effective remedial actions for Operable Unit 5. Proprietary institutional controls include restrictions placed on land use through rights-of-ownership and such measures as deed restrictions. For purposes of this FS, proprietary institutional controls would include controls placed on future land use through continued federal ownership. PRGs were developed to support the selection of PRLs and in turn the development and evaluation of a range of alternatives in the remainder of this report.

Operable Unit 5 extends over a large geographic area (by comparison to previously evaluated operable units) and wide variations exist in the physical and chemical characteristics of the soil. Traditionally PRGs are derived based on direct pathways from the source media to people. For

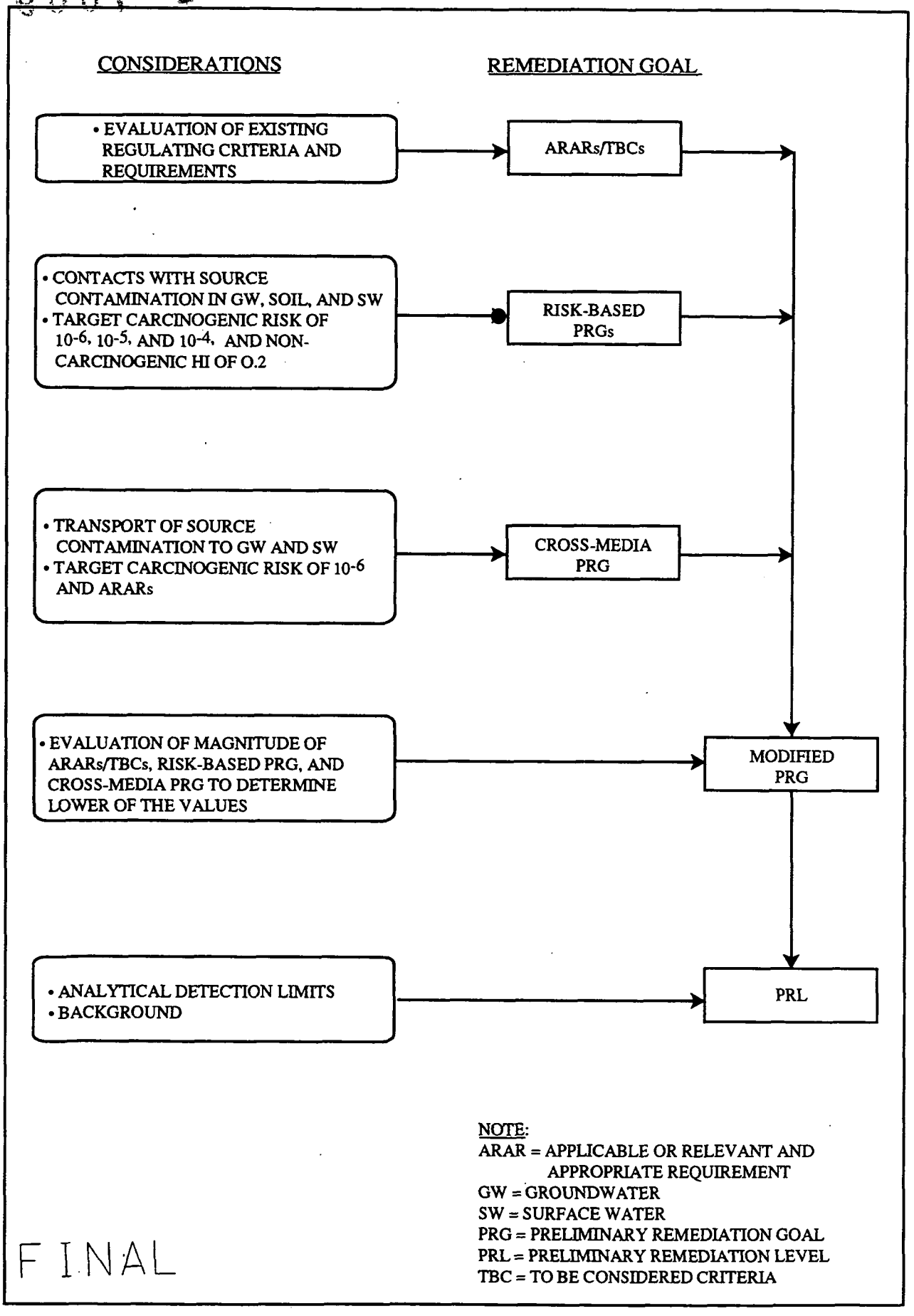


FIGURE 2-1. REMEDIATION LEVEL DETERMINATION PROCESS

example, U.S. Environmental Protection Agency's (EPA's) Risk Assessment Guidance for Superfund, Part B, Development of Risk-Based Preliminary Remediation Goals, suggests that PRGs for inorganic chemicals in soil be calculated by evaluating risk from inhalation of resuspended dust, dermal contact with soil, and incidental ingestion. This method does not take into account the potential for leaching of the contaminants from the soil (the source medium) into groundwater (the exposure medium) followed by consumption by people.

Under normal environmental conditions this is a reasonable approach; however, evaluation of the FEMP site has demonstrated that such indirect exposures or cross-media impacts (i.e., soil contaminant leaching to groundwater) can, in certain environmental settings, be more significant than the risk associated with direct media pathways (inhalation, dermal contact, and incidental ingestion). Therefore, for Operable Unit 5, DOE has modified the PRG development process to weigh cross-media impacts, termed cross-media PRGs (CPRGs), against direct media risks to establish final PRGs (termed modified PRGs) that are protective of human health and the environment.

Potential health effects resulting from exposures to radioactive and chemical contaminants are divided into two categories: carcinogenic and noncarcinogenic. For carcinogens, EPA has identified, in the NCP, a target range for incremental risks of 10^{-6} to 10^{-4}, or 1 in 1,000,000 to 1 in 10,000, to limit the possibility that an individual will develop cancer due to exposures to residual contaminants at a National Priorities List (NPL) site. As part of cleanup at sites named to the NPL, EPA strives to manage possible incremental cancer risks within that target range.

For noncarcinogens, EPA guidance provides that individuals be protected from health effects other than cancer by proposing that potential intakes or dermal exposures to a toxic chemical are maintained below the reference dose. The ratio of a chemical's actual or potential dose via one pathway to a reference dose set by EPA is referred to as its hazard quotient (HQ). The cumulative effects from all chemicals and all pathways is represented by the hazard index (HI), which is the sum of the HQs from all chemicals and pathways evaluated. Maintaining a receptor's HI below 1.0 is considered, under the NCP, to provide an adequate level of protection.

For sites where the total estimated incremental lifetime cancer risk (ILCR) for each receptor is less than 10^{-4} and the HI is less than 1.0, remedial actions may not be warranted. However, the total incremental risk should be in the range of or less than 10^{-4} after remediation and have a total HI of less than 1.0 for the noncarcinogenic toxic effects. The NCP targets the use of an ILCR of 10^{-6} as the point of departure for establishing whether response actions are warranted at a cleanup site.

In conjunction with the risk-based evaluations, chemical-specific ARARs and requirements to be considered (TBCs) that define health-based levels must also be used in the decision making process to

determine whether remedial actions are warranted at a site. For groundwater actions, the maximum concentration levels (MCLs) and nonzero MCL goals (MCLGs) presented in the Safe Drinking Water Act are generally used to gauge whether remedial action is warranted.

Although the upper end of the risk-based target range may be used to make risk management decisions to determine if remedial actions are necessary or warranted, EPA does not consider 1×10^{-4} a discrete limit. That is, risks above 1×10^{-4} (e.g., 4×10^{-4}) may be considered acceptable based on site-specific conditions (EPA 1991). In addition, factors other than the results of the site-specific risk assessment are used to make the final risk management decision, including conservative assumptions applied to estimate risks from possible exposures at the site and other health-based guidance available for certain constituents.

The methods and assumptions used to estimate carcinogenic and noncarcinogenic effects from exposures to site constituents are described in Appendix A of the Operable Unit 5 RI Report and are also described in Appendix C of this FS. The discussions presented in the remainder of this section are based on those detailed analyses.

One goal of the NCP is to manage total, site-wide risks such that the sum of all risks does not exceed 10^{-4}. The target risk of 10^{-6} for individual chemicals suggested as the point of departure by EPA (1991) was used as a target risk level for calculating PRGs.

EPA indicates that the cumulative site HI should be less that 1.0. However, no EPA guidance is available for apportioning the allowable level among the range of constituents in various environmental media. The most relevant guidance is provided by the Office of Drinking Water which, in calculating MCLGs, uses a relative source contribution factor to account for other sources of exposure (EPA 1989a) which results in a target HI of 0.2. DOE has elected to use this value as a point of departure for development of PRGs for individual noncarcinogens contributing to the total HI.

2.1.1 Methods

The following steps were used in deriving modified PRGs, PRLs and RAOs. The adopted technical approach for the derivation of PRGs and PRLs is displayed in Figure 2-1. While risk-based PRGs were calculated for critical receptors associated with each media for the three target risk levels (10^{-6}, 10^{-5}, and 10^{-4}) and an HI of 0.2 (Appendix C), modified PRGs and PRLs are presented for a reduced range of target risk levels. This reduced range is focused on those modified PRGs and PRLs which were considered as potentially viable for the FEMP site. Target risk levels yielding concentration-based preliminary cleanup levels considered inappropriate or nonprotective based upon cross-media impacts were screened from further consideration. The intent of the screening is to streamline the

alternative evaluation process and focus on the range of potential remediation levels considered viable for the site. This final range of PRLs for each media are then used as the foundation for development of the specific risk cases considered for the estimation of the areas and volumes of affected media in Section 2.13. These risk cases link together target risk levels for each media for each COC, which are subsequently used throughout the remainder of the report for remedial alternative development and analysis.

PRG Development

- Step 1: An evaluation of the potential postremediation land uses was made. The land use is important in determining likely receptors who may be exposed to residual concentrations of contaminants residing in environmental media following remediation. Based on the projected land use, receptors were identified and exposure scenarios developed which detail the potential exposure routes and exposure durations for each receptor (see Section 2.2).

- Step 2: From data developed in the Operable Unit 5 baseline risk assessment, COCs were selected by medium as those constituents contributing greater than a 10^{-7} ILCR or having an HI greater than 0.1 for the hypothetical on-property farmer. Additionally, this initial list of COCs was expanded to consider constituents from the other four operable units and the HWMUs (see Section 2.3).

- Step 3: For each COC a scenario-medium-specific, risk-based PRG was calculated for each receptor, using a target HI of 0.2 for non-carcinogenic effects and/or the selected target risk level for carcinogenic effects (either 10^{-6}, 10^{-5} or 10^{-4}) (see Section 2.4 and Appendix C).

- Step 4: A screening process, employing simplified modeling assumptions, was performed on the risk-based PRGs for soil based upon potential cross-media impacts to the Great Miami Aquifer (see Section 2.5).

- Step 5: To account for potential indirect exposures resulting from cross-media impacts (e.g., soil leaching to groundwater), cross-media risk-based PRGs were back-calculated to develop the required concentration in the source medium that corresponds to the target carcinogenic or noncarcinogenic risk level in the exposure medium. Additionally, ARARs/TBCs were identified for potentially impacted exposure media (e.g., MCLs) and cross-media PRGs (CPRGs) were similarly back-calculated as the maximum concentration in the source medium which would not exceed the identified ARAR in the exposure medium (see Section 2.6).

- Step 6: Pertinent ARARs/TBCs were identified for the source medium. For radionuclides, dose-based ARARs and TBCs were included in the evaluation (see Section 2.7).

- Step 7: For a selected risk level, the final PRG (i.e., modified PRG) for a source medium was derived by selecting the minimum value from among the COC source-medium risk-based PRG, the cross-media PRG based on exposure-media risk, the ARAR-based PRGs, and any ARARs and TBC criteria. This comparison of the various

methods ensures, to the extent that data are available, that the modified PRG is protective of human health and the environment considering both direct and indirect exposure routes (see Section 2.8 and Section F.3.0 of Appendix F).

PRLs Development

- Step 8: Analytical detection limits were arrayed for each COC in a solid and liquid matrix. These detection limits were considered in the development of PRLs as identified in Figure 2-1 (see Section 2.9).

- Step 9: The background concentration of COCs present in the environmental media was summarized for consideration in the development of PRLs, as identified in Figure 2-1. These background values were identified in the Operable Unit 5 RI Report (see Section 2.10).

- Step 10: For the radionuclides within each media, background was added to the modified PRG (except for ARAR-based PRGs) and compared against the analytical detection limit. The higher of the two values was adopted as the PRL. For the non-radiological parameters within each media, the modified PRG was compared against the background values and analytical detection limits for the individual COCs. The highest of the three values was adopted as the PRL (see Section 2.11).

- Step 11: PRLs that exceed the benchmark toxicity values (BTVs) for constituents identified in the Site-Wide Ecological Risk Assessment (DOE 1995e) as CPCs for ecological receptors were identified (see Section 2.11).

RAO Development

- Step 12: Qualitative objectives were developed for each environmental media for both human health and environmental protection. These objectives were then appropriately linked to the contaminant-specific, concentration-based PRLs for each affected media (see Section 2.12).

As referenced above, Sections 2.2 through 2.12 present more detail on each of the steps applied in the development of PRGs, PRLs, and RAOs.

2.2 LAND USE OBJECTIVES AND ASSOCIATED RECEPTORS

In an effort to ensure that an appropriate level of information is provided to support an informed remedy decision for Operable Unit 5, a broad range of land use objectives was developed with the intent to bound the range of viable future land uses for the site. The land use objective concept is a planning-level approach for assessing projected future land uses of the FEMP adopted for the purpose of developing and evaluating remedial action alternatives for the FS. Associated with each land use objective are receptors (e.g., residential user, agricultural user, commercial/industrial user, and recreational user) that are used to develop the corresponding risk-based PRGs.

By using a land use objectives approach to formulate the alternatives, the decision maker is provided with a comprehensive but manageable array of alternatives from which to evaluate technical site constraints, required administrative controls, and the overall cost implications of moving from totally restrictive to progressively less restrictive land use possibilities.

The prevailing land use in the FEMP area, residential farming was used as a point of departure for establishing potential future land uses. The FEMP would likely revert to this use if no administrative or development controls were put in place, and thus it serves as the "base case" land use for comparison purposes.

The Operable Unit 5 RI Report/Baseline Risk Assessment (DOE 1995e) presented risk information for a range of receptors under current and future land-use scenarios. The assumptions and receptors considered in the RI Report are refined in the FS to provide the range of information necessary to support informed decisions regarding potential remedial actions.

The land use objectives presented in this FS are intended solely for the identification of potential receptors to be used in the development of preliminary remediation levels for the FEMP and surrounding area. It is not the intent of the FS to recommend the ultimate use of federal land which comprises the FEMP. The interests and desires of the local citizens regarding the use of FEMP on-property areas are being compiled and evaluated by the Fernald Citizens Task Force, an independent group of interested community members formed to address this issue. The results of their study will be forwarded to the DOE for consideration.

Table 2-1 summarizes the land use objectives considered under the Operable Unit 5 FS. The table also shows the receptors associated with each land use objective that were considered in determining preliminary remediation levels. Each of the four land use objectives and the associated receptors for the soil and groundwater pathways are described in greater detail in the following paragraphs.

2.2.1 Land Use Objectives

Land Use Objective 1 - Full Unrestricted Use

In accordance with the Risk Assessment Work Plan Addendum (DOE 1992a), and to ensure consistency with EPA's Risk Assessment Guidance for Superfund, Part B, Development of Risk-Based PRGs, the development of PRGs for Operable Unit 5 evaluates a future land use scenario which includes termination of federal ownership of the FEMP. Under this scenario, the facility is assumed to revert to the primary use of land surrounding the FEMP, a family farm. While operation and maintenance are assumed to continue throughout the duration of on-property remedial actions, active maintenance is assumed to cease thereafter.

TABLE 2-1

RECEPTORS CONSIDERED UNDER EACH OF THE FOUR LAND USE OBJECTIVES

Land Use Objective		Soil and Groundwater Pathway Receptor	
1	Full unrestricted land use.	On Property	Reasonable maximum exposure (RME) resident farmer
		Off Property	RME resident farmer
2	Maximum consolidation of contaminated media to free the majority of the FEMP for unrestricted land use	On Property	(In consolidation area): expanded trespasser
		On Property	(Outside consolidation area): RME resident farmer
		Off Property	RME resident farmer
3	Maximum consolidation of contaminated media to free the majority of the FEMP for restricted land use. Restricted land uses evaluated include industrial use and recreational use in the form of a developed or undeveloped park	On Property	(In consolidation area): expanded trespasser.
		On Property	(Outside consolidation area): industrial user, recreation user (developed park) or recreational user (undeveloped park)
		Off Property	RME resident farmer
4	Continued federal ownership of the entire FEMP with consolidation of a portion of the contaminated media, but with no consideration for release of the remaining portions of the property for alternate land uses	On Property	Expanded trespasser
		Off Property	RME resident farmer

The reasonable maximum exposure (RME) resident farmer was assumed as both the on-property and off-property receptor for development of the PRLs. This scenario was examined to assess risk for the least restrictive potential future land use.

Land Use Objective 2 - Maximum Consolidation of Contaminated Material to Free the Majority of the FEMP for Unrestricted Land Use

This objective incorporates on-property waste consolidation and passive institutional controls to maximize FEMP on-property areas which can be released for alternative land uses. The federal government is assumed to retain ownership of the FEMP waste consolidation area and to take those actions necessary to preclude access to, or development within, the consolidation area. At the discretion of the federal government, land outside the waste consolidation area could be released for unrestricted use. Under Land Use Objective 2, the land outside the waste consolidation area is assumed to revert to a family farm. As with Objective 1, operation and maintenance are assumed to continue throughout the duration of on-property remedial actions. For purposes of the FS, active maintenance is assumed to continue within the consolidation area for 50 years after completion of remedial action. Active maintenance requirements are assumed to be re-assessed at the conclusion of this time period and extended if deemed appropriate by EPA. Examples of maintenance include fence repair or repair of erosion on a disposal facility cap. A long-term surveillance and monitoring program is assumed to be in place at the site to ensure continued performance of the disposal system. Five year CERCLA protectiveness reviews are assumed to be performed by EPA as provided for in the Amended Consent Agreement.

The Expanded Trespasser was assumed as the RME receptor within the FEMP consolidation area. Outside the consolidation area, the RME resident farmer was assumed as both the on-property and off-property receptor for derivation of PRLs.

Land Use Objective 3 - Maximum Consolidation of Contaminated Material to Free the Majority of the FEMP for Restricted Land Use

This objective assesses the potential contaminated soil volume and cost implications associated with restricting the potential future use of FEMP property which surrounds the on-property consolidation area. Like Objective 2, this scenario assumes that contaminated materials are consolidated into a centralized waste management area in order to maximize the land area which can potentially be released for alternative land uses. The federal government is assumed to retain ownership of the FEMP consolidation area and to take those actions necessary to prevent development within the consolidation area. At the discretion of the federal government, land outside the waste consolidation area could be released for restricted use. Alternative uses considered under Land Use Objective 3 include development as an industrial park, use as a developed recreational park, or use as an undeveloped recreational park.

Operation and maintenance are assumed to continue throughout the duration of on-property remedial actions. For purposes of the FS, active maintenance is assumed to continue within the consolidation area for 50 years after completion of remedial actions. Active maintenance requirements are assumed to be reassessed at the conclusion of this period and extended if deemed appropriate by EPA. Examples of maintenance include fence repair or repair of erosion on a disposal facility cap. A long-term surveillance and monitoring program is assumed to be in place at the site to ensure continued performance of the disposal system and ensures that institutional controls and remedial systems are maintained over the long term. Five-year CERCLA protectiveness reviews are assumed to be performed by EPA as provided for in the Amended Consent Agreement.

The expanded trespasser was assumed as the RME receptor within the FEMP consolidation area. Outside the consolidation area, the derivation of PRLs considered multiple on-property receptors including an industrial user, a recreational user of a developed park, and a recreational user of an undeveloped park. The RME resident farmer was assumed as the off-property receptor for derivation of PRLs.

Land Use Objective 4 - Continued Federal Ownership With No Consideration of Alternative Land Uses

This objective considers the continued use of FEMP property as a government reserve with the federal government retaining ownership of the property, exercising the rights of ownership to preclude further development for commercial, residential, or farming purposes. This scenario does not propose the purchase of additional land for inclusion in the reserve, nor does it assume any form of active access restrictions to the property following the completion of remedial actions and attainment of site-wide remediation goals. It is assumed that the FEMP property would be fenced, and that *No Trespassing* and *No Hunting* signs would be posted. This retention of ownership would support application of the proprietary form of institutional control.

Operation and maintenance are assumed to continue throughout the duration of on-property remedial actions. For purposes of the FS, active maintenance is assumed to continue within the consolidation area for 50 years after completion of remedial actions. Active maintenance requirements are assumed to be reassessed at the conclusion of this period and extended if deemed appropriate by EPA. Examples of maintenance include fence repair or repair of erosion on a disposal facility cap. A long-term surveillance and monitoring program is assumed to be in place at the site to ensure continued performance of the disposal system. Five-year CERCLA protectiveness reviews are assumed to be performed by EPA as provided for in the Amended Consent Agreement.

For this land use, an expanded trespasser is used as the RME receptor for development of risk-based PRGs for the retained property. For off-property locations, land use is expected to remain

agricultural in the future and this was assumed in developing PRLs for these locations. This scenario, then, typifies an on-property RME, given that institutional controls will discourage public use of the facility.

2.2.2 Receptor Scenarios

Soil and Groundwater Receptor Scenarios

In the agricultural/family farm scenario considered under Land Use Objectives 1 and 2, the FEMP site is assumed to be declared surplus (this applies only to that area outside the waste consolidation area under Land Use Objective 2) and sold to private individuals for unrestricted use (no deed restrictions). The principal land use under this scenario is farming. A family farm is assumed to be established on the FEMP property, growing crops and raising dairy and beef cattle.

For PRG development, the on-property resident farmer and child are assumed to be exposed to COCs in the soil from the inhalation of dust and volatile compounds, consumption of farm products contaminated by dust deposition, oral ingestion of soil, dermal contact, and external radiation pathways associated with the soil. The on-property resident farmer and child are assumed to be exposed to COCs in groundwater through ingestion (without treatment), inhalation during showering and dermal contact while bathing. The resident child is evaluated separately to examine noncarcinogenic effects to this sensitive receptor. The receptor pathways are summarized in Table 2-2 for each medium and include cross-media impacts.

In the commercial/industrial user scenario considered under Land Use Objective 3, that portion of the FEMP site surrounding the consolidation area is assumed to be developed for commercial/industrial use. Deed restrictions or continued ownership by the federal government are assumed to be used to ensure that development is controlled and the establishment of residential or agricultural land uses are precluded. For purposes of the FS, the commercial/industrial user is represented by the groundskeeper receptor. The groundskeeper is defined as a full time employee who does not reside on-property, but works on the property maintaining fences, cutting grass, performing general maintenance, and providing site security.

The groundskeeper is exposed to potential contaminants in surface soil through inhalation of dust, gases and volatile compounds. The groundskeeper receptor is also impacted by surface soil through ingestion of resuspended particulates, dermal contact, and direct (gamma) radiation exposure. The

TABLE 2-2
SUMMARY OF RECEPTOR EXPOSURE PATHWAYS BY LAND USE

Land Use and Receptor	Medium	Exposure Route	Cross-Media	Exposure Route
Land Use Objectives 1 and 2				
On-/Off-property Farmer (adult/child)	Soil	- Incidental ingestion - Dermal contact - Direct radiation - Fruits/Vegetables - Meat/Milk	Air	- Inhalation
			Perched groundwater	- Direct engestion - Dermal contact - Inhalation of volatiles/radon
			Groundwater (GMA)	- Direct ingestion - Dermal contact - Inhalation of volatiles/radon - Meat/Milk - Fruit/Vegetables
	Perched groundwater	- Direct ingestion - Inhalation of volatiles/radon - Dermal contact	Groundwater (GMA)	- Direct ingestion - Dermal contact - Inhalation of volatiles/radon - Meat/Milk - Fruit/Vegetables
	GMA groundwater	- Direct ingestion - Dermal contact - Inhalation of volatiles/radon - Meat/Milk - Fruit/Vegetables		
Expanded Trespasser/ Recreational User	Sediment	- Incidental ingestion - Dermal contact - Direct radiation		
	Surface water	- Incidental ingestion - Dermal contact		
Consumer of Meat and Milk	Surface Water	- Ingestion of meat/milk		

TABLE 2-2 (Continued)

Land Use and Receptor	Medium	Exposure Route	Cross-Media	Exposure Route
Land Use Objective 3				
Commercial industrial user	Soil	- Incidental ingestion - Dermal contact - Direct radiation	Air	- Inhalation
Recreational user (developed and undeveloped park)	Soil	- Incidental ingestion - Dermal contact - Direct radiation	Air	- Inhalation
	Surface water	- Ingestion/Wading - Dermal contact/Wading		
Expanded trespasser/recreational user	Sediment	See Land Use 1		
	Surface Water	See Land Use 1		
Consumer of meat and milk	Surface Water	See Land Use 1		
Land Use Objective 4				
Expanded trespasser	Soil	- Direct radiation - Incidental ingestion - Dermal contact	Air	- Inhalation
	Surface water	- See Land Use 1		
	Sediment	- See Land Use 1		

000115

7069

groundskeeper does not drink or bathe in groundwater originating from the site and does not consume food products grown on or near the FEMP.

In the recreational user scenarios considered under Land Use Objective 3, that portion of the FEMP site surrounding the consolidation area is assumed to be maintained as either a developed park or undeveloped park. Deed restrictions or continued ownership by the federal government would ensure that the appropriate land use is maintained. The receptors representing the RME users include:

- The developed park user - encourages longer exposure times due to the presence of rest rooms and developed recreational facilities which would allow increased duration of activities. Pathways of exposure include inhalation of particulates and gases, external radiation, incidental ingestion, and dermal contact with surface soil. The groundwater pathway is not developed because, for the developed park user, there is no viable means of exposure through the groundwater pathway.

- The undeveloped park user - no rest rooms or developed recreational facilities are presented in this scenario, with the exception of walking trails and open grassy areas which would allow picnicing, ball playing, and riding of bikes. Exposure pathways are the similar to the developed park user, but with a reduced duration of exposure.

For the use of the FEMP property under the assumption that it is maintained as a government reserve (Land Use Objective 4) it is assumed that the property is not productively used for any specific purpose. Two receptors were evaluated for the soil pathway under this land use: the expanded trespasser and the trespassing child. The expanded trespasser scenario was evaluated because it represents a reasonable maximum estimate of exposures under the assumption that the federal government continues to exercise its rights of ownership to preclude site development for residential, farming, industrial/commercial, and recreational uses.

The expanded trespasser receptor is assumed to be an individual who trespasses on the property during childhood and also during adulthood, perhaps for roaming, hiking, birding, or similar activities. The expanded trespasser is assumed to be exposed to soil contaminants through oral ingestion, dermal contact, inhalation of dust and volatile compounds, and external radiation pathways. Groundwater PRGs are not developed for the expanded trespasser because there are no viable pathways of exposure.

As a subpopulation, the trespassing child is evaluated under the future land use with continued federal ownership scenario for noncarcinogenic effects. Because of the high intake of contaminants relative to body weight, this receptor scenario may yield the more restrictive PRG for some of the COCs.

For all four land use objectives, the single off-property receptor considered was the off-property resident farmer. The off-property resident farmer is assumed to be indirectly exposed to soil within the Operable Unit 5 area through the inhalation of volatile compounds and resuspended dust containing COCs and the consumption of farm products (e.g., milk, meat, and vegetables) contaminated by dust deposition. The farmer is also assumed to use water from the Great Miami Aquifer for irrigation and household use.

For each land use objective, differing groundwater receptors were considered. For all land use objectives, a minimum protectiveness goal was established for the Great Miami Aquifer in recognition of its status as a sole-source aquifer, offering it protected status as a valued natural resource. This goal provides that an objective of Operable Unit 5 remedial actions would be to restore the aquifer such that the concentrations of site-related contaminants would be reduced to below those levels considered health protective for a resident user of the Great Miami Aquifer. Additionally, the objective was extended to ensure continued protection of the aquifer such that concentrations do not exceed these thresholds over the long-term (i.e., up to 1000 years into the future). In keeping with this goal, groundwater receptor scenarios were appropriately aligned with the land use objectives.

Under Land Use Objectives 1 and 2, the hypothetical on-property farmer is assumed to establish a well at any point on-property (except in the consolidation area for Land Use Objective 2) within the Great Miami Aquifer. Similarly for Objectives 1 and 2 (and all other land use objectives), the off-property farmer is assumed to establish a well at any point off-property within the Great Miami Aquifer. Pathways of exposure include those previously described for the resident farmer.

While it is assumed that the on-property target receptors for Land Use Objectives 3 and 4 do not have a viable pathway for exposure to groundwater, for purposes of this FS, PRGs and CPRGs were established based upon protecting the aquifer so that existing and proposed MCLs would be attained over the long-term at every point within the aquifer system underlying the FEMP or extending off-property. For those constituents which do not have an MCL or proposed MCL, a scenario consistent with the resident farmer was adopted for groundwater within the aquifer for all points under the site.

For perched groundwater, potential direct consumption is only considered as viable under Land Use Objectives 1 and 2. Due to the limited yields of the perched water system, exposures were only considered for the direct consumption pathway. To provide a reasonable limitation in the application of the direct consumption scenario, only those perched water systems capable of producing a sustained yield of greater than 1 gpm were considered as viable for supporting the direct consumption pathway. All contaminated perched water systems were evaluated as a potential source for cross-media impacts to surface water and the Great Miami Aquifer.

Sediment Receptor Scenarios

Sediment contained in on-property drainage ditches (excluding the storm sewer outfall ditch and Paddys Run) were considered to have the same receptor exposure scenarios as soil. The expanded trespasser scenario considers potential exposures to sediment contained in Paddys Run, the storm sewer outfall ditch, and the Great Miami River. Pathways for this receptor include incidental ingestion and dermal contact. This receptor scenario was applied to each land use objective for the derivation of PRGs and PRLs.

Surface Water Receptor Scenarios

Two receptor scenarios were evaluated for surface water in Paddys Run and the Great Miami River: the consumer of meat and milk and the recreational user/ expanded trespasser. The consumer of meat and milk is assumed to consume products from cows that used the surface water for consumption. The recreational user/ expanded trespasser is assumed to use the surface water for recreational purposes with potential exposure to contaminants through incidental ingestion and dermal contact.

Neither of the receptor scenarios presented are controlling for all COCs; therefore, both were evaluated in PRG development. The above receptor scenarios were also conservatively applied to each land use objective for the derivation of PRLs. A more detailed description of all receptors is included in Appendix C.

2.3 CONSTITUENTS OF CONCERN

The Operable Unit 5 baseline risk assessment evaluated constituents of potential concern (CPCs) and exposure pathways to ascertain their present and potential future impacts on human health. Not all CPCs identified in the Operable Unit 5 baseline risk assessment pose significant health risks, and many need not be considered in future remedial activities. Contaminants of concern are those constituents that remain a concern following analysis in the baseline risk assessment process. Only those contaminants identified as posing a concern at the site need be considered in the development of the FS. The purpose of restricting the number of COCs in the FS remedial alternative evaluations is to focus on the contaminants which require the implementation of remedial actions to ensure the protection of human health and the environment.

The NCP establishes a general point of departure for acceptable risk as one in a million (10^{-6}) for carcinogenic compounds including radionuclides. The acceptable limit for noncarcinogenic effects is a hazard index (HI) of 1.0. An HI of greater than 1.0 is considered indicative of a potential toxic effect. However, because multiple contaminants are considered, the screening point for selection of COCs for this FS is set at an ILCR of 10^{-7} and an individual HI of 0.1 to the hypothetical on-property farmer to ensure no significant COCs are ignored. Any contaminant with a risk level or HI less than this FS screening point for all media/pathway/receptor combinations is not considered further.

Constituents of concern by media, as developed in the Operable Unit 5 RI, are listed in Table 2-3. For groundwater these constituents were selected based on the previously discussed criteria and include those contaminants that have the potential to migrate to the Great Miami Aquifer over the long term (1000 years) at concentrations representing a risk. Table 2-3 also lists those COCs which were identified by other operable units, and may potentially impact environmental media. The previously discussed risk-based criteria were used in selecting these COCs.

Several of the COC's identified are regulated under the Resource Conservation and Recovery Act (RCRA). These hazardous constituents were found in soil and groundwater from various sources within the FEMP property boundaries. Several of these COCs may be attributable to spills, leaks and de-minimis process losses not related to HWMUs. Other COCs found in the glacial overburden may be a result of leaks and spills from processes performed in the HWMUs. The hazardous constituents from the HWMUs have EPA waste codes that define them either as "listed" or characteristically toxic. Tracking the COCs with waste code listings from the HWMUs to the underlying soil and groundwater may not be possible for most of the HWMUs. Table 2-3 shows the COCs adopted for this FS which are associated with the HWMUs.

2.4 RISK-BASED PRELIMINARY REMEDIATION GOALS

Risk-based PRGs were developed for critical receptors for each of the affected environmental media for the land use objectives. The risk-based PRGs were calculated using the equations and parameters for all exposure pathways as detailed in the Risk Assessment Work Plan Addendum (DOE 1992a) and the Operable Unit 5 baseline risk assessment for all receptors. For PRG development, a target risk for both chemical and radiological carcinogenic effects of 10^{-4}, 10^{-5}, and 10^{-6} were employed to derive PRGs for each of the receptors. A target HI of 0.2 was employed for noncarcinogenic effects. The risk-based PRGs are presented in Appendix C, along with a tabulation of the associated exposure parameters and example calculations.

2.5 SCREENING TO ENSURE PROTECTION OF GROUNDWATER

For purposes of reducing the number of target residual risk levels and associated risk-based PRGs considered in alternative evaluation, a screening process was adopted for impacted soil. This screening process is discussed in Section F.3.4.1 of Appendix F. The premise behind the screening process was to derive the maximum uranium concentration which could reside within the soil at the site and still ensure the continued (i.e., up to 1000 years into the future) protection of the Great Miami Aquifer. For this screening process a protectiveness goal was adopted to ensure that groundwater concentrations of uranium do not exceed the proposed federal drinking water standards of 20 ppb at any point in the aquifer system following the completion of remedial actions.

TABLE 2-3

CONSTITUENTS OF CONCERN IN EACH MEDIUM FOR EACH OPERABLE UNIT[a]

Constituent	OU1	OU2	OU3[b]	OU4	OU5
Radionuclide					
Cesium-137	Sed, SW, Soil	Soil, Sed	Soil		Soil
Neptunium-237	Soil, Per	Soil, Sed, GW, SW	Soil		Soil, GW, SW, Per
Protactinium-231				Soil	
Lead-210				Soil	Soil, Per, SW, Sed
Plutonium-238	Per, Soil, GW	Sed, Soil, SW	Soil		Soil, SW, Per
Plutonium-239	Sed, Soil	Soil, Sed, SW	Soil		Soil, SW, Per
Plutonium-240		Soil, Sed, SW	Soil		Soil, SW, Per
Radium-226		Sed, Soil, GW, SW	Soil	Soil	Soil, GW, Per, SW, Sed
Radium-228	Per, Soil, GW	Sed, Soil, GW, SW	Soil	Soil	Soil, GW, SW, Sed
Radon-222[c]	Air	Air	Air	Air	Air
Ruthenium-106		Sed			Soil
Strontium-90	SW, Soil, Per	Sed, Soil	Soil	Soil	Soil, GW, SW, Per
Technetium-99	Soil, SW, GW, Per	Soil, GW, Per, Sed	Soil	Soil	Soil, GW, Per, SW
Thorium-228	Soil, Per, GW, Sed	Sed, Soil	Soil	Soil	Soil, Per, SW, Sed, GW
Thorium-230	Soil, Per, GW	Sed, Soil, SW	Soil	Soil	Soil, Per, SW, GW
Thorium-232	Soil, Per, Sed	Sed, Soil	Soil	Soil	Soil, Per, SW, Sed, GW
Uranium-234	Soil, SW, Per, GW	Sed, GW, Soil, SW	Soil	Soil	Soil, GW, Per, SW
Uranium-235	Soil, SW, Per, GW, Sed	Sed, Soil, GW, SW	Soil		Soil, GW, Per, SW, Sed
Uranium-236		Sed, Soil, GW, SW	Soil		Soil, GW, Per, SW, Sed
Uranium-238	Soil, SW, Per, Sed, GW	Sed, GW, Soil, SW	Soil	Soil	Soil, GW, Per, SW, Sed
Chemical					
Acenaphthene		Soil	Soil	Soil	
Acetone			Soil, HWMU	Soil	Soil
Alpha-chlordane					GW, SW
Anthracene			Soil	Soil	
Antimony	Soil		Soil	Soil	Soil, GW, SW, Per
Aroclor-1221			Soil		
Aroclor-1248	Soil		Soil		
Aroclor-1254	Soil	Sed, Soil	Soil		Soil, SW, Sed, GW

TABLE 2-3 (Continued)

Constituent	OU1	OU2	OU3[b]	OU4	OU5
Chemical (continued)					
Aroclor-1260	Soil	Soil	Soil		Soil, SW, Sed, GW
Arsenic	SW, Soil, Sed	Sed, Soil, SW	Soil	Soil	Soil, SW, Sed, Per, GW
Barium		Soil, SW	Soil, HWMU	Soil	Soil, SW, Per, GW
Benzene			Soil, HWMU		GW, SW , Per
Benzoic acid			Soil	Soil	
Benzo(a)anthracene	Soil	Sed, Soil	Soil	Soil	Soil, SW
Benzo(a)pyrene	Soil	Sed, Soil	Soil	Soil	Soil, SW
Benzo(b)fluoranthene	Soil	Sed, Soil	Soil	Soil	Soil
Benzo(g,h,i)perylene		Sed, Soil	Soil	Soil	
Benzo(k)fluoranthene		Sed, Soil	Soil		Soil
Beryllium	Sed, Soil	Sed, Soil, GW	Soil	Soil	Soil, GW, SW, Per
Beta-BHC			Soil		Soil
Bis(2-chloroisopropyl)ether					Soil, GW, SW
Bis(2-ethylhexyl)phthalate		Sed, Soil, SW	Soil	Soil	Soil, Per, SW, GW
Boron	GW, Per				Soil, GW, Per
Bromodichloromethane			Soil		Soil, GW, SW
Bromomethane					GW, SW, Soil
2-Butanone			Soil	Soil	Soil
Butylbenzyl phthalate			Soil		
Cadmium	Soil	Sed, Soil, SW		Soil	Soil, Per, SW, GW
Carbazole		Per, Sed, Soil			Soil, GW, Per
Carbon disulfide			Soil		Per, GW
Carbon tetrachloride			Soil, HWMU		Per
4-Chloro-3-methylphenol			Soil		
Chlorobenzene			Soil		
Chloroethane			Soil		GW
Chloroform			Soil		GW, SW, Per
Chromium VI	Per, Soil	Sed, Soil		Soil	Soil, GW, SW
Chrysene	Soil	Sed, Soil	Soil		Soil
Cobalt		Sed, Soil	Soil		GW
Copper	Per	Soil	Soil	Soil	Soil, Per, SW, GW
Cyanide		Soil	Soil	Soil	SW, GW, Soil
4,4-DDE		Soil			
Dibenzo(a,h)anthracene		Soil	Soil	Soil	Soil, SW
3,3-Dichlorobenzidine					SW, Soil
1,1 -Dichloroethane			Soil	Soil, GW	Soil, GW
1,2-Dichloroethane			Soil		GW, Per
1,1-Dichloroethene					Soil, SW, Per, GW
1,1-Dichloroethylene			Soil		

TABLE 2-3 (Continued)

Constituent	OU1	OU2	OU3[b]	OU4	OU5
Chemical (continued)					
1,2-Dichloroethylene			Soil		Per
Dieldrin		Soil			SW
Diethyl phthalate			Soil		
Di-n-butyl phthalate		Sed	Soil	Soil	SW
Di-n-octyl phthalate			Soil		Soil, SW
Endrin		Soil			
Ethylbenzene			Soil, HWMU		
Ethylether			HWMU		
Fluoranthene		Sed	Soil	Soil	
Fluorene			Soil		
Fluoride					Soil, GW, Per, SW
Heptachlorodibenzo-p-dioxin	Soil, GW	GW, Per			Soil
Heptachlorodibenzofuran	Soil, GW				Soil
2-Hexanone			Soil		
Indeno(1,2,3-cd)pyrene	Soil	Sed, Soil	Soil	Soil	Soil
Lead		Soil, Sed, SW, GW	Soil, HWMU		Soil, SW, Sed
Manganese	Per, GW, Soil	Sed, SW	Soil		Soil, GW, Per, SW, Sed
Mercury	Soil	GW	Soil, HWMU		Soil, GW, SW
Methanol			HWMU		
Methylene chloride		Soil	Soil, HWMU	Soil	Soil, GW, Per, SW
2-Methylnaphthalene		Soil	Soil		
4-Methyl-2-pentanone			Soil, HWMU		
4-Methylphenol					SW, Soil, GW
Molybdenum	Per, Soil	GW		Soil	Soil, Per, GW
Naphthalene			Soil		
Nickel	Per, Soil	Soil	Soil	Soil	Soil, SW, GW
Nitrate					Soil, GW, Per, SW
4-Nitrophenol					Soil, GW, SW
N-Nitroso-di-n-propylamine			Soil		Soil, Per
N-Nitrosodiphenylamine			Soil		Soil, Sed
Octachlorodibenzo-p-dioxin	Soil, GW				Soil
Octachlorodibenzofuran					Soil
Pentachlorophenol	Soil				Per
Phenanthrene		Sed, Soil	Soil	Soil	
Phenol			Soil	Soil	

TABLE 2-3 (Continued)

Constituent	OU1	OU2	OU3[b]	OU4	OU5
Chemical (continued)					
Pyrene		Sed	Soil	Soil	
Selenium		Soil, SW	Soil		Soil, GW
Silver	Soil, Per, SW		HWMU		Soil, Per, GW
Styrene			Soil		
1,1,2,2-Tetrachloroethane			Soil		Soil, Per
1,1,1-Trichloroethane			Soil, HWMU		SW
1,1,2-Trichloroethane			Soil		SW, Per
Tetrachlorodibenzo-p-dioxin	Soil, GW	GW			
Tetrachlorodibenzofuran		Soil	Soil		
Tetrachloroethene					Soil, SW, Per
Thallium	Sed, Soil	Sed, Soil		Soil	Soil, Per
Toluene		Soil	Soil, HWMU	Soil	
Tributyl phosphate			Soil		Per
Trichloroethene			Soil, HWMU		Soil, GW, Per
Vanadium	Soil	Soil		Soil	Soil, Per, SW, GW
Vinyl chloride			Soil		Soil, GW, Per
Xylenes (Total)			Soil, HWMU	Soil	
Zinc	Soil, Per	Soil	Soil	Soil	Soil, SW, GW

[a] Abbreviations used in this table:

GW = Groundwater
Sed = Sediment
Per = Perched Groundwater
SW = Surface water
HWMU = Hazardous Waste Management Unit

[b] COCs for Operable Unit 3 were taken from the SWCR. COCs for Operable Units 1, 2, 4, and 5 were taken from their respective RI reports.

[c] Radon was the only COC detected in on-site air samples. However, all surface soil COC exposures through particulate inhalation are evaluated quantitatively in the CRARE.

Consistent with this protectiveness goal, a limiting CPRG for soil was derived to screen risk-based PRGs for different hypothetical on-property receptors. The CPRG for uranium in soil, used as the basis for the screening process, was developed assuming an area with a 20 foot thickness of gray clay, a 1-foot thick layer of residual contaminated soil, and a uranium leaching coefficient (K_l) of 325 L/kg. Using the ECTran model with the listed parameters yielded a value of 154 ppm for total uranium. Based upon actual conditions at the site (i.e., distributions of gray clay thickness and uranium K_l values), this CPRG is considered to reside at the high end of the range of potential CRPG values, and thus represents the upper limit from which to assess the protectiveness of the PRGs. All PRGs with a higher value than the screening level CPRG would be screened from further consideration.

The results of applying this screening process to the risk-based PRGs for soil developed in Appendix C is summarized in Table 2-4. The PRGs presented are for total uranium. These PRGs are based upon uranium-238 assuming a natural distribution of major uranium isotopes. The risk-based PRG cases screened out by this process (i.e., cases with a uranium soil PRG higher than 154 ppm) were eliminated from further consideration in the FS process for the development of final remediation levels. The risk-based PRGs and receptor scenarios passing through the screen were considered viable and potentially available for use in the development of remedial alternatives.

2.6 CROSS-MEDIA PRELIMINARY REMEDIATION GOALS

Following the initial screening process, a more detailed location-specific analysis was conducted to identify all potential cross-media impacts. This detailed analysis is presented in Sections F.3.0 and F.4.0 of Appendix F. Cross-media impacts occur when contaminants from waste or an environmental medium, such as soil, are transported into another environmental medium and result in the potential for secondary exposure to a receptor. When this occurs, receptors can be exposed to these contaminants by an exposure pathway indirectly related to the original contaminant source.

One key example of a cross-media exposure is the leaching of contaminants from soil into groundwater. In this situation, a receptor is potentially exposed to these contaminants not only by direct soil pathways but also by all additional pathways attributable to groundwater use (i.e., drinking water, dermal contact while bathing, irrigation of crops and consumption of foodstuffs). In Appendix F, Section F.3.0 develops soil CPRGs derived from contaminant transport to other media through the groundwater pathway, and Section F.4.0 evaluates additional protectiveness requirements for the air and surface water runoff pathways. The soil CPRGs were a consideration in the derivation of the soil PRLs as previously discussed in Section 2.1. The protectiveness requirements identified for the air and surface water pathways were applied to refine the remedial alternatives.

000124

TABLE 2-4

RESULTS OF RISK-BASED PRELIMINARY REMEDIATION GOALS SCREENING

(Shading denotes screened from further consideration)

Receptor	Total Uranium PRG (ppm)[a]			
	10^{-6}	10^{-5}	10^{-4}	HI=1
RME farmer/child	1.3	13	130[b]	44[c]
Groundskeeper (industrial user)	12	120	1200	250
Developed park user	33	330	3300	1100
Undeveloped park user	77	770	7700	1250
Trespasser (expanded exposure scenario)	120	1200	12000	1000

[a]Rounded to 2 significant figures
[b]Screened based upon use of HI=1 as threshold
[c]HI is for farm child

EPA regulatory guidance on development of PRGs does not require the inclusion of cross-media impacts in the calculation of PRGs. DOE has elected to consider these impacts for Operable Unit 5 to ensure the development of a range of alternatives for analysis. Experience has shown that cross-media impacts are only significant in very mobile inorganic constituents, radionuclides which are very mobile and have long radiological half-lives, and organic constituents which are mobile and do not degrade rapidly in the environment.

Fate and transport modeling is used to relate concentrations in an exposure medium back to the source medium. Once a relationship is established between two media (for example soil as a source medium and groundwater in the Great Miami Aquifer as an exposure medium), critical concentrations are established for the exposure medium which are risk- or regulatory-based (such as a contaminant MCL from 40 CFR 141). Calculations are then made to ascertain the concentration in the source medium necessary to yield the critical concentration in the receptor medium within the 1000-year time frame.

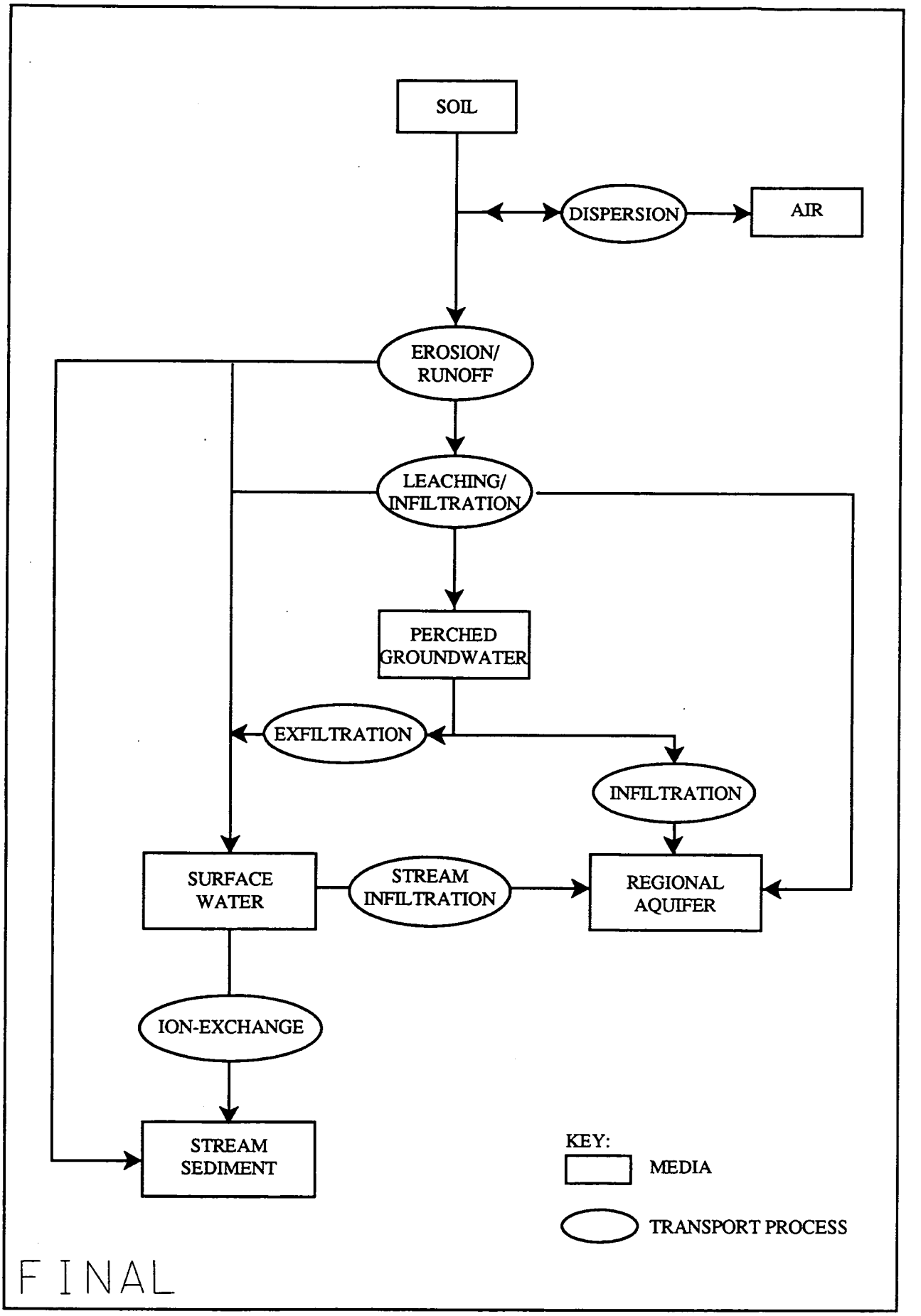
Figure 2-2 graphically represents the interrelationship between the various environmental media of Operable Unit 5 and soil. A number of factors were significant to the development of fate and transport models which were used to assess these cross-media impacts. Included in these are:

- The presence or absence of the glacial overburden and, if present, its thickness
- The presence of continuous sand lenses in the glacial overburden which may allow the lateral transport of contaminants
- The emergence of a sand lens to ground surface allowing perched groundwater transport to a surface water drainages
- The ability of a perched groundwater zone to yield sufficient water to serve as a drinking water source
- The chemical species of the contaminant and its impact on leaching and its mobility in the glacial till and continuous sand lenses.

Based on the foregoing considerations, areas of the site with distinctly different physical and chemical characteristics require the development of location-specific CPRGs that reflect these differences.

Summary maps that identify the location-specific CPRG zones are presented in Section F.2.0 of Appendix F.

Those COCs identified in the baseline risk assessment as contributing 95 percent of the risk to the hypothetical on-property resident farmer who uses the Great Miami Aquifer as a drinking water source were adopted as the COCs appropriate for consideration in the development of CPRGs. This



"ILLUS\OU-5\PO-113\CROSS MED IMPACT.EPS

FIGURE 2-2. CROSS-MEDIA IMPACTS FOR OU5 SOILS

list was then evaluated to determine which of these constituents had a potential to impact the underlying aquifer at a concentration which exceeded a 1 x 10^{-7} ILCR and a hazard quotient of 0.1 to the resident farmer through cross-media transport. CPRGs were derived for those COCs passing this screening criteria.

The following cross-media impacts were evaluated on a location-specific basis for soil as a source medium:

- Risk-based
  - Soil CPRGs were developed using soil contaminant leaching to a perched groundwater supply for areas where sufficient water yield can be obtained to support household use. Groundwater risk-based PRGs are used in calculating the soil CPRG.
  - Soil CPRGs were developed using soil contaminant leaching to the Great Miami Aquifer and its subsequent use as a water supply. Groundwater risk-based PRGs are used in calculating the soil CPRG.
  - Soil CPRGs were developed using soil contaminant leaching to surface water which, in turn, provides an exposure pathway to the user of meat and milk products.
  - Soil CPRGs were developed using soil contaminant transport/leaching to stream sediment followed by incidental ingestion of the sediment. Risk-based sediment PRGs are used to back-calculate a soil CPRG.
- ARAR/TBC Impacts
  - Soil CPRGs were developed using soil contaminant leaching to the Great Miami Aquifer as a protected resource as represented by the attainment of MCLs, proposed MCLs, and nonzero MCLGs at any point in the aquifer.

The CPRGs for soil were calculated by using the medium-specific, risk-based PRGs including ARARs (groundwater PRGs, surface water PRGs, or ARARs/TBCs) and reverse-modeling the fate and transport of the contaminant back to the required concentration in soil that corresponds to the limiting concentration in the exposure medium. The soil cross-media PRGs were derived for each of the areas of common physical conditions discussed earlier to identify which of the potential transport pathways were controlling.

To facilitate the development and presentation of PRGs for soil which could be field implemented as part of a remedial action, the mapping of the common physical attributes of the FEMP property discussed above were then simplified into three zones (see Figure F.3-2), established on the basis of similarities in the geophysical and geochemical characteristics of the soil. The most restrictive physical and geochemical conditions and the controlling transport pathway within each of the

individual zones were applied to the entire zone for each individual COC. The derived CPRGs for each of these zones were then arrayed and the most restrictive value identified for each COC considered. This limiting value was then used in the development of modified PRGs. The CPRG values considered in the development of modified PRGs are presented in Table 2-5. As identified in the table and Figure F.3-2 of Appendix F, two CPRG values are presented for uranium; one for uranium with a K_l of 325 L/kg and one for uranium with a K_l of 15 L/kg. Attachments F.3.I and F.3.II of Appendix F of the Operable Unit 5 RI Report (DOE 1995e) present original data and mapping of the areas of the site projected to exhibit uranium contamination with these leaching coefficients. Results of additional field and laboratory studies which were conducted to support the FS are summarized in Attachment F.2.I of Appendix F of this FS. This K_l mapping for uranium has been applied to aid in the determination of the volume of soil requiring excavation to ensure the protection of the groundwater system, as discussed in Section 2.13.

Table 2-5 presents CPRG values for two cases. First, the CPRG values for COCs in soil are presented based upon protection of the Great Miami Aquifer to an ILCR of 1×10^{-6} (i.e., for total uranium this corresponds to 3 ppb including background) to the resident farmer at any point in the aquifer system. This CPRG value represents the maximum concentration of a COC which could reside in soil at the FEMP site following remedial actions and still ensure the long-term protection of the aquifer at or less than a concentration equivalent to the 1×10^{-6} ILCR level. For purposes of this FS, in establishing PRLs and volumes of affected media, the soil CPRGs for the 1×10^{-6} ILCR level in groundwater were linked with any land use objective contemplating an on-property resident farmer receptor scenario (i.e., Land Use Objectives 1 and 2) at a target residual risk level of 1×10^{-6} to the resident farmer.

Table 2-5 also presents CPRG values for COCs in soil based upon protection of the Great Miami Aquifer to MCL or proposed MCL (or nonzero MCLG) concentrations. For COCs without MCLs or proposed MCLs, a 1×10^{-5} ILCR or HQ of 0.2 to the resident farmer was adopted as the protectiveness objective for calculation of the CPRG.

Cross-media impacts were also considered for soil in contact with perched water. As discussed in Section 4.0, excavation has been adopted as the representative process option for addressing contaminated perched water zones. As part of the evaluation of the required extent of excavation to address perched water, modeling was conducted on an alternative-by-alternative basis to ascertain the incremental volume of excavation required beyond that required to address soil. All COCs present in perched groundwater zones, based upon available Type 1 monitoring well measurements, were screened and modeled to determine the final acceptable extent of excavation. Because the extent of excavation was determined directly through residual contaminant fate and transport modeling, no

TABLE 2-5

PRELIMINARY REMEDIATION GOALS FOR SOIL WITH CROSS-MEDIA IMPACT

Constituent	ILCR of 10^{-6} HI of 0.2[a]	MCL[b]
Radionuclides		
Strontium-90 (pCi/g)	1.35	13.5
Technetium-99 (pCi/g)	3.01	30.1
Total uranium (mg/kg) K_1 = 15[c]	2.5	20
Total uranium (mg/kg) K_1 = 325[c]	13	98
Chemicals		
1,2-Dichloroethane (mg/kg)	0.0025	0.16
Alpha chlordane (mg/kg)	0.003	1.4
Mercury (mg/kg)	0.6	7.5

[a] Soil CPRGs were developed using a resident farmer/child receptor scenario.
[b] Where MCLs not available, an ILCR of 10^{-5} or HQ of 0.2 was used.
[c] Determined from leaching coefficients of 15 and 325 for uranium.
Note: Cross-media preliminary remediation goals were developed in Appendix F.3.0

perched groundwater CPRGs were developed for the FS. Section F.6.0 of Appendix F presents the modeling process and the acceptable extent of excavation for contaminated perched groundwater zones.

2.7 CHEMICAL-SPECIFIC ARARS AND TBC CRITERIA

The proposed Operable Unit 5 ARARs and TBCs are identified in Appendix B. A discussion of the major chemical-specific ARARs and TBCs is presented in this section to assist in the development of PRGs and PRLs.

Chemical-specific ARARs for Operable Unit 5 constituents of concern are arranged in this section according to the following categories:

- Drinking water and groundwater ARARs and TBC criteria
- Surface water ARARs and TBC criteria
- Surface soil ARARs and TBC criteria
- Sediment ARARs and TBC criteria
- Air emissions ARARs and TBC criteria
- Radiation ARARs and TBC criteria
- As low as reasonably achievable (ALARA) requirements.

In addition to the human health-based ARARs and TBCs, ecological criteria BTVs are also presented. The BTVs were developed as part of the Site-Wide Ecological Risk Assessment in the Operable Unit 5 RI Report to identify constituent concentrations for soil, sediment and surface water that are protective of ecological receptors.

2.7.1 Drinking Water and Groundwater ARARs and TBC Criteria

The NCP [40 CFR 300.430 (e)(2)(i)(B)-(D)] states that nonzero MCLGs and the MCLs (if the MCLG is zero) are considered to be relevant and appropriate for any aquifer that is a drinking-water source. Chemical-specific requirements for drinking water and groundwater beneath the site are relevant and appropriate for Operable Unit 5 remedial actions, because the Great Miami Aquifer is a drinking water source. These same requirements would apply to those portions of the perched system that require protection as a groundwater supply, as discussed in the remedial strategy for perched groundwater in Section 4.1.

MCLs and MCLGs (or proposed MCLs) are summarized in Table B-1, Appendix B, for drinking water standards (Safe Drinking Water Act) and the RCRA, Subtitle C and D. Table 2-6 summarizes the COCs found in groundwater with the corresponding MCLs, MCLGs or proposed MCLs from the

TABLE 2-6
GROUNDWATER CHEMICAL-SPECIFIC ARARs AND TBCs

Constituent	Federal Status[b]	U.S. EPA SDWA Standards [a] MCL[c]	MCLG[d]	Ohio Drinking Water MCL[e]
Radionuclides		**(pCi/L)**	**(pCi/L)**	**(pCi/L)**
Radium-226	P	20	0	NA
Radium-228	P	20	0	NA
Radon-222	P	300	0	NA
Strontium-90	F	NA	NA	8
Uranium	P	20 (μg/L)	NA	NA
Chemicals		**(μg/L)**	**(μg/L)**	**(μg/L)[e]**
Antimony	F	6	6	6
Arsenic	*	50	NA	50
Barium	F	2000	2000	2000
Benzene	F	5	0	5
Benzo(a)anthracene	P	0.1	0	NA
Benzo(a)pyrene	F	0.2	0	0.2
Benzo(b)fluoranthene	P	0.2	0	NA
Benzo(k)fluoranthene	P	0.2	0	NA
Beryllium	F	4	4	4
Bis(2-ethylhexyl)phthalate	F	6	0	NA
Bromodichloromethane	T	100	0	100
Butyl benzyl phthalate	P	100	0	NA
Cadmium	F	5	5	5
Carbon tetrachloride	F	5	0	5
Chlordane	F	2	0	2
Chloroform	T	100	0	100
Chromium (total)	F	100	100	100
Chrysene	P	0.2	0	NA
Copper	F	TT[f]	1300	TT[f]
Cyanide	P	200	200	200
1,1-Dichloroethene	F	7	7	7
1,2-Dichloroethane	F	5	0	5
Dibenzo(a,h)anthracene	P	0.3	0	NA
Endrin	F	2	2	2
Ethylbenzene	F	700	700	NA

TABLE 2-6 (Continued)

Constituent	Federal Status[b]	U.S. EPA SDWA Standards [a] MCL[c]	MCLG[d]	Ohio Drinking Water MCL[e]
Chemicals (continued)		(μg/L)	(μg/L)	(μg/L)[e]
Indeno(1,2,3-cd)pyrene	P	0.4	0	NA
Lead	F	TT[f]	0	TT[f]
Mercury	F	2	2	2
Methylene chloride	F	5	0	NA
Molybdenum[g]	F	100	NA	NA
Nickel	F	100	100	100
PCBs	F	0.5	0	0.5
Pentachlorophenol	F	1	0	1
Selenium	F	50	50	50
Silver	P	NA	NA	50
Sulfate	P	500000	500000	NA
Styrene	F	100	100	100
Tetrachloroethene	F	5	0	5
Thallium	F	2	0.5	2
Toluene	F	1000	1000	1000
Total xylenes	F	10000	10000	10000
1,1,1-Trichloroethane	F	200	200	200
1,1,2-Trichloroethane	F	5	3	5
Trichloroethene	F	5	0	5
Vinyl chloride	F	2	0	2

[a]SDWA (Safe Drinking Water Act) standards and health advisories obtained from Drinking Water Regulations and Health Advisories, U.S. EPA, Office of Water. December 1993.
[b]Status Indicators:
F Final
D Draft
L Listed for regulation
P Proposed
T Tentative
* Under Review
[c]MCL - Maximum contaminant level. Only nonzero MCLGs are pertinent under CERCLA.
[d]MCLG - Maximum contaminant level goal. Only nonzero MCLGs are pertinent under CERCLA
[e]State of Ohio Drinking Water MCL (maximum contaminant level) obtained from Bureau of National Affairs, 1991. Environmental Reporter, Ohio Drinking Water Regulations, Sections 3745-81-11, 12,13,14,15, and 16.
[f]Treatment technique
[g]The standard for molybdenum is taken from the Uranium Mill Tailings Radiation Control Act (40 CFR 192.20(a)(2) and (3)).
NA - Information not available

Safe Drinking Water Act. If the natural background level of a chemical is higher than the MCL or MCLG, attainment of the MCL or MCLG is not required. Under this criterion, the standard is not considered relevant or appropriate (EPA 1990a).

2.7.2 Surface Water ARARs and TBC Criteria

CERCLA 121 states that hazardous substances, pollutants, or contaminants left on site at the conclusion of a remedial action shall attain federal water quality criteria where they are relevant and appropriate under the circumstances of the release or threatened release. CERCLA 121(d)(2)(B)(i) requires that this determination be based on the designated or potential use of the water, the media affected, the purpose of the criteria, and current information. The Ohio Environmental Protection Agency (OEPA), which has jurisdiction over surface water bodies in the State of Ohio, has designated the following uses for the Great Miami River and its tributaries (including Paddys Run):

- Warm water aquatic life habitat
- Agricultural and industrial water supply
- Primary contact recreational use.

The definitions of water designation terms from the Ohio Administrative Code (OAC) 3745-1-07 are summarized as follows:

"Warm water" refers to water capable of supporting and maintaining a balanced, integrated, adaptive community of warm water aquatic organisms having a species composition and diversity and functional organization comparable to the 25th percentile at the identified reference sites within each of the following ecoregions: the interior plateau ecoregion, the Erie/Ontario lake plains ecoregion, the western Allegheny plateau ecoregion, and the eastern corn belt plains ecoregion.

"Agricultural water" is water that is suitable for irrigation and livestock watering without treatment.

"Industrial water" is water that is suitable for commercial and industrial uses, with or without treatment.

The "primary contact" designation is a description of recreational use water. This is water that, during the recreational season, is suitable for full-body contact recreation such as swimming, canoeing, and scuba diving with minimal threat to public health as a result of water quality.

The Ohio water quality standards provide limits on the maximum concentration of effluent both inside and outside the "area of initial mixing," where discharge-induced mixing occurs at the end of an effluent line. The "outside mixing zone maximum" concentrations must be met after the effluent and

the receiving water have been determined to be reasonably well mixed. The "maximum 30-day average" concentrations are applicable to the surface water outside the mixing zone over a 30-day period. The criteria listed as "inside mixing zone maximum" concentrations are applicable as end-of-pipe maximum effluent limits or as criteria to be met within a short distance of the effluent pipe if it can be demonstrated that discharge-induced mixing occurs per the definition of "area of initial mixing" in OAC 3645-1-02. The "inside the mixing zone maximum" criteria are applied on a case-by-case basis.

The Ohio water quality standards are specific to the actual or potential uses of surface water. For example, the maximum allowable concentrations for surface water which may impact human health differ from the maximum allowable concentrations in surface water intended for agricultural purposes. The OEPA standards are considered applicable for the direct discharge of wastewater generated during a CERCLA action and are considered relevant and appropriate for use in determining cleanup goals for soil or groundwater that has the potential to impact surface water. The OEPA standards are provided in Table 2-7 and Appendix B, Table B-1. The standards provided in the appendix are in-stream levels established to be protective of the designated uses. Acceptable discharge levels are governed by the most stringent-use standard based on the designated level of protection. The protection levels designated by OEPA are based on minimum low-flow quantities of the receiving stream.

In addition to the Ohio Water Quality Standards, OEPA Policy DSW-DERR 0100.027, National Discharge Elimination System; Wastewater Discharges Resulting from Cleanup of Response Action Sites Contaminated with Volatile Organic Compounds, is evaluated as a TBC. The policy established guidelines for the discharge of wastewater contaminated with volatile organic compounds (VOCs). The policy designates NPDES permits as a requirement for short-term actions such as pumping tests and treatability studies. Long-term actions, including remedial actions, require an NPDES permit as well as best available treatment technology/best demonstrated available control technology for volatile organic compounds.

2.7.3 Soil ARARs and TBC Criteria

Few ARARs or TBCs have been established for soil contaminants. Those which are established are presented below.

- The EPA promulgated standards for radium-226 and radium-228 in soil at uranium and thorium mill tailings sites (40 CFR 192 Subpart B). While the FEMP is not a designated facility under 40 CFR 192, the standards are considered relevant and appropriate to Operable Unit 5 soil and sediment. The type and concentration of radiological contaminants present in Operable Unit 5 soil and sediment are similar in characteristics to soil found at uranium mill tailing sites. These radionuclides are not to exceed background

TABLE 2-7
ARARs/TBCs FOR SURFACE WATER[a]

Parameter (μg/L or as marked)	Outside Mixing Zone: Maximum[b]	Outside Mixing Zone: 30-Day Average[c]	Outside Mixing Zone: Human Health 30-Day Average[d]	Outside Mixing Zone: Agricultural Water Supply 30-Day Average	Inside Mixing Zone Maximum
Antimony (total)	650	190	4,300		1300
Arsenic	360	190		100	720
Benzene	1100	560	710		2100
Beryllium (total) (assumes water hardness of 100 mg/L)	520	23	1.17	100	1000
Bis(2-ethylhexyl) phthalate	1100	8.4	59		2200
Cadmium (total) (assumes water hardness of 100 mg/L)	5.6	1.4		50	11
Carbon tetrachloride	1800	280	44		3500
Chlorobenzene	590	26			1200
Chromium (total) (assumes water hardness of 100 mg/L)	1800	210	3,433,000	100	3600
Chloroform	1800	79			3600
Copper (total) (assumes water hardness of 100 mg/L)	18	12		500	35
Cyanide (free)	46	12			92
1,2-Dichloroethane	12,000	3500	990		24,000
Dieldrin		0.005	0.00076		
Fluoride				2000	
Lead (total) (assumes water hardness of 100 mg/L)	130	6.9		100	260
Mercury (total)	1.1	0.2	0.012	10	2.2
Methylene chloride	9700	430			19,000
Nickel (total) (assumes water hardness of 100 mg/L)	1600	170	4600	200	3100
Pentachlorophenol (at pH of 6.5)	5.3	3.2			11
Polychlorinated biphenyls (PCBs)		0.001	0.00079		
Selenium (total)	20	5.0		50	40
Silver (total) (assumes water hardness of 100 mg/L)	1.6	1.3			3.2
Thallium (total)	71	16	48		140
Zinc (total) (assumes water hardness of 100 mg/L)	120	110		25,000	230

[a] OAC 3745-01-07
[b] Maximum discharge calculations are based on the 7-day, 10-year low flow (Great Miami River = 267 Paddys Run = 0 cfs).
[c] 30-day average discharge calculations are based on the 30-day, 10-year low flow (Paddys Run = 0).
[d] Human health and agricultural water supply criteria discharge calculations are based on the harmonic mean flow (Great Miami River = 3305 cfs).

concentrations by more than 5 pCi/g in the top 15 centimeters of soil or 15 pCi/g in each successive 15-centimeter layer beneath the surface, averaged over an area of 100 square meters.

- The maximum concentration of lead in soil of 400 ppm may not be exceeded whether it is the extract of a waste or a waste treatment residual. This criteria is provided under the Revised Interim Soil Lead Guidance for CERCLA sites and RCRA Corrective Action Facilities, OSWER Directive 9355.40-12, and has been adopted as a TBC for Operable Unit 5 remedial activities.

- The PCB spill cleanup policy is not a binding regulation for the cleanup of PCBs. It is, therefore, not an ARAR but a TBC, as described in Appendix B. The final determination of the PCBs cleanup levels within Operable Unit 5 will be determined through the development of PRLs for each proposed alternative in each land-use scenario considered in this document (Section 4). The final selection of the appropriate cleanup level will be established in the ROD, as NCP guidance suggests for the CERCLA program ("A Guide of Remedial Actions at Superfund Sites with PCB Contamination," OSWER Directive No. 9355.4-01 FS (August 1990).

2.7.4 Sediment ARARs and TBC Criteria

Promulgated criteria have not been established for contaminants in sediment. Additionally, no TBC criteria were identified for sediment. The development of ecological based BTVs for sediment are discussed in Section 2.7.7.

2.7.5 Air Emissions ARARs and TBC Criteria

EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) provide an applicable air emission standard for remedial activities in Operable Unit 5 (40 CFR 61.92). This regulation limits airborne radionuclide emissions from DOE facilities to those amounts that will not cause any member of the public to receive an effective dose equivalent of more than 10 mrem per year.

Subpart A of 40 CFR 192.02 requires that reasonable assurance be provided that releases of radon-222 from residual radioactive material to the atmosphere will not:

- Exceed an average release rate of 20 pCi/m^2/s, averaged over the entire surface of the disposal site over a period of at least a one year

- Increase the annual average concentration of radon-222 in the air at the disposal site or any location outside the disposal site by more than 0.5 pCi/L

This requirement is relevant and appropriate because radium-226, an isotope that decays to form radon-222, has been detected in on-property soil.

The National Ambient Air Quality Standards (NAAQS) would be applicable for remedial treatment units (e.g., soil stabilization) because treatment plants may release airborne pollutants. Any proposed

remedial treatment units for Operable Unit 5 would be designed to maintain the NAAQ Standards for carbon monoxide, nitrogen dioxide, particulate matter (PM_{10}), ozone, sulfur oxides, and volatile organic compounds. These standards are provided in Appendix B. State of Ohio regulations (OAC 3145.31-05[A][3]) require that all new sources of air emissions employ best demonstrated available technology (BDAT) to minimize air emissions of regulated pollutants.

The OEPA Air Toxic Policy would be a TBC for air emissions from any proposed treatment units. Consistent with this policy, if a Class A, B1, or B2 carcinogen is released in an amount which exceeds the de minimis emission levels established in this policy, a health impact/risk assessment study on the carcinogen is to be performed to determine the maximum individual risk. The calculated maximum individual risk must be less than 1.0×10^{-5} for each toxicant. For compounds that are non-carcinogenic, consistent with the OEPA Air Toxic Policy, the maximum acceptable ground-level concentration would need to be met to ensure acceptable ground-level ambient concentrations.

2.7.6 Radiation ARARS and TBC Criteria

The Atomic Energy Act (AEA) requirements for management of radioactive waste are incorporated in DOE Order 5820.2A, developed under the DOE's AEA authority. The order is generally consistent with, and typically includes equivalent Nuclear Regulatory Commission (NRC) 10 CFR Parts 40 and 61 requirements. DOE Order 5820.2A requirements are TBCs which, when included in a CERCLA ROD, are enforceable cleanup standards under CERCLA for DOE facilities.

DOE Orders 5400.5 and 5820.2A provide dose levels for the protection of the general public from releases of radioactivity. Under these requirements, the exposure of members of the public associated with activities at DOE facilities from all pathways must not exceed, in one year, an effective dose equivalent greater than 100 mrem. DOE Order 5820.2A, Chapter III(3), states that the concentrations of radioactive material which may be released from radioactive waste management activities at DOE facilities to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose to any member of the public exceeding 25 mrem.

2.7.7 Ecological Criteria

The Site-Wide Ecological Risk Assessment used BTVs to identify constituent concentrations that are protective of ecological receptors. BTVs identified for nonradiological and radiological COCs in soil, sediment, and surface water were not used in the development of PRLs. However, PRLs exceeding BTVs were identified in the PRL development process. After remediation activities, if residual concentrations for those constituents exceed BTVs, further ecological investigation and cleanup may be warranted. Constituents present in concentrations less than these benchmark values are unlikely to adversely impact ecological receptors.

The bioavailability of contaminants is a function of interrelated chemical and physical processes. Although some models have been developed to predict the bioavailability (and thus toxicity) of contaminants in soil, most benchmark values used in the Site-Wide Ecological Risk Assessment were obtained from benchmark values developed by a number of agencies, including:

- Those established by the Quebec Ministry of the Environment (Direction des Substances Dangereuses 1988)
- Maximum allowable concentrations established by various regulatory agencies for amending farm soil with sewage sludge
- Toxicity values published in journal articles
- EPA Region III Risk-Based Contamination Tables, Second Quarter (EPA 1994).

Although these agencies have identified protective soil contaminant levels from a human health perspective, only a few have developed soil benchmark values that identify ecologically protective soil contaminant concentrations. When possible, the Site-Wide Ecological Risk Assessment preferentially selected those benchmark values that considered impacts to ecological receptors. However, when not available, human health-based values were employed. Soil benchmark values are discussed in greater detail in Appendix B of the Operable Unit 5 RI Report (DOE 1995e); the compiled benchmark values for soil are presented in Table 2-8.

The potential risks to ecological receptors resulting from chronic exposure to low levels of radiological contaminants were also evaluated using a benchmark criterion. As discussed in the publication, Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards (IAEA 1992), there is no convincing evidence from the scientific literature that chronic radiation exposure rates below 36.5 rad/yr will harm animal or plant life. Models were developed to determine media-specific activity concentrations for various radionuclides associated with the FEMP which would result in a combined internal/external exposure rate of 36.5 rad/yr. Radionuclide concentrations lower than these threshold values are presumed not to pose a hazard to ecological receptors. Greater details regarding the development of the models used to establish these concentrations are presented in Appendix B of the Operable Unit 5 RI Report.

Chronic ambient water quality criteria (WQC) developed by EPA and OEPA serve as conservative benchmark values for many of the COCs identified in the Operable Unit 5 ecological risk assessment. WQC were established to protect species from the harmful effects associated with long-term (chronic) exposure to low-level contaminant concentrations. These WQCs were selected as conservative and appropriate screening criteria. However, chronic toxicity data are not uniformly available. Surrogate

TABLE 2-8

BENCHMARK TOXICITY VALUES (BTVs) FOR SOIL FROM THE SITE-WIDE ECOLOGICAL RISK ASSESSMENT

Constituent	Surface Soil	Reference Footnote
Radionuclides	**(pCi/g)**	
Cesium-137+1d	$1.2x10^4$	g
Plutonium-238	$3.8x10^6$	g
Plutonium-239/240	$4.1x10^6$	g
Radium-226+8d	$6.7x10^2$	g
Radium-228+1d	$3.4x10^5$	g
Strontium-90+1d	$2.8x10^3$	g
Technetium-99	$9.3x10^4$	g
Thorium-228+7d	$1.4x10^6$	g
Thorium-230	$2.1x10^5$	g
Thorium-232+10d	$2.4x10^5$	g
Uranium-234	$1.1x10^4$	g
Uranium-235/236	$1.1x10^4$	g
Uranium-238+2d	$1.2x10^4$	g
Chemicals	**(mg/kg)**	
Aluminum	10103	e
Antimony	10	d
Aroclor-1254	1	a
Arsenic	30	a
Barium	500	a
Benzo(a)anthracene	1	a
Benzo(b)fluoranthene	1	a
Benzo(k)fluoranthene	1	a
Benzo(g,h,i)perylene	1	a
Benzo(a)pyrene	1	a
Beryllium	56	e
Bis(2-ethylhexyl)phthalate	70	b

TABLE 2-8
(Continued)

Constituent	Surface Soil	Reference Footnote
Chemicals (continued)	**(mg/kg)**	
Cadmium	5	a
Carbon disulfide	7800	c
Chromium	250	a
Chromium VI	0.05	d
Chrysene	1	a
Copper	100	a
Dieldrin	0.04	c
Indendo(1,2,3-cd)pyrene	1	a
Lead	200	a
Manganese	1500	d
Mercury	5	d
Methylene chloride	85	c
Molybdenum	10	a
Nickel	100	a
Phenanthrene	5	a
Selenium	3	a
Silver	10	a
Tetrachloroethene	25	c
Thallium	6.3	c
Uranium total	230	c
Vanadium	150	f
Zinc	500	a

[a] BTV=Threshold level for contaminated soil (Direction des Substances Dangereuses 1988)
[b] Richardson (1987)
[c] EPA (1994)
[d] Kabata-Pendias and Pendias (1992)
[e] Missouri DNR (1988; Maximum Cumulative Addition)
[f] USSR (1984; Maximum Allowable Concentration)
[g] Calculated in the Site-wide Ecological Risk Assessment

chronic benchmark values were therefore estimated from acute toxicity data in some instances. Acute toxicity is generally expressed as the "LC50" which represents the aqueous concentration of contaminant lethal to 50 percent of a test population. Surrogate chronic benchmark values were derived by dividing available LC50 values by 100. In a number of instances, lowest observable effect concentration values rather than LC50 values were available; these were converted to surrogate chronic benchmark values by dividing by a factor of 10.

Arithmetic average, study area-specific, surface water hardness values (mg $CaCO_3$/L) were used to calculate WQCs for those metals whose toxicity is hardness-dependent. Average site-specific hardness values were calculated for each body of water using the equation provided in Method 314A of Standard Methods. All calcium and magnesium values reported in the RI/FS database for a given body of water were used to determine the concentrations. The number of chemicals under preliminary consideration as final surface water CPCs (e.g., calcium, magnesium, phosphorus, potassium, sodium, and silicon) are also essential nutrients and usually considered to be nontoxic. These chemicals were, therefore, eliminated from further consideration as final surface water CPCs even though they were present in concentrations greater than background concentrations. The remaining chemicals detected in filtered and unfiltered surface water samples were compared to background values. Those chemicals that exceeded background concentrations were then compared to WQC (or surrogate values) and final surface water CPCs were identified.

Unlike surface water, criteria have yet to be established for contaminants in sediment. The current lack of sediment criteria is largely a function of the difficulties associated with identifying biologically available concentrations of sediment contaminants. Adverse impacts associated with contaminated sediment is largely a function of the concentration of contaminants in interstitial water. The absorption/desorption of contaminants from sediment particles into interstitial water is governed by complex interrelated chemical and physical processes. Models have been developed to predict the concentration of non-polar organic contaminants that may be dissolved in interstitial water and therefore become biologically available. However, no equivalent acceptable models currently exist for predicting the partitioning of metals or polar organic compounds between water and sediment particles. As a result of these factors, several approaches were used to develop benchmark toxicity values for sediment. These methods are discussed as part of the Site-Wide Ecological Risk Assessment (Appendix B of the Operable Unit 5 RI Report). These benchmark values are presented in Table 2-9.

2.7.8 ALARA Requirements

In addition to establishing PRLs that comply with ARARs and which are protective of human health and the environment, DOE Order 5400.5 requires that the principles of ALARA be applied to all activities at DOE facilities with a potential for human or environmental exposures to contaminants.

TABLE 2-9

BENCHMARK TOXICITY VALUES (BTVs) FOR SURFACE WATER AND SEDIMENT FROM THE SITE-WIDE ECOLOGICAL RISK ASSESSMENT

Constituent	Water BTVs	Water Notes* a-i	Sediment BTVs	Sediment Notes** a-f
Radionuclides	**(pCi/L)**		**(pCi/g)**	
Radium-226 + 8d	1.2×10^3	h	5.8×10^5	e
Thorium-228 + 7d	1.9×10^3	h	4.9×10^6	e
Thorium-230	2.2×10^3	h	2.9×10^7	e
Thorium-232 +10d	2.5×10^3	h	8.0×10^8	e
Uranium-234	1.9×10^5	h	1.3×10^9	e
Uranium-235/236			2.8×10^4	
Uranium-238 + 2d	2.2×10^5	h		e
Chemicals	**(µg/L)**		**(mg/kg)**	
Aluminum	87	i		
Ammonia	1000	a		
Antimony	190	a		
Arsenic	190	a	33	a
Barium	145	c	40	e
Benzo(b)fluoranthene			210	b,f
Benzo(k)fluoranthene			380	b,f
Benzo(g,h,i)perylene			880	b,f
Benzo(a)pyrene			40i	c,f
Beryllium***	150	a		
Bis(2-ethylhexyl)phthalate	8.4	a		
Cadmium***	3.5	a	5	a
Carbon disulfide	1490	b		
Chromium VI***	11	a	80	a
Chrysene			18	d,f
Copper***	34	a	70	a
Cyanide	12	a	0.1	e
1,2 - Dichlorethene	310	a		

TABLE 2-9
(Continued)

Constituent	Water BTVs	Water Notes* a-i	Sediment BTVs	Sediment Notes** a-f
Chemicals (continued)	**(µg/L)**		**(mg/kg)**	
Indendo(1,2,3-cd)pyrene			2220	b,f
Iron			17000	c
Lead***	30	a	35	a
Manganese	98	d	300	e
Mercury	0.2	a	0.15	a
Methylene chloride	430	a		
Molybdenum	700	e		
Nickel***	470	a	30	a
Selenium	5	a		
Silver	1.3	a	1	a
Tetrachloroethene	73	a		
Thallium	16	a		
Trichloroethene	75	a		
Uranium-total***	890	f		
Vanadium	41	g		
Zinc***	280	a	120	a

*Water notes
a Warmwater (OEPA 1993)
b Verschueren (1983)
c Water quality advisory concentration (EPA 1988a)
d Lowest 48-H LC50/100 (Jorgensen et al., 1990)
e Lowest 96-H LC50/100 (McConnell 1977)
f Parkhurst et al. (1984)
g 48-H LC50/100 (Buesen and Neven 1987)
h Calculated - OU5 RI Appendix B
i BTV = Chronic Ambient Water Quality Criteria (EPA 1988 b,c)

**Sediment notes
a Long and Morgan (1991)
b Lowest 96-H LC50/100 for PAHs (FWS 1987b)
c Lowest 96-H LC50/100 (FWS 1987b)
d Calculated - OU5 RI Appendix B
e Baudo et al. 1990
f Sediment BTVs were converted from AWQC Report

***Hardness-dependent criteria equations:
Beryllium: e (1.609 [ln (HARDNESS mg $CaCO_3$)]-4.266)
Cadmium: e (0.7852 [ln (HARDNESS mg $CaCO_3$)]-3.283)
Chromium: e (0.8190 [ln (HARDNESS mg $CaCO_3$)] + 1.561)
Copper: e (0.9231 [ln (HARDNESS mg $CaCO_3$)]-1.784)
Lead: e (1.279 [ln (HARDNESS mg $CaCO_3$)]-3.965)
Nickel: e (0.8710 [ln (HARDNESS mg $CaCO_3$)] + 1.144)
Uranium: (-2.84 + [0.337 (ALK) + 0.0406 (HARD)]/100)1000
Zinc: e (0.8432 [ln HARDNESS mg $CaCO_3$)] + 0.7799)
Hardness value of 317.98 mg $CaCO_3$/L was based on the average of on- and off-site Ca and mg concentrations in Paddys Run.
Paddys Run Alkalinity = 235.3 mg $CaCO_3$/L.

The goal of the process is to reduce exposures and the risks associated with residual contamination to levels that are as low as reasonably achievable, considering technical, economic, and social constraints, as appropriate. ALARA was considered in the derivation of target risk levels for application to the development and evaluation of remedial action alternatives. More specifically, for the Operable Unit 5 FS, recognition was given to the opportunity to apply best available technology to the detection of select radiological parameters in soil. Where more stringent cleanup levels could be achieved at a reasonable cost through the application of the best available and proven technologies, the more stringent cleanup levels were pursued.

For example, experience at sites similar to the FEMP has identified that the application of hand-held radiological instrumentation can be effective, under certain conditions, in providing real-time, cost-effective data regarding in situ soil concentrations of gamma-emitting radionuclides. Hand-held radiological survey instruments have been effectively used to economically survey large areas of surface soil, providing reasonable indications (relative to the site-specific detection limit of the constituent) of the level of the gamma-emitting radionuclides present. The efficiency of field instrumentation is site specific and is influenced by the type and mix of radionuclides present, the detector efficiency, background radiation fields, and the detection geometry.

Instrumentation in a shielded configuration has been successfully applied at the FEMP in support of removal actions and the Characterization Investigation Study. In general, this experience, coupled with similar experience at other facilities, indicates that hand-held radiological survey instruments can be effectively used for the detection of total uranium in the range of 50 to 100 ppm in surface soil. Consideration of this ability to economically detect uranium contamination in the range of 50 to 100 ppm in surface soil has been included in the development of remedial action alternatives. For alternatives examining soil cleanup levels in the range of 50 to 100 ppm total uranium, an examination was conducted as part of the FS to determine if a lower cleanup level could be economically attained by applying the use of hand-held radiological instrumentation to its lowest projected detection capability (i.e., approximately 50 ppm of uranium).

The ALARA process includes both planning and field components. The discussions presented in this section are consistent with the planning component of ALARA, in which PRGs are estimated for residual contamination based on hypothetical exposures. This initial analysis will be used to support implementation of ALARA in the field, where additional contamination might be removed below those levels determined in the planning phase, when reasonably achievable based on specific field conditions.

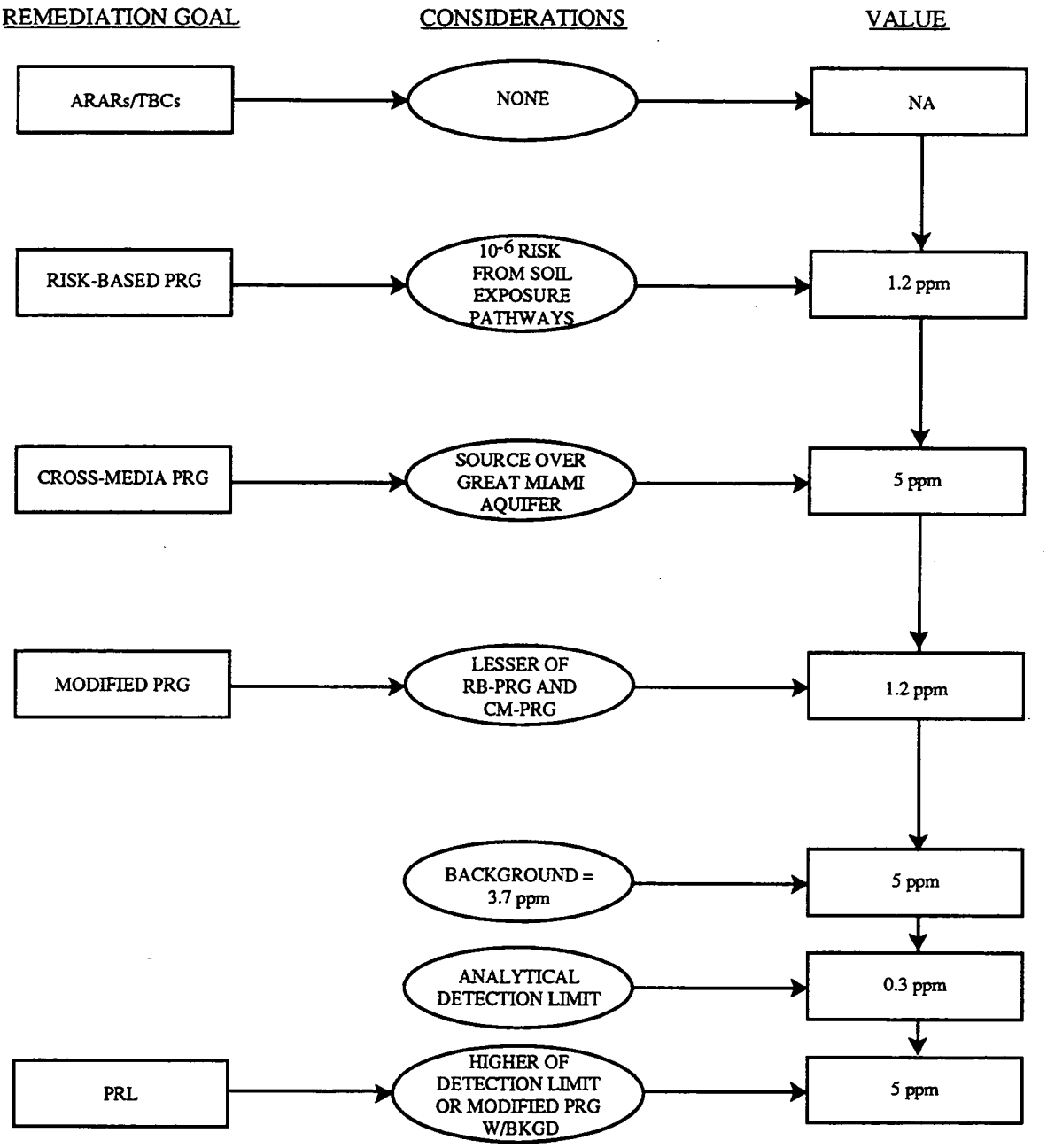
2.8 MODIFIED PRELIMINARY REMEDIATION GOALS

Modified PRGs were developed for each media for each receptor associated with the land use objectives. Modified PRGs, representing an intermediate product in the derivation of PRLs, are not presented. Modified PRGs, as displayed in Figure 2-1, were developed by comparing a risk-based PRG with available ARAR/TBCs and the appropriate CPRG and selecting the lowest of the values.

This process can be illustrated through an example of the development of a 10^{-6} target risk level modified PRG for surface soil contaminated with uranium with a low leaching coefficient (K_l= 15 L/kg) as depicted in Figure 2-3. The receptor for this example is an on-property resident farmer, (land use objectives 1 and 2). After evaluation of available ARARs and TBCs (none exist for uranium in surface soil), the risk-based PRGs presented in Appendix C are examined for surface soil contaminated with U-238 (0.42 pCi/g based on carcinogenic risk) and for total uranium (8.7 ppm based on uranium as a toxicant to the resident child). The risk-based PRGs are calculated in the example for a target risk of 10^{-6} and an HI of 0.2 for incidental ingestion, inhalation of dust particulates, ingestion of crops grown in the soil, and consumption of meat and dairy products. The activity concentration for U-238 is then adjusted on the basis of the assumption of natural distribution of the major uranium isotopes to yield a mass-based concentration of approximately 1.2 ppm. Fate and transport modeling is performed next to determine the concentration of U-238 in the soil which will be protective of the underlying aquifer. A risk-based PRG for U-238 in groundwater (0.86 pCi/L) is used as the target groundwater concentration for this modeling effort. The soil concentration that results in the target concentration (approximately 0.8 pCi/g of U-238 or 2.5 ppm total uranium assuming a natural distribution) in the aquifer is referred to as the cross-media PRG (or CPRG). The risk-based PRG and the CPRG are then compared to determine the lower (i.e., more protective) concentration. The result of this comparison (0.42 pCi/g U-238 or 1.2 ppm total uranium assuming a natural distribution) becomes the modified PRG for uranium in soil for the 10^{-6} target risk level to the on-property resident farmer.

2.9 ANALYTICAL DETECTION LIMITS

Table 2-10 summarizes the lowest reasonably achievable analytical detection limits for Operable Unit 5 COCs, by medium, providing there are no analytical interference problems with the sample. These detection limits were used in the PRL development process for those COCs with risk-based levels that fall below analytical detection limits. The stated detection thresholds for chemical constituents are based on experience at the FEMP regarding actual instrument detection limits reported by subcontract laboratories for requested analyses at analytical support levels (ASLs) C and D conducted under the CERCLA Sitewide Quality Assurance Plan (SCQ). The stated thresholds for radiological analyses are based upon the SCQ detection limits for ASLs C and D. For soil, a 25 percent moisture content was assumed in the detection limit development. For sediment, a 60 percent moisture content was assumed in establishing analytical detection limits.



NOTE:
ARAR = APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENT
GW = GROUNDWATER
SW = SURFACE WATER
PRG = PRELIMINARY REMEDIATION GOAL
PRL = PRELIMINARY REMEDIATION LEVEL

FINAL

\ILLUS\OU-5\PO-1132-SOIL CONTAM U238.EPS

FIGURE 2-3. PROCESS FOR DEVELOPMENT OF A TARGET RISK-LEVEL MODIFIED PRG FOR SOIL CONTAMINATED WITH TOTAL URANIUM FOR THE ON-PROPERTY FARMER

TABLE 2-10

LOWEST REASONABLE AND ACHIEVABLE DETECTION THRESHOLD FOR BOTH CHEMICAL[a] AND RADIOLOGICAL[b] ANALYSIS

	Water	Soil (25% moist)	Sediment (60% moist)
Radionuclides	**(pCi/L)**	**(pCi/g)** [c]	**(pCi/g)** [c]
Cesium - 137	4.0	0.2	0.2
Lead - 210	3.0	0.5	0.5
Neptunium - 237	0.5	0.2	0.2
Plutonium - 238	0.5	0.2	0.2
Plutonium - 239/240	0.5	0.2	0.2
Radium - 226	1.0	0.25	0.25
Radium - 228	3.0	0.5	0.5
Radon - 222	NA	NA	NA
Strontium - 90	1.0	0.5	0.5
Technetium - 99	15.0	1.0	1.0
Thorium - 228	0.2	0.1	0.1
Thorium - 230	0.2	0.1	0.1
Thorium - 232	0.2	0.1	0.1
Uranium (total)	0.1(μg/L) ppb	0.1(mg/kg) ppm	0.1(mg/kg) ppm
Chemicals	**(μg/L) ppb**	**(mg/kg) ppm** [d]	**(mg/kg) ppm** [d]
Acetone	5.0 [e,f]	0.007 [e,f]	0.013 [e,f]
Antimony	2.0 [a]	0.5 [a]	1.0 [a]
Aroclor - 1221	0.4 [e]	0.09 [e]	0.16
Aroclor - 1248	0.2 [e]	0.04 [e]	0.08 [e]
Aroclor - 1254	0.2 [e]	0.04 [e]	0.08 [e]
Aroclor - 1260	0.2 [e]	0.04 [e]	0.08 [e]
Arsenic	5.0 [a]	1.3 [a]	2.5 [a]
Barium	5.0 [a]	1.3 [a]	2.5 [a]
Benzene	1.0 [f]	0.001 [f]	0.003 [f]
Benzo (a) anthracene	1.0 [h]	0.0007 [h]	0.0015 [h]
Benzo (b) fluoranthene	1.0 [h]	0.0007 [h]	0.0015 [h]
Benzo (k) fluoranthene	1.0 [h]	0.0007 [h]	0.0015 [h]
Benzo (a) pyrene	1.0 [h]	0.0007 [h]	0.0015 [h]
Benzo (g, h, i) perylene	1.0 [h]	0.0007 [h]	0.0015 [h]
Beryllium	0.2 [a]	0.05 [a]	0.1 [a]
Beta BHC	0.01 [e]	0.002 [e]	0.004 [e]
Bis (2-Ethylhexyl) phthalate	5.0 [f]	0.22 [f]	0.41 [f]
Bis (2-chloroisopropyl) ether	5.0 [f]	0.22 [f]	0.41 [f]
Boron	15.0 [l]	4.0 [l]	7.5 [l]
Bromodichloromethane	1.0 [f]	0.001 [f]	0.003 [f]
Bromoform	1.0 [f]	0.001 [f]	0.003 [f]
Bromomethane	1.0 [f]	0.001 [f]	0.003 [f]

TABLE 2-10 (Continued)

	Water	Soil (25% moist)	Sediment (60% moist)
Chemicals (continued)	**(μg/L) ppb**	**(mg/kg) ppm[d]**	**(mg/kg) ppm[d]**
2-Butanone	5.0[f]	0.007[f]	0.013[f]
Cadmium	0.4[a]	0.1[a]	0.2[a]
Carbazole	1.0[f]	0.04[f]	0.08[f]
Carbon tetrachloride	1.0[f]	0.001[f]	0.003[f]
Carbon disulfide	1.0[f]	0.001[f]	0.003[f]
Chlordane	0.01[c]	0.002[c]	0.004[c]
Chlorobenzene	1.0[f]	0.001[f]	0.003[f]
Chloroethane	1.0[f]	0.001[f]	0.003[f]
Chloroform	1.0[f]	0.001[f]	0.003[f]
2-Chlorophenol	5.0[f]	0.2[f]	0.4[f]
Chromium (total)	5.0[a]	1.3[a]	2.5[a]
Chromium + 6	10.0[g]	2.7[g]	5.0[g]
Chrysene	1.0[h]	0.002[h]	0.005[h]
Cobalt	1.0[a]	0.3[a]	0.5[a]
Copper	2.0[a]	0.5[a]	1.0[a]
Cyanide	5.0[a]	0.33[a,i]	0.63[a,i]
Di-n-octylphthalate	5.0[f]	0.2[f]	0.4[f]
Dibenzo (a, h) anthracene	1.0[h]	0.0005[h]	0.0015[h]
3,3-Dichlorobenzidene	5.0[f]	0.2[f]	0.4[f]
1,1-Dichloroethane	1.0[f]	0.001[f]	0.003[f]
1,2-Dichloroethane	1.0[f]	0.001[f]	0.003[f]
1,1-Dichloroethene	1.0[f]	0.001[f]	0.003[f]
1,2-Dichloroethene	1.0[f]	0.001[f]	0.003[f]
Dieldrin	0.02[c]	0.004[c]	0.008[c]
Ethyl ether	5.0[f]	0.007[f]	0.013[f]
Ethylbenzene	1.0[f]	0.01[f]	0.003[f]
Fluoride	50.0[a]	0.7[j]	1.25[j]
Heptachlor epoxide	0.01[c]	0.002[c]	0.004[c]
Heptachlorodibenzofuran	0.00005[c]	0.000006[c]	0.000013[c]
Hexachlorodibenzofuran	0.00005[c]	0.000006[c]	0.000013[c]
Hexachlorodibenzo-P-dioxin	0.00005[c]	0.000006[c]	0.000013[c]
Indeno (1,2,3-cd) pyrene	1.0[h]	0.004[h]	0.01[h]
Lead	2.0[a]	0.05[a]	1.0[a]
Manganese	4.0[a]	1.0[a]	2.0[a]
Mercury	0.2[a]	0.13[a,k]	0.25[a,k]
Methanol	160.0[m]	0.2[m]	0.4[m]
4-Methyl-2-pentanone	5.0[f]	0.007[f]	0.013[f]
Methylene chloride	2.0[f]	0.003[f]	0.005[f]
4-Methylphenol	5.0[f]	0.2[f]	0.4[f]
Molybdenum	50.0[a]	13.0[a]	25.0[a]
N-nitroso-di-n-propylamine	5.0[f]	0.2[f]	0.4[f]
N-nitroso-diphenylamine	5.0[f]	0.2[f]	0.4[f]

TABLE 2-10 (Continued)

	Water	Soil (25% moist)	Sediment (60% moist)
Chemicals (continued)	**(μg/L) ppb**	**(mg/kg) ppm [d]**	**(mg/kg) ppm [d]**
Nickel	15.0 [a]	4.0 [a]	7.5 [a]
Nitrate	8.0 [n]	N/A	N/A
4-Nitroanaline	20.0 [f]	0.9 [f]	1.7 [f]
4-Nitrophenol	20.0 [f]	0.9 [f]	1.7 [f]
Octachlorodibenzofuran	0.0001 [e]	0.000013 [e]	0.000025 [e]
Octachlorodibenzo-p-dioxin	0.0001 [e]	0.000013 [e]	0.000025 [e]
Pentachlorodibenzofuran	0.00005 [e]	0.000006 [e]	0.000013 [e]
Pentachlorophenol	20.0 [f]	0.9 [f]	1.7 [f]
Phenanthrene	1.0 [h]	0.001 [h]	0.003 [h]
Selenium	5.0 [a]	1.3 [a]	2.5 [a]
Silver	5.0 [a]	1.3 [a]	2.5 [a]
Styrene	1.0 [f]	0.001 [f]	0.003 [f]
Tetrachlorodibenzofuran	0.00001 [e]	0.000001 [e]	0.0000025 [e]
Tetrachlorodibenzo-p-dioxin	0.00001 [e]	0.000001 [e]	0.0000025 [e]
1,1,2,2-Tetrachloroethane	1.0 [f]	0.001 [f]	0.003 [f]
Tetrachloroethene	1.0 [f]	0.001 [f]	0.003 [f]
Thallium	4.0 [a]	1.0 [a]	2.0 [a]
Toluene	1.0 [f]	0.001 [f]	0.003 [f]
Tributyl phosphate	1.0 [f]	0.04 [f]	0.008 [f]
1,1,1-Trichloroethane	1.0 [f]	0.001 [f]	0.003 [f]
1,1,2-Trichloroethane	1.0 [f]	0.001 [f]	0.003 [f]
Trichloroethene	1.0 [f]	0.001 [f]	0.003 [f]
Vanadium	4.0 [a]	1.0 [a]	2.0 [a]
Vinyl chloride	1.0 [f]	0.001 [f]	0.003 [f]
Xylenes	1.0 [f]	0.001 [f]	0.003 [f]
Zinc	4.0 [a]	1.0 [a]	2.0 [a]

[a]Supporting evidence for chemical analysis come from laboratory reported Assurance Project Plan (IDLs). (instrument detection limits used in (IDLs) laboratory contracts under the RI/FS QAPP or SCQ.)
[b]Supporting evidence for radiologicals come from Sitewide CERCLA Quality (SCQ)
[c]All radionuclide (including total uranium) soil/sediment analyses quantitation limits are based on general sample preparation methods that will dry samples before the analyses are performed, therefore percent moisture does not impact quantitation limits.
[d]Method using 200 mL for digestion of 1 gram of soil -- Contract Laboratory Program (CLP)
[e]CLP Statement of Work contract required detection limit (3/90 or later version for organics and inorganics, 9/91 for dioxin/furans)
[f]Superfund Analytical Methods for low concentration water for Organics Analysis 10/92.
[g]SW 846 method 7195
[h]Method for determining PAHs will be a non SCQ method; EPA Method 8310, "Polynuclear Aromatic Hydrocarbons"
[i]Method using 250 mL for digestion of 5 grams of soil -- CN
[j]Method using 10 mL for digestion of 10 grams of soil
[k]Method using 100 mL for digestion of 0.2 grams of soil
[l]EPA method 600/4
[m]EPA method SW 846 8015
[n]EPA method 353.2
NA Not Applicable

2.10 BACKGROUND CONCENTRATIONS

Table 2-11 presents, by medium, the 95 percentile of the background distribution for naturally occurring and anthropogenic COCs. The background concentrations were adopted from the Operable Unit 5 RI Report. These background concentrations were used in the development of PRLs when modified PRGs fell below the background concentration. The maximum reported value for soil (considering both surface and subsurface reported values) was adopted as the background concentration for use in deriving PRLs.

The reported background concentrations for many of the COCs in surface water and sediment are based on limited data sets. This limitation of available data yields significant uncertainty in the identification of a 95 percentile for the background data sets. Following selection of the remedy for Operable Unit 5, additional sampling may be required to refine the 95 percentile background concentration estimates.

2.11 PRELIMINARY REMEDIATION LEVELS

PRLs differ from PRGs in that PRLs consider the practicality of attaining and verifying the attainment of a remediation goal. This differentiation is important to allow the development of cost-effective alternative remedial actions.

PRLs for nonradiological COCs were developed in a two-step process. First, all modified PRGs were reviewed against the routinely achieved analytical detection limits. For PRGs below this limit, the analytical detection limits were substituted as the PRL. Next, the PRGs were compared to background concentrations of COCs in the local environment. In the event the modified PRG was less than the 95 percentile of the background distribution for that constituent in that medium, the PRL was considered indistinguishable from background concentrations. DOE considers constituent concentrations at or below the 95 percentile of the background distribution acceptable as a target for remediation and established that PRL in these cases as the 95 percentile.

For radiological COCs, a slightly altered approach to developing PRLs was adopted. First, the 95 percentile background concentration was added to the modified PRG. This value was then compared to the analytical detection limit. The higher of the two values was adopted as the PRL. In two instances background was not added to the modified PRGs for radiological COCs to derive PRLs: 1) if the modified PRG was based directly upon an ARAR/TBC (e.g. proposed MCL for uranium of 20 ppb); or 2) if the modified PRG was based upon a CPRG derived on the basis of attaining an ARAR/TBC in the aquifer.

TABLE 2-11

95TH PERCENTILE[a] BACKGROUND CONCENTRATIONS OF COCs BY MEDIUM[b]

	Paddys Run		Great Miami River				
Constituent	Surface Water (Unfiltered)	Sediment	Surface Water (Unfiltered)	Sediment	Soil	Perched Water (Unfiltered)	Groundwater (Unfiltered)
Radionuclides	(pCi/L)	(pCi/g)	(pCi/L)	(pCi/g)	(pCi/g)	(pCi/L)	(pCi/L)
Cesium - 137	3.1	NA	ND	ND	0.7	ND	5.8
Lead - 210	NA	NA	NA	NA	1.3	NA	NA
Neptunium - 237	NA	NA	ND	ND	NA	0.25	0.25
Plutonium - 238	ND	NA	ND	ND	NA	0.08	0.05
Plutonium - 239/240	0.09	NA	ND	ND	NA	ND	0.05
Radium - 226	0.35	0.5	0.41	0.57	1.5	0.9	1.5
Radium - 228	2.1	ND	2.2	ND	1.3	3	3.6
Radon - 222	NA	NA	NA	NA	NA	NA	NA
Strontium - 90	0.96	NA	ND	ND	0.44	2.0	0.65
Technetium - 99	ND	NA	ND	ND	ND	30	22
Thorium - 228	ND	NA	0.62	ND	1.4	1.6	0.77
Thorium - 230	ND	NA	0.36	0.72	2.0	1.3	0.89
Thorium - 232	ND	NA	ND	0.8	1.4	0.34	0.23
Uranium (total ppm)	0.001	3	0.001	3	3.7	0.001	0.001
Inorganics	(mg/L)	(mg/kg)	(mg/L)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)
Antimony	ND	NA	ND	NA	ND	ND	ND
Arsenic	ND	7	0.0036	NA	9.6	0.019	0.029
Barium	0.053	21	0.1	NA	120	0.45	0.77
Beryllium	ND	0.5	ND	NA	0.62	ND	ND
Boron	NA	NA	NA	NA	NA	NA	NA

TABLE 2-11 (Continued)

Constituent	Paddys Run Surface Water (Unfiltered)	Paddys Run Sediment	Great Miami River Surface Water (Unfiltered)	Great Miami River Sediment	Soil	Perched Water (Unfiltered)	Groundwater (Unfiltered)
Inorganics (cont'd)	(mg/L)	(mg/kg)	(mg/L)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)
Cadmium	ND	3.7	0.01	NA	0.91	ND	0.014
Chromium (total)	ND	8.3	ND	NA	21	0.0046	0.021
Chromium VI	NA	NA	NA	NA	NA	NA	NA
Cobalt	ND	4.9	ND	NA	16	ND	0.0086
Copper	ND	11	0.012	NA	20.0	0.029	0.035
Cyanide	ND	NA	0.005	NA	0.27	ND	ND
Fluoride	0.22	NA	0.9	NA	NA	1.3	0.89
Lead	ND	NA	0.010	NA	26.4	0.0016	0.002
Manganese	0.035	410	0.08	NA	1400	0.21	0.90
Mercury	ND	ND	ND	NA	0.30	ND	ND
Molybdenum	ND	ND	0.02	NA	2.70	ND	ND
Nickel	ND	13.7	0.023	NA	34.3	0.0072	0.0514
Nitrate	1.7	NA	6.6	NA	NA	0.29	11
Selenium	ND	NA	ND	NA	0.72	ND	0.00075
Silver	ND	NA	ND	NA	ND	0.0031	0.0117
Thallium	ND	NA	ND	NA	0.58	ND	ND
Vanadium	ND	12	ND	NA	38	0.005	0.012
Zinc	ND	14	0.045	NA	82	0.35	0.02

[a]For small data sets (≤ 7 samples) the frequency is undefined and the maximum detected concentration is used as the 95th percentile.
[b]Values from Operable Unit 5 RI Report (DOE 1995e)
ND Not Detected
NA Not Analyzed

000153

2069

As discussed in Appendix A, the range of uranium enrichments processed at the FEMP was 0.2 to 2 weight percent uranium -235. Normal enrichment is 0.72 weight-percent uranium -235. The enrichment process (i.e., gaseous diffusion) impacts not only the uranium -235 content but also the weight-percent of uranium-234 present in the feed materials. Over the 38 year production history of the plant the weighted average enrichment was determined to be in the range of natural uranium for the major uranium isotopes. Additionally, the RI data set was evaluated to determine the average enrichment of uranium in collected soil samples. This average isotopic distribution was determined to be slightly depleted (0.69 weight-percent uranium-235). On this basis, and to simplify the overall approach for the FS and eventually the site cleanup, PRLs were derived only for total uranium on a mass basis. To derive PRLs, a normal distribution of the major uranium isotopes was assumed for all media.

PRLS were derived for soil for those cases passing the CPRG screen previously discussed in Section 2.5, with two exceptions. First, PRLs were not derived for a 10^{-5} ILCR/HI = 0.2 target for the industrial user. These PRLs closely reflected the PRLs for the 10^{-6} ILCR to the expanded trespasser and the need to present the values was deemed duplicative and unnecessary.

Recognizing the potential for multiple noncarcinogenic COCs to be present on the FEMP property, PRLs were not derived for COCs at a HI of 1.0 level. During the preparation of the FS it was determined that limiting the volume and cost evaluations performed for off-property soil to the 10^{-6} and the 10^{-5} ILCR PRLs for uranium did not provide a sufficient range of data to support an informed decision. On this basis, it was determined that because the principal (if not only) COC present off the FEMP property was uranium, consideration would be given to developing a decision data set for uranium with a HI of 1.0 to the resident farmer. The PRL for uranium, including background, at a HI of 1.0 is approximately 50 ppm (based upon a resident child). This value yields an ILCR of approximately 3.5×10^{-5} to the resident farmer considering only uranium in soil.

For perched groundwater (i.e., zones with a sustained yield greater than 1 gpm) and the Great Miami Aquifer, PRLs were developed for the two cases. Case 1 considered a target risk level of 10^{-6} ILCR and an HI of 0.2 to a resident farmer. Case 2 employed the MCLs, proposed MCLs and nonzero MCLGs as target cleanup values. For those COCs with no MCLs, proposed MCLs or nonzero MCLGs, Case 2 considered a target risk level of 10^{-5} and an HI of 0.2 to a resident farmer. These levels were selected to complement the aquifer protection goals adopted by the FS for alternative development. These levels are consistent with the aquifer protection goals adopted for CPRG development.

For surface water and sediment, PRLs were developed for the 10^{-5} and 10^{-6} ILCR risk targets (each including a HI of 0.2 goal).

To illustrate the PRL development process, the example previously discussed in Section 2.8 for uranium in soil at a 10^{-6} ILCR/ HI=0.2 level is extended to derive PRLs (see Figure 2-3). As reflected in Section 2.8, the modified PRG for total uranium in soil at this risk level was 1.2 ppm assuming natural uranium. Background for uranium in soil was added to this value (3.7 ppm total uranium assuming natural uranium) to arrive at 5 ppm total uranium. This value was compared against the analytical detection level. The higher of the two values, 5 ppm total uranium, was adopted as the PRL.

Had the example been for an inorganic metal, background would not have been added but rather compared to the modified PRG. If the modified PRG is less than the 95th percentile of the background distribution, then the PRL would be set at the background concentration since the modified PRG would be indistinguishable from background.

Table 2-12 presents PRLs for soil. Identified in the table is the basis for each value, indicating whether the PRL was derived from a risk-based PRG, an ARAR/TBC, a CPRG, background concentrations or the analytical detection limit. Also identified are PRLs which exceed BTVs. Tables 2-13, 2-14, 2-15, and 2-16 present the PRLs for sediment, surface water, perched water, and the Great Miami Aquifer, respectively.

2.12 REMEDIAL ACTION OBJECTIVES

Based on the preceding discussion, RAOs are presented in Table 2-17 for Operable Unit 5 environmental media. These objectives serve as a foundation for the evaluation of remedial alternatives in the remainder of this report.

PRLs as developed here will be finalized in the ROD for Operable Unit 5. Proposed final remediation levels will be presented in the Operable Unit 5 Proposed Plan coupled with the preferred remedial alternative. Following completion of excavation operations, including any required hot spot removal, final certification sampling will be conducted to demonstrate attainment of the final cleanup levels. The final certification approach adopted for use at the FEMP will be established in the Operable Unit 5 remedial action work plan, consistent with the Amended Consent Agreement.

2.13 REMEDIAL ACTION FOOTPRINT AND VOLUME ESTIMATES

Proposed remediation areas (referred to as footprints) and volumes of affected media were estimated for those actions required to achieve each of the four land use objectives over a range of potentially viable PRLs. The PRLs considered, under each of the land use objectives, were developed to bound the range of potential cleanup levels deemed practical for the site. This range of PRLs was developed following discussions with representatives of the Fernald Citizens Task Force.

TABLE 2-12
PRELIMINARY REMEDIATION LEVELS (PRLs) FOR SOIL

Constituent	Resident Farmer/Child ILCR of 10^{-6} HI of 0.2	Basis[a]	Resident Farmer/Child ILCR of 10^{-5} HI of 0.2	Basis[a]	Developed Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Undeveloped Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Industrial User PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Government Reserve PRL ILCR of 10^{-6} HI of 0.2	Basis[a]
Radionuclides (pCi/g):												
Cesium-137+1d	7.2×10^{-1}	R[b]	8.2×10^{-1}	R[b]	1.0×10^{0}	R[b]	1.4×10^{0}	R[b]	8.6×10^{-1}	R[b]	1.8×10^{0}	R[b]
Neptunium-237+1d	2.0×10^{-1}	D	4.9×10^{-1}	R	1.4×10^{0}	R	3.2×10^{0}	R	5.9×10^{-1}	R	5.0×10^{0}	R
Lead-210+2d	1.4×10^{0}	R[b]	2.2×10^{0}	R[b]	1.7×10^{1}	R[b]	3.8×10^{1}	R[b]	3.7×10^{0}	R[b]	4.7×10^{1}	R[b]
Plutonium-238	9.3×10^{-1}	R	9.3×10^{0}	R	3.3×10^{1}	R	7.8×10^{1}	R	4.3×10^{0}	R	1.0×10^{2}	R
Plutonium-239/240	9.0×10^{-1}	R	9.0×10^{0}	R	3.3×10^{1}	R	7.7×10^{1}	R	4.2×10^{0}	R	1.0×10^{2}	R
Radium-226+8d	1.5×10^{0}	R[b]	1.5×10^{0}	R[b]	1.6×10^{0}	R[b]	1.7×10^{0}	R[b]	1.5×10^{0}	R[b]	1.8×10^{0}	R[b]
Radium-228+1d	1.3×10^{0}	R	1.4×10^{0}	R[b]	1.5×10^{0}	R[b]	1.8×10^{0}	R[b]	1.4×10^{0}	R[b]	2.1×10^{0}	R[b]
Strontium-90+1d*	5.0×10^{-1}	D	6.1×10^{-1}	R[b]	1.4×10^{1}	C	1.4×10^{1}	C	1.4×10^{1}	C	1.4×10^{1}	C
Technetium-99*	1.0×10^{0}	D	1.0×10^{0}	D	3.0×10^{1}	C	3.0×10^{1}	C	3.0×10^{1}	C	3.0×10^{1}	C
Thorium-228+7d	1.4×10^{0}	R[b]	1.5×10^{0}	R[b]	1.5×10^{0}	R[b]	1.7×10^{0}	R[b]	1.5×10^{0}	R[b]	1.8×10^{0}	R[b]
Thorium-230	9.8×10^{0}	R[b]	8.0×10^{1}	R[b]	1.3×10^{2}	R[b]	2.8×10^{2}	R[b]	1.4×10^{1}	R[b]	4.3×10^{2}	R[b]
Thorium-232+10d	1.4×10^{0}	R[b]	1.4×10^{0}	R[b]	1.4×10^{0}	R[b]	1.5×10^{0}	R[b]	1.4×10^{0}	R[b]	1.6×10^{0}	R[b]
Uranium, total (K_d=325 L/kg)(ppm)*	5.0×10^{0}	R[b]	1.6×10^{1}	R[b]	3.7×10^{1}	R[b]	8.2×10^{1}	R[b]	1.6×10^{1}	R[b]	9.8×10^{1}	C
Uranium, total (K_d=15 L/kg)(ppm)*	5.0×10^{0}	R[b]	1.6×10^{1}	R[b]	2.0×10^{1}	C	2.0×10^{1}	C	1.6×10^{1}	R[b]	2.0×10^{1}	C
Chemicals (mg/kg):												
Acetone	4.3×10^{-1}	R	4.3×10^{-1}	R	3.4×10^{4}	R	4.3×10^{4}	R	6.6×10^{3}	R	3.5×10^{4}	R
Antimony	6.1×10^{-1}	R	6.1×10^{-1}	R	8.0×10^{1}	R[c]	9.6×10^{1}	R[c]	1.7×10^{1}	R[c]	7.9×10^{1}	R[c]
Aroclor-1254	4.0×10^{-2}	D	4.0×10^{-2}	D	1.1×10^{-1}	R	1.3×10^{-1}	R	6.6×10^{-2}	R	1.7×10^{-1}	R
Aroclor-1260	4.0×10^{-2}	D	4.0×10^{-2}	D	1.1×10^{-1}	R	1.3×10^{-1}	R	6.6×10^{-2}	R	1.7×10^{-1}	R
Arsenic	9.6×10^{0}	B	9.6×10^{0}	B	9.6×10^{0}	B	1.2×10^{1}	R	9.6×10^{0}	B	1.7×10^{1}	R
Barium	1.2×10^{2}	B	1.2×10^{2}	B	4.0×10^{4}	R[c]	6.8×10^{4}	R[c]	4.0×10^{3}	R[c]	5.9×10^{4}	R[c]
Benzene	4.3×10^{-2}	R	4.3×10^{-1}	R	3.1×10^{2}	R	8.5×10^{2}	R	9.6×10^{1}	R	1.2×10^{3}	R
Benzo(a)anthracene	9.0×10^{-2}	D	1.6×10^{-1}	R	6.6×10^{0}	R[c]	2.0×10^{1}	R[c]	2.0×10^{0}	R[c]	2.9×10^{1}	R[c]
Benzo(a)pyrene	9.0×10^{-2}	D	9.0×10^{-2}	D	6.6×10^{-1}	R	2.0×10^{0}	R[c]	2.0×10^{-1}	R	2.9×10^{0}	R[c]
Benzo(b)fluoranthene	9.0×10^{-2}	D	1.6×10^{-1}	R	6.6×10^{0}	R[c]	2.0×10^{1}	R[c]	2.0×10^{0}	R[c]	2.9×10^{1}	R[c]
Benzo(k)fluoranthene	9.0×10^{-2}	D	9.0×10^{-2}	D	6.6×10^{1}	R[c]	2.0×10^{2}	R[c]	2.0×10^{1}	R[c]	2.9×10^{2}	R[c]
Beryllium	6.2×10^{-1}	B	6.2×10^{-1}	B	9.7×10^{-1}	R	1.5×10^{0}	R	6.2×10^{-1}	B	2.0×10^{0}	R

TABLE 2-12 (continued)

Constituent	Resident Farmer/Child ILCR of 10^{-6} HI of 0.2	Basis[a]	Resident Farmer/Child ILCR of 10^{-5} HI of 0.2	Basis[a]	Developed Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Undeveloped Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Industrial User PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Government Reserve PRL ILCR of 10^{-6} HI of 0.2	Basis[a]
Chemicals mg/kg: (cont'd)												
Bis(2-chloroisopropyl)ether	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D	$1.4x10^{2}$	R	$4.2x10^{2}$	R	$4.1x10^{1}$	R	$6.0x10^{2}$	R
Bis(2-ethylhexyl)phthalate	$2.9x10^{0}$	R	$2.6x10^{1}$	R	$4.4x10^{2}$	R	$8.2x10^{2}$	R[c]	$1.6x10^{2}$	R[c]	$1.1x10^{3}$	R[c]
Boron	$4.0x10^{0}$	D	$4.0x10^{0}$	D	$6.4x10^{3}$	R	$7.4x10^{3}$	R	$1.5x10^{3}$	R	$6.1x10^{3}$	R
Bromodichloromethane	$1.8x10^{-2}$	R	$1.8x10^{-1}$	R	$3.5x10^{0}$	R	$4.0x10^{0}$	R	$2.3x10^{0}$	R	$5.2x10^{0}$	R
Bromoform	$2.1x10^{-1}$	R	$1.6x10^{0}$	R	$2.8x10^{1}$	R	$3.1x10^{1}$	R	$1.8x10^{1}$	R	$4.1x10^{1}$	R
Bromomethane	$2.4x10^{-2}$	R	$2.4x10^{-2}$	R	$2.7x10^{3}$	R	$8.2x10^{3}$	R	$2.9x10^{2}$	R	$7.3x10^{3}$	R
2-Butanone	$3.7x10^{0}$	R	$3.7x10^{0}$	R	NA		NA		$1.2x10^{5}$	R	NA	
Cadmium	$9.1x10^{-1}$	B	$9.1x10^{-1}$	B	$7.2x10^{1}$	R	$8.2x10^{1}$	R[c]	$1.6x10^{1}$	R[c]	$6.8x10^{1}$	R[c]
Carbazole	$3.1x10^{-1}$	R	$3.1x10^{0}$	R	$1.1x10^{1}$	R	$1.2x10^{1}$	R	$7.1x10^{0}$	R	$1.6x10^{1}$	R
Carbon Disulfide	$6.2x10^{0}$	R	$6.2x10^{0}$	R	$4.3x10^{3}$	R	$5.0x10^{3}$	R	$1.0x10^{3}$	R	$4.1x10^{3}$	R
Carbon tetrachloride	$1.9x10^{-2}$	R	$9.1x10^{-2}$	R	$1.8x10^{0}$	R	$2.1x10^{0}$	R	$1.2x10^{0}$	R	$2.8x10^{0}$	R
Chlordane*	$1.1x10^{-2}$	R	$3.8x10^{-2}$	R	$1.7x10^{-1}$	R	$1.9x10^{-1}$	R	$1.1x10^{-1}$	R	$2.5x10^{-1}$	R
Chlorobenzene	$1.9x10^{0}$	R	$1.9x10^{0}$	R	$3.1x10^{2}$	R	$3.4x10^{2}$	R	$7.2x10^{1}$	R	$9.2x10^{2}$	R
Chloroform	$1.6x10^{-1}$	R	$5.0x10^{-1}$	R	$4.0x10^{1}$	R	$4.5x10^{1}$	R	$2.6x10^{1}$	R	$5.9x10^{1}$	R
Chromium vi	$1.1x10^{1}$	R[c]	$1.1x10^{1}$	R[c]	$1.1x10^{2}$	R	$3.0x10^{2}$	R[c]	$1.7x10^{1}$	R[c]	$4.6x10^{2}$	R[c]
Chrysene	$1.6x10^{0}$	R[c]	$1.6x10^{1}$	R[c]	$6.6x10^{2}$	R	$2.0x10^{3}$	R[c]	$2.0x10^{2}$	R[c]	$2.9x10^{3}$	R[c]
Cobalt	$2.6x10^{1}$	R	$2.6x10^{1}$	R	$2.8x10^{2}$	R	$7.4x10^{2}$	R	$1.6x10^{1}$	B	$7.1x10^{2}$	R
Copper	$2.0x10^{1}$	B	$2.0x10^{1}$	B	$7.1x10^{4}$	R	$2.2x10^{5}$	R[c]	$7.6x10^{3}$	R[c]	$1.9x10^{5}$	R[c]
Cyanide	$8.0x10^{-1}$	D	$8.0x10^{-1}$	D	$3.9x10^{4}$	R	$1.2x10^{5}$	R	$4.1x10^{3}$	R	$1.0x10^{5}$	R
Dibenzo(a,h)anthracene	$5.0x10^{-4}$	D	$1.6x10^{-3}$	R	$6.6x10^{-1}$	R	$2.0x10^{0}$	R	$2.0x10^{-1}$	R	$2.9x10^{0}$	R
3,3'-Dichlorobenzidine	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D	$4.8x10^{-1}$	R	$5.5x10^{-1}$	R	$3.2x10^{-1}$	R	$7.2x10^{-1}$	R
1,1-Dichloroethane	$1.0x10^{-3}$	D	$1.0x10^{-3}$	D	NA		NA		NA		NA	
1,2-Dichloroethane*	$2.5x10^{-3}$	C	$1.3x10^{-1}$	R	$1.6x10^{-1}$	C	$1.6x10^{-1}$	C	$1.6x10^{-1}$	C	$1.6x10^{-1}$	C
1,1-Dichloroethene	$5.9x10^{-3}$	R	$5.9x10^{-2}$	R	$3.6x10^{-1}$	R	$4.1x10^{-1}$	R	$2.3x10^{-1}$	R	$5.3x10^{-1}$	R
Dieldrin	$4.0x10^{-3}$	D	$8.8x10^{-3}$	R	$1.4x10^{-2}$	R	$1.5x10^{-2}$	R	$8.9x10^{-3}$	R	$2.0x10^{-2}$	R
Di-n-octylphthalate	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D	$9.7x10^{2}$	R	$1.1x10^{3}$	R	$2.2x10^{2}$	R	$9.1x10^{2}$	R
Ethylbenzene	$1.0x10^{-3}$	D	$1.0x10^{-3}$	D	$4.5x10^{3}$	R	$5.1x10^{3}$	R	N/A	R	$4.2x10^{3}$	R

TABLE 2-12 (continued)

Constituent	Resident Farmer/Child ILCR of 10^{-6} HI of 0.2	Basis[a]	Resident Farmer/Child ILCR of 10^{-5} HI of 0.2	Basis[a]	Developed Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Undeveloped Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Industrial User PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Government Reserve PRL ILCR of 10^{-6} HI of 0.2	Basis[a]
Chemicals mg/kg: (cont'd)												
Fluoride	$8.5x10^{2}$	R	$8.5x10^{2}$	R	$5.0x10^{4}$	R	$7.8x10^{4}$	R	$7.8x10^{3}$	R	$6.5x10^{4}$	R
Heptachlorodibenzofuran	$5.0x10^{-5}$	D	$5.0x10^{-5}$	D	$7.3x10^{-4}$	R	$8.8x10^{-4}$	R	$4.3x10^{-4}$	R	$1.2x10^{-3}$	R
Heptachlorodibenzo-p-dioxin	$5.0x10^{-5}$	D	$5.0x10^{-5}$	D	$7.3x10^{-4}$	R	$8.8x10^{-4}$	R	$4.3x10^{-4}$	R	$1.2x10^{-3}$	R
Indeno(1,2,3-cd)pyrene	$4.0x10^{-3}$	D	$1.6x10^{-2}$	R	$6.6x10^{0}$	R[c]	$2.0x10^{1}$	R[c]	$2.0x10^{0}$	R[c]	$2.9x10^{1}$	R[c]
Lead	$4.0x10^{2}$	A	$4.0x10^{2}$	A	$4.0x10^{2}$	A	$4.0x10^{2}$	A	$4.0x10^{2}$	A	$4.0x10^{2}$	A
Manganese	$1.4x10^{3}$	B	$1.4x10^{3}$	B	$4.2x10^{3}$	R	$4.6x10^{3}$	R[c]	$1.4x10^{3}$	B	$1.5x10^{3}$	B
Mercury*	$3.0x10^{-1}$	B	$3.0x10^{-1}$	B	$7.5x10^{0}$	C	$7.5x10^{0}$	C[c]	$3.0x10^{0}$	R	$7.5x10^{0}$	C[c]
Methyl-2-pentanone	$9.4x10^{-1}$	R	$9.4x10^{-1}$	R	$3.2x10^{1}$	R	$2.5x10^{3}$	R	$5.1x10^{0}$	R	$2.0x10^{3}$	R
Methylene chloride	$6.3x10^{-2}$	R	$6.3x10^{-1}$	R	$2.2x10^{3}$	R	$3.7x10^{1}$	R	$2.1x10^{1}$	R	$4.8x10^{1}$	R
4-Methylphenol	$2.7x10^{-1}$	R	$2.7x10^{-1}$	R	$2.2x10^{2}$	R	$2.5x10^{2}$	R	$5.1x10^{1}$	R	$2.0x10^{2}$	R
Molybdenum	$1.3x10^{1}$[a]	D	$1.3x10^{1}$[a]	D	$2.2x10^{3}$	R[c]	$2.9x10^{3}$	R[c]	$4.1x10^{2}$	R[c]	$2.4x10^{3}$	R[c]
Nickel	$3.4x10^{1}$	B	$3.4x10^{1}$	B	$5.7x10^{3}$	R[c]	$1.5x10^{4}$	R[c]	$8.5x10^{2}$	R[c]	$2.4x10^{4}$	R[c]
Nitrate	$2.5x10^{4}$	R	$2.5x10^{4}$	R	NA		NA		$3.3x10^{5}$	R	NA	
4-Nitroanaline	$8.0x10^{-1}$	D	$8.0x10^{-1}$	D	$1.3x10^{2}$	R	$1.5x10^{2}$	R	$3.0x10^{1}$	R	$1.2x10^{2}$	R
N-nitrosodiphenylamine	$1.3x10^{0}$	R	$1.3x10^{1}$	R	$4.4x10^{1}$	R	$5.1x10^{1}$	R	$2.9x10^{1}$	R	$6.6x10^{1}$	R
N-nitrosodipropylamine	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D	$2.0x10^{-1}$	D
Octachlorodibenzofuran	$1.0x10^{-5}$	D	$1.0x10^{-5}$	D	$7.3x10^{-3}$	R	$8.8x10^{-3}$	R	$4.3x10^{-3}$	R	$1.2x10^{-2}$	R
Octachlorodibenzo-p-dioxin	$1.0x10^{-5}$	D	$1.0x10^{-5}$	D	$7.3x10^{-3}$	R	$8.8x10^{-3}$	R	$4.3x10^{-3}$	R	$1.2x10^{-2}$	R
Pentachlorophenol	$8.0x10^{-1}$	D	$9.7x10^{-1}$	R	$2.0x10^{0}$	R	$2.3x10^{0}$	R	$1.3x10^{0}$	R	$3.0x10^{0}$	R
Phenanthrene	$5.0x10^{0}$	B	$5.0x10^{0}$	B	N/A		N/A		N/A		N/A	
Selenium	$2.5x10^{0}$	R	$2.5x10^{0}$	R	$3.7x10^{3}$	R[c]	$5.4x10^{3}$	R[c]	$5.9x10^{2}$	R[c]	$4.5x10^{3}$	R
Silver	$1.0x10^{0}$	D	$1.0x10^{0}$	D	$9.6x10^{3}$	R[c]	$2.9x10^{4}$	R[c]	$1.0x10^{3}$	R[c]	$2.6x10^{4}$	R
Tetrachloroethene	$1.0x10^{-1}$	R	$1.0x10^{0}$	R	$3.2x10^{0}$	R	$3.6x10^{0}$	R	$2.1x10^{0}$	R	$4.7x10^{0}$	R
Thallium	$1.0x10^{0}$	D	$1.0x10^{0}$	D	$5.9x10^{1}$	R[c]	$9.1x10^{1}$	R[c]	$9.1x10^{0}$	R[c]	$7.6x10^{1}$	R[c]
Toluene	$2.7x10^{1}$	R	$2.7x10^{1}$	R	$7.9x10^{4}$	R	$1.0x10^{5}$	R	$1.5x10^{4}$	R	$8.4x10^{4}$	R
Tributyl phosphate	$2.9x10^{0}$	R	$2.9x10^{0}$	R	$2.2x10^{2}$	R	$2.5x10^{2}$	R	$5.1x10^{1}$	R	$2.0x10^{2}$	R
1,1,2-Trichloroethane	$1.9x10^{-2}$	R	$1.9x10^{-1}$	R	$3.8x10^{0}$	R	$4.3x10^{0}$	R	$2.5x10^{0}$	R	$5.7x10^{0}$	R

TABLE 2-12 (continued)

Constituent	Resident Farmer/Child ILCR of 10^{-6} HI of 0.2	Basis[a]	Resident Farmer/Child ILCR of 10^{-5} HI of 0.2	Basis[a]	Developed Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Undeveloped Park PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Industrial User PRL ILCR of 10^{-6} HI of 0.2	Basis[a]	Government Reserve PRL ILCR of 10^{-6} HI of 0.2	Basis[a]
Chemicals mg/kg: (cont'd)												
Trichloroethene	$1.5x10^{-1}$	R	$1.5x10^{0}$	R	$2.2x10^{1}$	R	$2.5x10^{1}$	R	$1.4x10^{1}$	R	$3.2x10^{1}$	R
Vanadium	$5.8x10^{1}$	R	$5.8x10^{1}$	R	$3.8x10^{3}$	R[c]	$5.1x10^{3}$	R[c]	$6.7x10^{2}$	R[c]	$4.2x10^{3}$	R
Vinyl chloride	$1.0x10^{-3}$	D	$2.3x10^{-3}$	R	$1.1x10^{-1}$	R	$1.3x10^{-1}$	R	$7.5x10^{-2}$	R	$1.7x10^{-1}$	R
Xylenes, total	$4.0x10^{2}$	R	$4.0x10^{2}$	R	$7.2x10^{5}$	R	$9.2x10^{5}$	R	$3.0x10^{-1}$	R	$7.0x10^{5}$	R
Zinc	$8.2x10^{1}$	B	$8.2x10^{1}$	B	$9.3x10^{4}$	R[c]	$1.2x10^{5}$	R[c]	$1.9x10^{4}$	R[c]	$9.7x10^{4}$	R

[a]Basis - A = Soil ARAR; see Section 2.7.3
B = Background from Table 2-11
C = Cross-media impact to groundwater to meet ARAR or risk-based PRG; values taken from Table 2-5.
D = Detection limits from Table 2-10
R = Risk-based PRL; values taken from Tables C.2-1a, C.2-1b, C.2-2, C.2-3, C.2-4, and C.2-6.

[b]Value includes risk-based PRG plus background concentration.

[c]This constituent was identified as a CPC in the Operable Unit 5 RI Ecological Risk Assessment. The PRL developed exceeds the BTV listed in Table 2-8. If post-remedial concentrations for this constituent exceed the benchmark toxicity values, further ecological investigation may be warranted.

- Cross-media impacts were determined to be a significant consideration for these mobile constituents.

NA = Not applicable
ND = No toxicity data available for the development of risk-based PRGs

TABLE 2-13

PRELIMINARY REMEDIATION LEVELS FOR SEDIMENT

	10^{-6} ILCR/HI=0.2		10^{-5} ILCR/HI=0.2	
Constituent	Value	Basis[a]	Value	Basis[a]
Radionuclides (pCi/g):				
Cesium-137(+1d)	7.0×10^{0}	R	7.0×10^{1}	R
Neptunium-237(+1d)	3.2×10^{1}	R	3.2×10^{2}	R
Lead-210(+2d)	3.9×10^{2}	R	3.9×10^{3}	R
Plutonium-238	1.2×10^{3}	R	1.2×10^{4}	R
Plutonium-239/240	1.1×10^{3}	R	1.1×10^{4}	R
Radium-226(+8d)	2.9×10^{0}	R[b]	2.4×10^{1}	R[b]
Radium-228(+1d)	4.8×10^{0}	R	4.8×10^{1}	R
Strontium-90(+1d)	7.1×10^{3}	R	7.1×10^{4}	R
Technetium-99	2.0×10^{5}	R	2.0×10^{6}	R
Thorium-228(+7d)	3.2×10^{0}	R[b]	2.6×10^{1}	R[b]
Thorium-230	1.8×10^{4}	R[b]	1.8×10^{5}	R[b]
Thorium-232(+10d)	1.6×10^{0}	R	1.6×10^{1}	R
Uranium, total mg/kg	2.1×10^{2}	R[b]	2.1×10^{2}	R[b]
Chemical (mg/kg):				
Aroclor-1254	6.7×10^{-1}	R	6.7×10^{0}	R
Aroclor-1260	6.7×10^{-1}	R	6.7×10^{0}	R
Arsenic	9.4×10^{1}	R[c]	9.4×10^{2}	R[c]
Benzo(a)anthracene	1.9×10^{2}	R	1.9×10^{3}	R[c]
Benzo(a)pyrene	1.9×10^{1}	R	1.9×10^{2}	R
Benzo(b)fluoranthene	1.9×10^{2}	R	1.9×10^{3}	R[c]
Benzo(k)fluoranthene	1.9×10^{3}	R[c]	1.9×10^{4}	R[c]
Beryllium	3.3×10^{1}	R	3.3×10^{2}	R
Bis(2-ethylhexyl)phthalate	5.0×10^{3}	R	4.8×10^{4}	R
Bromoform	1.6×10^{2}	R	8.6×10^{2}	R
Cadmium	7.1×10^{1}	R[c]	7.1×10^{1}	R[c]
Carbazole	6.3×10^{1}	R	6.3×10^{2}	R
Chromium VI	3.0×10^{3}	R[c]	3.0×10^{3}	R[c]
Chrysene	1.9×10^{4}	R[c]	1.9×10^{5}	R[c]

TABLE 2-13 (Continued)

	10^{-6} ILCR/HI=0.2		10^{-5} ILCR/HI=0.2	
Constituent	Value	Basis[a]	Value	Basis[a]
Chemicals (mg/kg): (Cont'd.)				
Cobalt	3.6×10^4	R	3.6×10^4	R
Indeno(1,1,2-cd)-pyrene	1.9×10^2	R	1.9×10^3	R
Lead	NA		NA	
Manganese	4.1×10^2	B	4.1×10^2	B
4-Methyl-2-pentanone	2.1×10^3	R	2.1×10^3	R
N-Nitrosodiphenylamine	2.6×10^2	R	2.6×10^3	R
Phenathrene	3.0×10^{-3}	D	$3.0 \times 10^{-}$	D
Thallium	8.8×10^1	R	8.8×10^1	R

[a]B = Background concentrations from Table C.2-11
D = Analytical detection limit; values taken from Table 2-10
R = Risk based PRG; values taken from Table C.2-12
[b] = Risk-based PRL includes both the risk-based PRG plus background concentration for the radionuclide
[c] = This constituent was identified as a CPC in the Operable Unit 5 RI Ecological Risk Assessment. This PRL exceeds the benchmark toxicity values. If postremedial concentrations for this constituent exceed the BTV, further ecological investigation may be warranted.
NA = Not applicable/not available

TABLE 2-14

PRELIMINARY REMEDIATION LEVELS FOR SURFACE WATER

Constituent	Recreation User/Trespasser[a] ILCR=10^{-6} or HQ=0.2 Value	Basis[b]	Recreation User/Trespasser[a] ILCR=10^{-5} or HQ=0.2 Value	Basis[b]
Radionuclides (pCi/L):				
Cesium-137+1d	1.0×10^{1}	R[c]	7.6×10^{1}	R[c]
Neptunium-237+1d	2.1×10^{2}	R	2.1×10^{3}	R
Lead-210+2d	1.1×10^{1}	R	1.1×10^{2}	R
Plutonium-238	2.1×10^{2}	R	2.1×10^{3}	R
Plutonium-239/240	2.0×10^{2}	R[c]	2.0×10^{3}	R[c]
Radium-226+8d	3.8×10^{1}	R[c]	3.8×10^{2}	R[c]
Radium-228+1d	4.7×10^{1}	R[c]	4.5×10^{2}	R[c]
Strontium-90+1d	4.1×10^{1}	R[c]	4.0×10^{2}	R[c]
Technetium-99	1.5×10^{2}	R[c]	1.5×10^{3}	R[c]
Thorium-228+7d	8.3×10^{2}	R[c]	8.3×10^{3}	R[c,d]
Thorium-230	3.5×10^{3}	R[c,d]	3.5×10^{4}	R[d]
Thorium-232+10d	2.7×10^{2}	R	2.7×10^{3}	R[d]
Uranium, total (mg/L)	5.3×10^{-1}	R[c]	5.3×10^{0}	R[c,d]
Chemical (mg/L):				
Alpha-chlordane	3.1×10^{-4}	R	8.3×10^{-4}	R
Antimony	1.9×10^{-1}	A	1.9×10^{-1}	A
Aroclor-1254	2.0×10^{-4}	D	2.0×10^{-4}	D
Aroclor-1260	2.0×10^{-4}	D	2.0×10^{-4}	D
Arsenic[e]	4.9×10^{-2}	R	4.9×10^{-2}	R
Barium	1.0×10^{2}	R	1.0×10^{2}	R
Benzene	2.8×10^{-1}	R	5.6×10^{-1}	A
Benzo(a)anthracene	1.0×10^{-3}	D	3.4×10^{-3}	R
Benzo(a)pyrene	1.0×10^{-3}	D	1.0×10^{-3}	D
Beryllium	1.2×10^{-3}	A	1.2×10^{-3}	A
Bis(2-chloroisopropyl)ether	2.8×10^{-1}	R	2.8×10^{0}	R
Bis(2-ethylhexyl)phthalate	8.4×10^{-3}	A	8.4×10^{-3}	A

TABLE 2-14 (continued)

Constituent	Recreation User/Trespasser[a] ILCR=10^{-6} or HQ=0.2 Value	Basis[b]	Recreation User/Trespasser[a] ILCR=10^{-5} or HQ=0.2 Value	Basis[b]
Chemical (mg/L): (Continued)				
Bromodichloromethane	2.4×10^{-1}	R	2.4×10^{0}	R
Bromomethane	1.3×10^{0}	R	1.3×10^{0}	R
Cadmium	9.8×10^{-3}	B	9.8×10^{-3}	B
Chloroform	7.9×10^{-2}	A	7.9×10^{-2}	A
Chromium VI	1.0×10^{-2}	D	1.0×10^{-2}	D
Copper	1.2×10^{-2}	A	1.2×10^{-2}	A
Cyanide	1.2×10^{-2}	A	1.2×10^{-2}	A
Dibenzo(a,h)anthracene	1.0×10^{-3}	D	1.0×10^{-2}	D
3,3-Dichlorobenzidene	7.7×10^{-3}	R	7.7×10^{-2}	R
Di-n-butylphthalate	6.0×10^{0}	R	6.0×10^{0}	R
1,1-Dichloroethene	1.5×10^{-2}	R	1.5×10^{-1}	R
Dieldrin	2.0×10^{-5}	D	2.0×10^{-5}	D
Di-n-octylphthalate	5.0×10^{-3}	D	5.0×10^{-3}	D
Fluoride	2.0×10^{0}	A	2.0×10^{0}	A
Lead	1.0×10^{-2}	B	1.0×10^{-2}	B
Manganese	1.5×10^{0}	R[d]	1.5×10^{0}	R[d]
Mercury	2.0×10^{-4}	D	2.0×10^{-4}	D
Methylene Chloride	4.3×10^{-1}	A	4.3×10^{-1}	A
4-Methylphenol	2.2×10^{0}	R	2.2×10^{0}	R
Molybdenum	1.5×10^{0}	R	1.5×10^{0}	R
Nickel	1.7×10^{-1}	A	1.7×10^{-1}	A
Nitrate	2.4×10^{3}	R	2.4×10^{3}	R
4-Nitrophenol	7.4×10^{3}	R	7.4×10^{3}	R
Selenium	5.0×10^{-3}	A	5.0×10^{-3}	A
Silver	5.0×10^{-3}	D	2.0×10^{-1}	R[d]
Tetrachloroethene	4.5×10^{-2}	R	4.5×10^{-1}	R
1,1,1-Trichloroethane	1.0×10^{-3}	D	1.0×10^{-3}	D
1,1,2-Tricholoroethane	2.3×10^{-1}	R	1.8×10^{0}	R

TABLE 2-14 (continued)

Constituent	Recreation User/Trespasser[a] ILCR=10^{-6} or HQ=0.2		Recreation User/Trespasser[a] ILCR=10^{-5} or HQ=0.2	
	Value	Basis[b]	Value	Basis[b]
Vanadium	3.1×10^{0}	R[d]	3.1×10^{0}	R[d]
Zinc	1.1×10^{-1}	A	1.1×10^{-1}	A

[a]Includes consideration of consumer of meat and milk.

[b]A - ARAR values from Table 2-7

B - Background values from Table 2-11

D - Detection Limit values from Table 2-10

R - Risk-based PRGs-minimum values from Table C.2-9 or C.2-10

[c]Risk-based PRL, includes the risk-based PRG plus the 95 percentile background concentrations.

[d]This constituents was identified as a CPC in the Operable Unit 5 Ecological Risk Assessment. If postremedial concentrations for this constituent exceed the BTV, further ecological investigation and/or clean-up may be warranted.

[e]The 10^{-6} PRL for arsenic was not attainable based on background groundwater concentrations. Therefore, the PRL defaulted to the 10^{-5} PRG level.

TABLE 2-15

PERCHED GROUNDWATER PRELIMINARY REMEDIATION LEVELS (PERCHED GROUNDWATER USER)

Constituent	Resident Farmer ILCR = 10^{-6} or HQ = 0.2	Basis [a]	Resident Farmer MCLs ILCR= 10^{-5} or HQ = 0.2	Basis [a]
Radionuclides (pCi/L)				
Lead-210(+2d)	3.0×10^{0}	D	3.0×10^{0}	D
Neptunium-237(+1d)	5.0×10^{-1}	D	1.2×10^{0}	R [b]
Plutonium-238	5.0×10^{-1}	D	1.0×10^{0}	R [b]
Plutonium-239/240	5.0×10^{-1}	D	8.9×10^{-1}	R
Radium-226(+8d)	1.0×10^{0}	D	2.0×10^{1}	A
Strontium-90(+1d)	2.6×10^{0}	R [b]	8.0×10^{0}	B [b]
Technetium-99	4.6×10^{1}	R [b]	1.9×10^{2}	R [b]
Thorium-228(+7d)	2.0×10^{0}	R [b]	5.3×10^{0}	R [b]
Thorium-230	2.9×10^{0}	R [b]	1.7×10^{1}	R [b]
Thorium-232(+10d)	4.6×10^{-1}	R [b]	1.5×10^{0}	R [b]
Uranium, total (mg/L)	5.4×10^{-3}	R [b]	2.0×10^{-2}	A
Chemical (mg/L)				
Alpha-chlordane	1.0×10^{-5}	D	2.0×10^{-3}	A
Antimony	2.9×10^{-3}	R	6.0×10^{-3}	A
Arsenic	1.9×10^{-2}	B	5.0×10^{-2}	A
Barium	5.1×10^{-1}	R	1.0×10^{0}	A
Benzene	1.0×10^{-3}	D	5.0×10^{-3}	A
Beryllium	2.0×10^{-4}	D	4.0×10^{-3}	A
Bis(2-ethylhexyl)phthalate	5.0×10^{-3}	D	6.0×10^{-3}	A
Boron	6.2×10^{-1}	R	6.2×10^{-1}	R
Cadmium	5.0×10^{-3}	A	5.0×10^{-3}	A
Carbazole	1.8×10^{-3}	R	1.8×10^{-2}	R
Carbon disulfide	5.5×10^{-3}	R	5.5×10^{-3}	R
Carbon tetrachloride	1.0×10^{-3}	D	5.0×10^{-3}	A
Chloroform	1.0×10^{-3}	D	1.0×10^{-1}	A
Chromium VI	3.6×10^{-2}	R	3.6×10^{-2}	R
Copper	2.7×10^{-1}	R	1.3×10^{0}	A
1,2-Dichloroethane	1.0×10^{-3}	D	5.0×10^{-3}	A

TABLE 2-15 (Continued)

Constituent	Resident Farmer ILCR = 10^{-6} or HQ = 0.2	Basis [a]	Resident Farmer MCLs ILCR= 10^{-5} or HQ = 0.2	Basis [a]
Chemical (mg/L) (continued)				
1,1-Dichloroethene	1.0×10^{-3}	D	7.0×10^{-3}	A
1,2-Dichloroethylene	2.2×10^{0}	R	2.2×10^{0}	R
Fluoride	1.3×10^{0}	B	1.3×10^{0}	B
Heptachlorodibenzo-p-dioxin	5.0×10^{-8}	D	5.0×10^{-8}	D
Manganese	2.1×10^{-1}	B	2.1×10^{-1}	B
Mercury	2.0×10^{-3}	A	2.0×10^{-3}	A
Methylene chloride	2.6×10^{-3}	R	5.0×10^{-3}	A
Molybdenum	5.0×10^{-2}	D	1.0×10^{-1}	A
N-nitroso-di-n-propylamine	5.0×10^{-3}	D	5.0×10^{-3}	D
Nickel	1.0×10^{-1}	A	1.0×10^{-1}	A
Nitrate	1.2×10^{1}	R	1.2×10^{1}	R
Pentachlorophenol	2.0×10^{-2}	D	2.0×10^{-2}	D
Silver	3.7×10^{-2}	R	5.0×10^{-2}	A
1,1,2,2-Tetrachloroethane	1.0×10^{-3}	D	1.0×10^{-3}	D
Tetrachloroethene	1.0×10^{-3}	D	5.0×10^{-3}	A
Thallium	4.0×10^{-3}	D	4.0×10^{-3}	D
Tributyl phosphate	1.8×10^{-2}	R	1.8×10^{-2}	R
1,1,2-Trichloroethane	1.0×10^{-3}	D	3.0×10^{-3}	A
Trichloroethene	1.0×10^{-3}	R	5.0×10^{-3}	A
Vanadium	4.8×10^{-2}	R	4.8×10^{-2}	R
Vinyl chloride	1.0×10^{-3}	D	2.0×10^{-3}	A
Zinc	2.2×10^{0}	R	2.2×10^{0}	R

[a]A - ARAR; values from Table 2-6
D - Detection limit; values from Table 2-10
B - Background in unfiltered samples greater than PRG; values from Table 2-11
R - Risk based PRG; values from Table C.2-8
[b]Risk based PRL includes the radionuclide's risk-based PRG plus its 95th percentile background concentration.

TABLE 2-16

GROUNDWATER PRELIMINARY REMEDIATION LEVELS FOR THE GREAT MIAMI AQUIFER

Constituent	ILCR = 10^{-6} or HQ = 0.2	Basis[a]	MCLs ILCR = 10^{-5} or HQ = 0.2	Basis[a]
Radionuclides (pCi/L)				
Neptunium-237(+1d)	5.0×10^{-1}	D	1.0×10^{0}	R [b]
Radium-226(+8d)	1.5×10^{0}	R [b]	2.0×10^{1}	A
Radium-228(+1d)	3.8×10^{0}	R [b]	2.0×10^{1}	A
Strontium-90(+1d)	1.0×10^{0}	D	8.0×10^{0}	A
Technetium-99	2.9×10^{1}	R [b]	9.4×10^{2}	R [b]
Thorium-228(+7d)	1.1×10^{0}	R [b]	4.0×10^{0}	R [b]
Thorium-230	2.3×10^{0}	R [b]	1.5×10^{1}	R [b]
Thorium-232+(10d)	3.3×10^{-1}	R [b]	1.2×10^{0}	R [b]
Uranium, total (mg/L)	4.5×10^{-3}	R [b]	2.0×10^{-2}	A
Chemical (mg/L)				
Alpha-chlordane	1.0×10^{-4}	D	2.0×10^{-3}	A
Antimony	2.0×10^{-3}	D	6.0×10^{-3}	A
Aroclor-1254	2.0×10^{-4}	D	2.0×10^{-4}	D
Arsenic	2.9×10^{-2}	B	5.0×10^{-2}	A
Barium	7.7×10^{-1}	B	2.0×10^{0}	A
Benzene	1.0×10^{-3}	D	5.0×10^{-3}	A
Beryllium	2.0×10^{-4}	D	4.0×10^{-3}	A
Bis(2-chloroisopropyl)ether	5.0×10^{-3}	D	5.0×10^{-3}	D
Bis(2-ethylhexyl)phthalate	5.0×10^{-3}	D	6.0×10^{-3}	A
Boron	3.3×10^{-1}	R	3.3×10^{-1}	R
Bromodichloromethane	1.0×10^{-3}	D	1.0×10^{-1}	A
Bromomethane	2.1×10^{-3}	R	2.1×10^{-3}	R
Cadmium	1.4×10^{-2}	B	1.4×10^{-2}	B
Carbazole	1.1×10^{-3}	R	1.1×10^{-2}	R
Carbon disulfide	5.5×10^{-3}	R	5.5×10^{-3}	R
Chloroethane	1.0×10^{-3}	D	1.0×10^{-3}	D
Chloroform	1.0×10^{-3}	D	1.0×10^{-1}	A
Chromium VI	2.2×10^{-2}	R	2.2×10^{-2}	R

TABLE 2-16 (Continued)

Constituent	ILCR = 10^{-6} or HQ = 0.2	Basis[a]	MCLs ILCR = 10^{-5} or HQ = 0.2	Basis[a]
Chemical (mg/L) (continued)				
Cobalt	1.7×10^{-1}	R	1.7×10^{-1}	R
Copper	4.1×10^{-2}	R	1.3×10^{0}	A
1,1-Dichloroethane	2.8×10^{-1}	R	2.8×10^{-1}	R
1,1-Dichloroethene	1.0×10^{-3}	D	7.0×10^{-3}	A
1,2-Dichloroethane	1.0×10^{-3}	D	5.0×10^{-3}	A
Fluoride	8.9×10^{-1}	B	8.9×10^{-1}	B
Lead	2.0×10^{-3}	B,D	2.0×10^{-3}	B,D
Manganese	9.0×10^{-1}	B	9.0×10^{-1}	B
Mercury	2.0×10^{-4}	D	2.0×10^{-3}	A
Methylene chloride	2.4×10^{-3}	R	5.0×10^{-3}	A
4-Methylphenol	2.9×10^{-2}	R	2.9×10^{-2}	R
Molybdenum	1.0×10^{-1}	A	1.0×10^{-1}	A
Nickel	5.1×10^{-2}	B	1.0×10^{-1}	A
Nitrate	1.1×10^{1}	B	1.1×10^{1}	B
4-Nitrophenol	3.2×10^{-1}	R	3.2×10^{-1}	R
Octachlorodibenzo-p-dioxin	1.0×10^{-7}	D	1.0×10^{-7}	D
Selenium	1.0×10^{-2}	R	5.0×10^{-2}	A
Silver	1.2×10^{-2}	B	5.0×10^{-2}	A
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.0×10^{-8}	D	1.0×10^{-5}	D
Trichloroethene	1.0×10^{-3}	D	5.0×10^{-3}	A
Vanadium	3.8×10^{-2}	R	3.8×10^{-2}	R
Vinyl Chloride	1.0×10^{-3}	D	2.0×10^{-3}	A
Zinc	2.1×10^{-2}	B	2.1×10^{-2}	B

[a]A - ARAR based; values from Table 2-6
B - Background groundwater concentrations; values from Table 2-11
D - Detection limit; values from Table 2-10
R - Risk based PRG; values from Table C.2-7
[b]Risk based PRL includes the radionuclide's risk-based PRG plus its 95th percentile background concentration.

TABLE 2-17

REMEDIAL ACTION OBJECTIVES FOR OPERABLE UNIT 5

Medium	Remedial Action Objective
Surface Soil	For Human Health: Prevent direct contact with, inhalation of, or ingestion of soil having constituent concentrations in excess of the PRLs identified in Table 2-12. Prevent exposures to soil materials which may cause an individual to exceed annual dose limits of 25 mrem/yr whole body, 75 mrem/yr to the thyroid or 25 mrem/yr to any other organ. Prevent exposures to soil materials which may cause an individual to exceed a 100 mrem/yr effective dose equivalent, above background, from all exposure routes. For Environmental Protection: Prevent direct contact of ecological receptors with soil exceeding the benchmark toxicity values presents in Table 2-8. Prevent release or leaching of soil which would result in surface water concentrations in the Great Miami River and Paddys Run in excess of the PRLs identified in Table 2-14.
Surface Water	For Human Health: Prevent direct contact with or ingestion of water in the Great Miami River and Paddys Run having constituent concentrations in excess of the PRLs identified in Table 2-14. For Environmental Protection: Prevent release of constituents of concern into surface water which would result in surface water concentrations in excess of the water quality standards in Table 2-7 and the benchmark toxicity values presented in Table 2-9.
Sediment	For Human Health: Prevent the direct contact or ingestion of sediment having constituent concentrations in excess of the PRLs identified in Table 2-13. For Environmental Protection: Prevent the direct contact of ecological receptors with sediments having constituent concentrations in excess of the benchmark toxicity values presented in Table 2-9.
Groundwater	For Human Health: Prevent direct contact with, ingestion of, or inhalation of constituents from groundwater in excess of the PRLs identified in Table 2-16. For Human Health and Environmental Protection: Restore the Great Miami Aquifer to the highest beneficial use (drinking water) in a reasonable time frame.
Perched Groundwater	For Human Health: Prevent the use of perched groundwater for crop irrigation or for household use in excess of the concentrations identified in Table 2-15.

In total, nine cases, presented in Table 2-18, were developed for the performance of volume estimates. Each case specifies, for each media, an associated land use, a target receptor, a target risk range, and the resultant uranium PRLs. The uranium PRLs were listed in the table because uranium is the most prevalent COC and is used as the initial basis for volume estimates, as explained throughout this section. PRLs for the other 88 COC's, corresponding to the risk ranges shown in the table, were not included for the sake of brevity. Those PRLs are provided in Tables 2-12 through 2-16. In order to limit the number of cases considered, each case considered PRLs for all media. For each case, the receptors considered for each medium represent the most restrictive credible receptors for that medium consistent with the projected land use for the case under consideration.

For each case under evaluation, Table 2-18 presents the target risk range being pursued for each media. The target risk range was established to provide a practical and implementable goal for potential remedial actions. Such a target range was deemed appropriate due to the number of COCs present at the site and their relative spatial distribution. To achieve each target risk range, each case for which volumes and footprints were developed employed the PRLs representing the lower bound of the range. For example, for a case where the target risk range is 1×10^{-6} to 1×10^{-5}, the individual PRLs derived for each COCs at the 1×10^{-6} or HI of 0.2 level were used as the basis for estimating volumes and footprints. For all cases, the goal for alternative development was to attain an HI of 1.0 or less to the target receptor. As previously discussed, select cases adopted a HI of 1.0 for uranium for soil to provide a broad range of alternatives for evaluating off property soil volumes and footprints.

As discussed in Section 2.13.1.1, the initial steps of the volume calculations were based upon uranium concentrations, and the associated uranium PRLs, in each media. For that reason, Table 2-18 includes the uranium PRLs for each target receptor and risk range. The PRLs for uranium have been rounded to the nearest 5 ppm for purposes of estimating volumes of affected media only..

The development of the nine cases began with the PRG screening results presented in Table 2-4. Table 2-4 lists risk-based concentrations of uranium in soil which, if achieved, would be protective of both the target receptors (listed in the table) and the Great Miami Aquifer. As shown, following the screening, only eight viable combinations of target receptors and risk-based PRGs remain for consideration. They include:

- The RME farmer/child at an ILCR of 10^{-6} (PRG=1.3 ppm uranium (U)
- The RME farmer/child at an ILCR of 10^{-5} (PRG=13 ppm U)
- The RME farmer/child at an HI=1.0 (PRG=44 ppm U)
- The industrial user (groundskeeper) at an ILCR of 10^{-6} (PRG=12 ppm U)
- The industrial user (groundskeeper) at an ILCR of 10^{-5} (PRG=120 ppm U)

TABLE 2-18
TARGET RISK CASES EVALUATED IN FEASIBILITY STUDY

	Preliminary Remediation Levels (PRLs)											
	Soil PRLs											
	On-Property - Central Area (K_l = 15 L/kg) Target Risk Range				On-Property - Border Area (K_l = 325 L/kg) Target Risk Range				Off-Property Risk Target			
Case	Lower Limit	Upper Limit	Target Receptor[a]	PRLs Total U (ppm)	Lower Limit	Upper Limit	Target Receptor[a]	PRLs Total U (ppm)	Lower Limit	Upper Limit	Target Receptor[a]	PRLs Total U (ppm)
	Land Use Objectives 1 and 2											
1	1×10^{-6}	1×10^{-5}	Resident	5	1×10^{-6}	1×10^{-5}	Resident	5	1×10^{-6}	1×10^{-5}	Resident	5
2	1×10^{-5}	1×10^{-4}	Resident	15	1×10^{-5}	1×10^{-4}	Resident	15	1×10^{-5}	1×10^{-4}	Resident	15
	Land Use Objective 3											
3	1×10^{-6}	1×10^{-5}	Industrial	15	1×10^{-6}	1×10^{-5}	Industrial	15	1×10^{-5}	1×10^{-4}	Resident	15
4	1×10^{-6}	1×10^{-5}	Dev. Park	20	1×10^{-6}	1×10^{-5}	Dev. Park	40	1×10^{-5}	1×10^{-4}	Resident	15
5	1×10^{-6}	1×10^{-5}	Undev. Park	20	1×10^{-6}	1×10^{-5}	Undev. Park	80	1×10^{-5}	1×10^{-4}	Resident	15
6	1×10^{-6}	1×10^{-5}	Undev. Park	20	1×10^{-6}	1×10^{-5}	Undev. Park	80	1×10^{-5}	1×10^{-4}	Resident	50[b]
7	1×10^{-6}	1×10^{-5}	Undev. Park	20	1×10^{-6}	1×10^{-5}	Undev. Park	50[c]	1×10^{-5}	1×10^{-4}	Resident	50[b]
	Land Use Objective 4											
8	1×10^{-6}	1×10^{-5}	Trespasser	20	1×10^{-6}	1×10^{-5}	Trespasser	100	1×10^{-5}	1×10^{-4}	Resident	15
9	1×10^{-6}	1×10^{-5}	Trespasser	20	1×10^{-6}	1×10^{-5}	Trespasser	100	1×10^{-5}	1×10^{-4}	Resident	50[b]

TABLE 2-18 (Continued)

Surface Water and Sediment PRLs								
	Sediment Target Risk Range				Surface Water Target Risk Range			
Case	Lower Limit	Upper Limit	Target Receptor	PRLs Total U (ppm)	Lower Limit	Upper Limit	Target Receptor	PRLs Total U (ppb)
Land Use Objectives 1 and 2								
1	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Resident	5.4×10^{2}
2	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Resident	5.4×10^{2}
Land Use Objective 3								
3	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Industrial	5.4×10^{2}
4	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Dev. Park	5.4×10^{2}
5	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Undev. Park	5.4×10^{2}
6	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Undev. Park	5.4×10^{2}
7	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Undev. Park	5.4×10^{2}
Land Use Objective 4								
8	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Trespasser	5.4×10^{2}
9	1×10^{-6}	1×10^{-5}	Youth/Rec. User	2.1×10^{2}	1×10^{-6}	1×10^{-5}	Trespasser	5.4×10^{2}

TABLE 2-18 (Continued)

	Groundwater PRLs							
	Perched Groundwater Target Risk Range				Great Miami Aquifer Groundwater Target Risk Range			
Case	Lower Limit	Upper Limit	Target Receptor	PRLs Total U (ppb)	Lower Limit	Upper Limit	Target Receptor	PRLs Total U (ppb)
				Land Use Objectives 1 and 2				
1	1×10^{-6}	1×10^{-5}	Resident	5	1×10^{-6}	1×10^{-5}	Resident	5
2	1×10^{-5}	1×10^{-4}	Resident	20	PMCL[d]	PMCL	ARAR[e]	20
				Land Use Objective 3				
3	1×10^{-5}	1×10^{-4}	Off-Prop Res.	NA	PMCL	PMCL	ARAR	20
4	1×10^{-5}	1×10^{-4}	Off-Prop Res.	NA	PMCL	PMCL	ARAR	20
5	1×10^{-5}	1×10^{-4}	Off-Prop Res.	NA	PMCL	PMCL	ARAR	20
6	1×10^{-5}	1×10^{-4}	Off-Prop Res.	NA	PMCL	PMCL	ARAR	20
7	1×10^{-5}	1×10^{-4}	Off-Prop Res.	NA	PMCL	PMCL	ARAR	20
				Land Use Objective 4				
8	1×10^{-5}	1×10^{-4}	Off-Prop Res.	NA	PMCL	PMCL	ARAR	20
9	1×10^{-5}	1×10^{-4}	Off-Prop Res.	NA	PMCL	PMCL	ARAR	20

[a] Resident is resident farmer
[b] Corresponds to an ILCR in the range of 1×10^{-5} to 1×10^{-4} with HQ 1.0
[c] Uses the principle of ALARA to reduce on-property residual contamination
[d] Proposed maximum contaminant level
[e] At residual risk level of 10^{-5} to the resident farmer, PMCLs are more restrictive and are therefore used in lieu of the risk-based limits.

- The developed park user at an ILCR of 10^{-6} (PRG=33 ppm U)
- The undeveloped park user at an ILCR of 10^{-6} (PRG=77 ppm U)
- The expanded trespasser at an ILCR of 10^{-6} (PRG=120 ppm U).

These target receptors were combined into the nine cases shown in Table 2-18. Of the eight potential receptors listed above, only one, the industrial user at an ILCR of 10^{-5}, was not included in any of the cases. In this instance, the industrial user at an ILCR of 10^{-5} yielded the same PRG as the expanded trespasser at an ILCR of 10^{-6}. The expanded trespasser was therefore considered in lieu of the industrial user, with the understanding that if the RAOs for the expanded trespasser are achieved, the resultant area would also be suitable for industrial use at the target risk level.

Of the nine cases listed, Cases 1 and 2 consider the use of the FEMP as a resident farm, consistent with Land Use Objectives 1 and 2. Case 1 considers a resident farmer with an ILCR of 10^{-6} while Case 2 considers a resident farmer with an ILCR of 10^{-5} and both cases contemplate that the resident farmer may use on-property perched water as a drinking water supply. Since the other seven cases do not consider the on-property resident farmer as a potential receptor, they consider perched water based upon its cross-media impacts (e.g., these cases consider the potential for contaminated perched water to migrate to the Great Miami Aquifer).

All other cases consider PRLs for groundwater based upon the MCLs, proposed MCLs and nonzero MCLGs for the COCs. In the absence of such an ARAR/TBC-based level for a COC, a 10^{-5} ILCR or HI of 0.2 level to the resident farmer was adopted as the PRL.

Consistent with the ILCR of 10^{-6} to the resident farmer under Case 1, this case also considers an ILCR of 10^{-6} to the on- and off-property resident farmer by the groundwater pathway (this corresponds to a uranium concentration of 3 ppb in the Great Miami Aquifer). In these cases (i.e., Cases 2 through 9) the PRL for uranium in the Great Miami Aquifer is 20 ppb (i.e., the proposed MCL for uranium). All cases consider an ILCR of 10^{-6} /HI of 0.2 to target receptors through the surface water and sediment pathways.

Cases 3 through 7 consider those uses of the FEMP on-property areas consistent with Land Use Objective 3. Cases 3 and 4 consider the industrial user (groundskeeper) and the developed park user, respectively, both with an ILCR of 10^{-6}. Cases 5 and 6 both consider an undeveloped park user with an ILCR of 10^{-6}. Case 5, however, adopts a 15 ppm uranium PRL for off-property soil. This corresponds to a 1×10^{-5} ILCR to the resident farmer due to uranium only. Case 6, in contrast, considers a PRL of 50 ppm for uranium for off-property soil. This corresponds to a 3.5×10^{-5} ILCR and a HI of 1.0 to the resident farmer due to uranium only. In both cases, the PRLs for other COCs are established at 1.0×10^{-5} ILCR to the off-property resident farmer or a HI of 0.2, whichever is

lower. Case 7 is similar to Case 6, but evaluates the use of ALARA, as discussed in Section 2.7.8, to further reduce the level of residual contamination on-property.

Cases 8 and 9 consider the maintenance of the FEMP on-property areas as a government reserve. Thus, both cases evaluate an ILCR in the range of 10^{-6} to the expanded trespasser. The difference in these two cases lies in the residual risk to the off-property resident farmer. Case 8 contemplates an ILCR of 10^{-5} to the off-property resident farmer while Case 6 considers the off-property resident farmer with an ILCR in the range of 1×10^{-5} to 1×10^{-4} and an HI of 1.0.

Volumes and footprints of affected media were estimated using the validated and nonvalidated data set and plate of maps provided as part of the Operable Unit 5 RI Report, as supplemented by the data collected subsequent to the report submittal as previously described in Section 1.0. For soil and sediment, the available on-property site investigation results for total and isotopic uranium were used as the foundation for geostatistical interpolation of the data (i.e., kriging) to support the estimation of volumes for the nine cases. For other contaminants in soil and sediment, as well as the off-property uranium results, insufficient data was available to support proper application of the kriging process. For these contaminants, a direct comparison was made between individual measured values and the corresponding PRL value to determine the incremental footprint of required excavation outside the previously defined area of excavation for uranium. The kriged results and the results of the manual interpolation, were both entered into a computer-aided drafting system (i.e., Intergraph) to support the estimation of volumes and the production of graphics. More details on this process and the estimation of the areas of affected perched and Great Miami Aquifer groundwater are presented later in this section. Areas of affected surface water were not derived for this process; surface water would be addressed concurrently through the removal of the sources of contaminants in the soil, sediment and perched water.

Footprints and volumes of affected media presented in this section are estimates only (suitable for FS-level planning and cost estimating), developed using available site characterization data. Significant reductions or increases in these volumes could occur through the application of cleanup levels during the implementation of remedial actions. To ensure that the affected media above a selected cleanup level are identified and removed, verification and certification sampling programs would be undertaken as a component of each remedial action alternative considered in this FS. The goals of the verification sampling program will be to establish the specific areas and depths of soil and sediment requiring excavation to the degree necessary to guide the use of conventional excavation equipment. In those specific areas or media where current information indicates that no or only limited action is necessary, an additional goal of the verification process would be to confirm that the existing data sets are representative . Examples of these situations would be the off-site portions of Paddys Run or the sediment in the Great Miami River, where only limited data was collected during

the RI/FS process. Sampling would be targeted during the verification sampling program to ensure that the established final remediation levels are not exceeded in these areas.

2.13.1 Soil and Sediment Excavation Volumes and Footprints

This section presents the methods used to estimate the volume of soil and sediment requiring remediation under each of the land use objectives considered for Operable Unit 5. The methods are followed by a summary of the soil volumes and footprints which would be impacted by remedial action activities required to achieve the identified PRLs for each of the nine cases identified in Table 2-18.

2.13.1.1 Methods

The volume of soil and sediment which would require excavation to achieve the PRLs for each of the nine cases presented in Table 2-18 was estimated using the nine-step process outlined below.

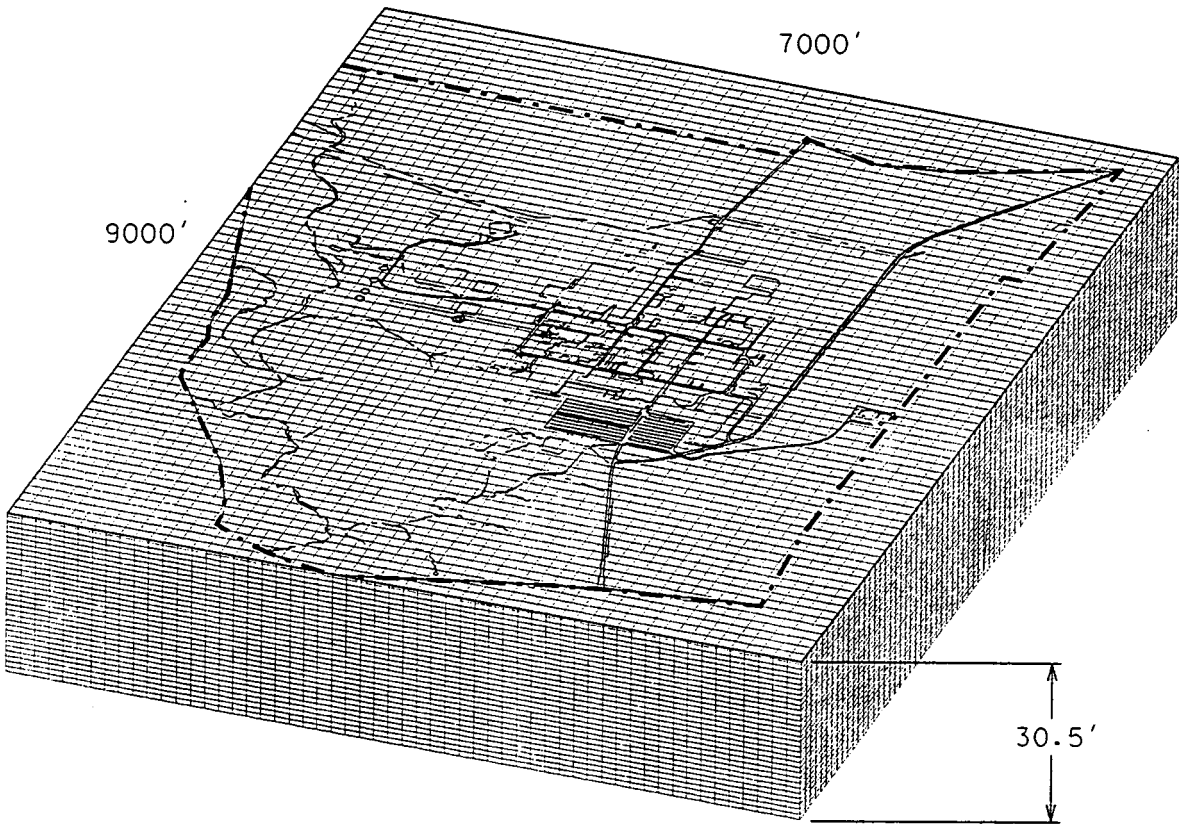
Step 1: Develop solid block model - assign uranium concentrations for each block
Step 2: Apply the PRLs for soil and sediment based upon cross-media impacts - estimate volume of soil with uranium concentrations exceeding PRLs based upon cross-media impacts
Step 3: Identify on-property perched groundwater zones requiring remediation
Step 4: Apply the PRLs for soil and sediment based upon all pathways with the exception of groundwater - estimate the incremental volume of soil with uranium concentrations exceeding PRLs
Step 5: Estimate the incremental volume of soil requiring remediation to achieve PRLs for other COCs
Step 6: Estimate residual soil from other operable units which will be addressed by Operable Unit 5
Step 7: Estimate miscellaneous soil volumes required to be addressed by Operable Unit 5 remedial actions
Step 8: Estimate volume of off-property soil requiring remediation
Step 9: Estimate incremental volume of sediments requiring remediation.

Each step in the process is discussed in greater detail in the sections that follow.

Step 1: Development of Solid Block Model

The solid block model is a tool used to establish volume estimates of environmental media to be remediated at the FEMP. The solid block model consists of a three-dimensional rendering of the FEMP and surrounding area created using software developed by Intergraph Corporation of Huntsville, Alabama (Figure 2-4).

The model represents both the surface and subsurface features of the FEMP, including buildings, utilities, roads, piping and other site features. Moreover, the model represents environmental media, including glacial overburden and other subsurface soil, perched groundwater, and Great Miami Aquifer groundwater. Finally, the model contains the results of environmental media sampling



LEGEND:

FINAL

NOT TO SCALE

FEMP BOUNDARY

/USR/ERMS/SAI SI/DGN/FSC-01.DGN FER OU5 RIDATA 07/15/94 STATE PLANAR COORDINATE SYSTEM 1927

FIGURE 2-4. SCHEMATIC OF THE FEMP SOLID BLOCK MODEL

collected from various locations across the site. Sample data incorporated into the solid block model consists of total uranium concentrations only. Data for other constituents were not sufficient to use the solid block modeling approach described herein.

Uranium data from the Characterization Investigation Study (Weston 1987), the RI Report for Operable Unit 5 (DOE 1995e), and the Fernald litigation support study (IT 1986) were all entered into the solid block model. For consistency, uranium data, including isotopic uranium analytical results, were normalized to total uranium with units of parts per million (ppm). To accomplish this normalization, if isotopic uranium results were available for a sample, they were preferentially used to derive a total uranium value in lieu of using an available total uranium analytical result for that same sample. In the event that uranium-238 was the only uranium isotopic result available, the isotopic ratios of natural uranium were used to derive a total uranium concentration.

To support the calculation and storage of a finite quantity of data, the model consists of a three-dimensional representation of the FEMP extending to a depth of 30.5 feet. The total model volume is divided into discrete volumes, or solid blocks. Subsurface blocks represent a volume of soil which is 125 feet by 125 feet by 1 foot deep. Surface soil blocks are 6-inches deep to support a more refined estimate of contaminated soil at shallower depths where contamination is more prevalent.

As noted above, the solid block model is based upon the results of soil samples collected from various locations and depths across the FEMP site. These sampling results provide uranium concentrations only at the point from which the samples were collected. A geostatistical analysis technique known as kriging was used to establish contaminant concentrations between sampling locations. The kriging model begins with a single block location in the FEMP three-dimensional solid block model then looks in both the vertical and horizontal directions to find other data points which it can use to support the process of establishing constituent concentrations between available sampling points. The model is tuned by establishing limits, in both the vertical and horizontal directions, in which the model is allowed to search to establish relationships between data points.

The kriging program employed an ellipsoidal search, using a distance of 16 feet in the vertical direction and 275 feet in the horizontal direction. These limits were set after examining the semi-variogram constructed from the measured sample data. In other words, when estimating the concentration of uranium within a block, the kriging routine was allowed to search up to 16 feet vertically and up to 275 feet horizontally around each model cell for correlative samples with which to interpolate a concentration for the cell. If no measured sampling points were found within the search ellipsoid, no estimate of concentration was made for that block.

The distribution of sample data in the semi-variogram indicated that kriging would be best applied to the log-transform of the measured total uranium values. The expected value of total uranium for each model block was obtained by back-transforming the kriged logarithmic estimate and the kriged standard error: Estimated Total U = exp(kriged estimate + std. error/2).

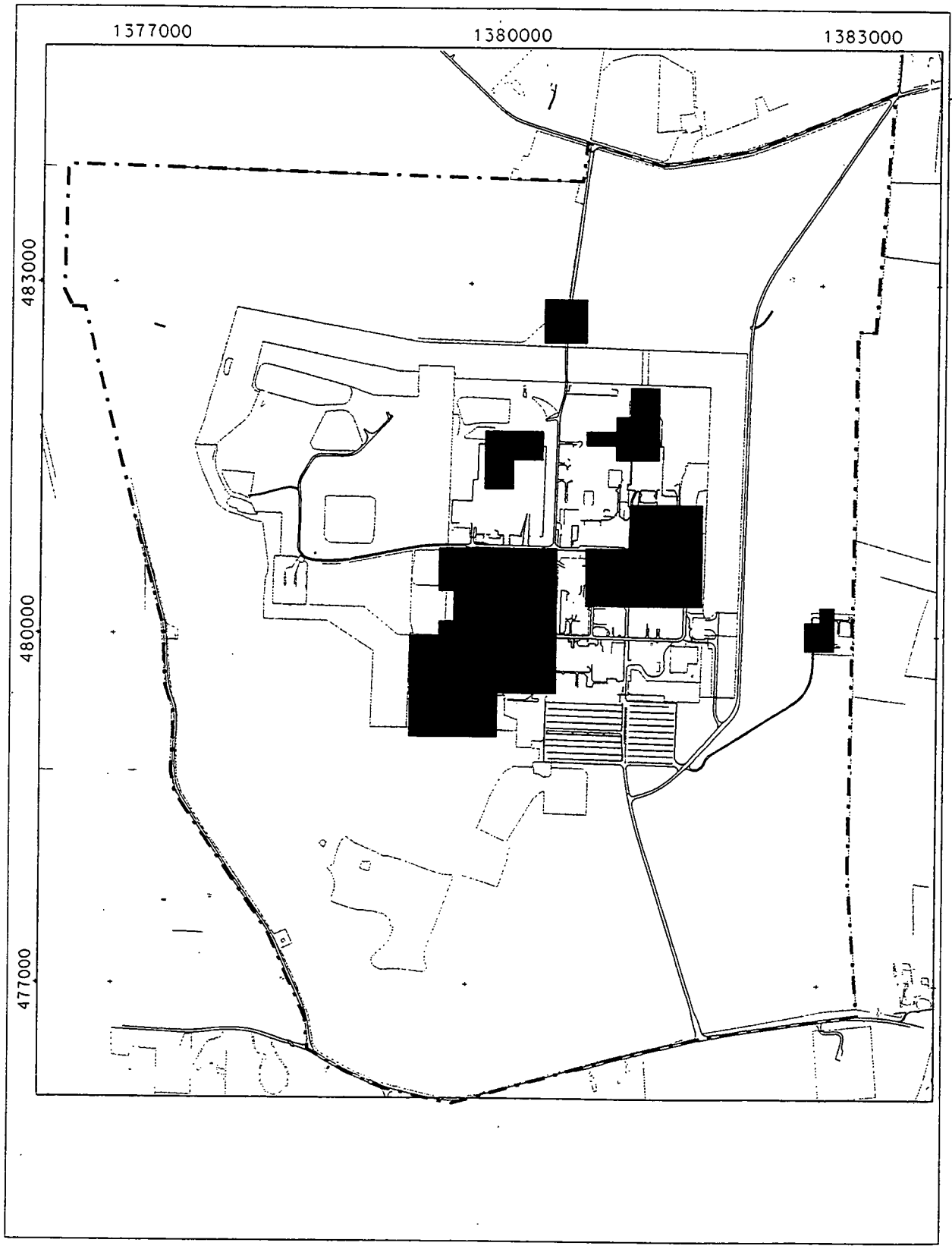
As the distance from model grid cell to measured sampling locations within the search ellipsoid increased, so too did the kriged error, which in turn exponentially increased the expected value of total uranium for the model block. This resulted in areas with extrapolated values of uranium concentration caused solely by the exponential effect of the standard error increasing away from the measured sampling points.

To prevent this effect, a lower bounding surface was constructed from measured sampling results and from knowledge of site geology. Because much of the contamination present at the FEMP, particularly in regions outside the production area, is the result of air deposition and is present at elevated concentrations in only the upper 2 to 6 inches of soil, the bounding depth was set at 0.5 feet in these areas. This assumption is supported by the preliminary results of the K_l sampling program presented in Appendix F, Attachment F.2.I. In areas where deeper contamination was measured or where knowledge of site geology allowed the possibility of deeper contamination, the bounding depth was set 5 feet below the deepest known contamination and the kriged values down to that depth were used in soil volume estimates.

Step 2: Determine Volume of Soil Excavation to Address Cross-Media Impacts for Uranium

As discussed in Section 2.5, a PRG represents that concentration of a COC in soil which, following leaching and subsequent migration through the perched groundwater or Great Miami Aquifer groundwater pathway, would yield a specified level of risk to a target receptor (e.g., the RME resident farmer). Because the calculated risk is due to the leaching of COCs through the soil to the groundwater pathway and then to the receptor, acceptable concentrations of COCs in soil are dependent upon both the permeability of the soil and the ability to leach the constituent from the contaminated soil (referred to as the K_l of the soil). Thus, cross-media impacts of residual COCs in soil are location specific.

To account for the potential cross-media impacts associated with uranium in soil at the FEMP, the site was subdivided based upon the leaching properties (K_l) of uranium in site soil (Appendix F, Attachment F.2.I). Figure 2-5 shows those regions of the site which exhibit uranium with a K_l of 15 L/kg (this is a low K_l, meaning that the soil has a relatively high uranium leachability factor). The remaining areas in Figure 2-5 are estimated to have a K_l of 325 L/kg.



LEGEND:

$K_1 = 15$

FEMP BOUNDARY

SCALE

1250 625 0 1250 FEET

FINAL

/USR/ERMA5/SAFS1/DGN/BMP/EST_PRG.DGN FER QU5 RIDATA 07/15/94 STATE PLANAR COORDINATE SYSTEM 1927

FIGURE 2-5. AREAS WHERE THE SOIL LEACHING COEFFICIENT = 15

000180

ECTran modeling was performed to estimate the maximum concentration of uranium which could reside within the K_d=15 L/kg and K_d=325 L/kg regions to yield concentrations of uranium in groundwater equivalent to the 10^{-6} PRL (3 ppb uranium) and the proposed MCL for uranium in groundwater (20 ppb uranium). Details of the ECTran modeling process used in deriving cross-media impact PRGs is presented in Section F.3.0 of Appendix F. The modeled concentrations are presented in Table 2-5. These calculated concentrations were compared with the uranium concentrations assigned to each block of the FEMP on-property solid block model by the kriging program. If the assigned concentration exceeded the acceptable concentration for that block, the block was identified as requiring remediation. The soil blocks requiring remediation were summed to determine the volume of soil to be excavated in order to achieve the cross-media impact goals under each of the land use objectives.

Step 3: Determine Incremental Soil Excavation to Address Affected Perched Groundwater

As presented in Section 4.1, affected perched groundwater zones will be excavated concurrently with the affected soil present at the FEMP. On-property perched groundwater zones which yield in excess of 1 gallon per minute and which contain elevated concentrations of COCs may represent an unacceptable risk to the on-property resident farmer under Cases 1 and 2 presented in Table 2-18 and a threat to the Great Miami Aquifer under all cases considered. Because of this, remedial actions considered to address contaminated perched groundwater must, for Cases 1 and 2, prevent a hypothetical resident from pumping and drinking contaminated perched groundwater and, for Cases 1 through 9, mitigate the vertical migration of contaminated perched water to the Great Miami Aquifer. Three cases, as described in Section F.6.0 of Appendix F, were considered in order to estimate the volume of the perched water zone requiring excavation.

As presented in detail in Section 2.13.2, hydrologic modeling was performed to determine the lateral and vertical extent of perched groundwater to be excavated to meet the target risk levels presented in Table 2-18. The horizontal and vertical boundaries of the perched water zones identified as requiring excavation were compared against the solid block model, following removal of the blocks identified to address cross-media impacts, to establish the additional blocks and incremental volume of soil requiring excavation. The soil volumes estimated were then summed with the cross-media soil volumes developed in the previous section.

Step 4: Determine Incremental Soil Excavation Required to Meet Soil PRLs for Uranium (Does not Consider Cross-Media Impacts)

As presented in Section 2.5, PRGs were established for the soil and sediment at a risk level of 10^{-6} and 10^{-5} to the hypothetical resident farmer receptor and at a risk level of 10^{-6} to the hypothetical users of an industrial park, a developed recreational park and an undeveloped recreational park. For uranium and other radionuclides, the PRGs were added to their background values and compared

against the analytical detection limits of the constituents to arrive at PRLs. The uranium concentration assigned to each block of the FEMP on-property solid block model was compared to the PRL for that block. If the contaminant concentration exceeded the PRL for a block, the block was identified as requiring remediation. Soil blocks requiring remediation to meet PRLs, which had not already been identified as requiring remediation to mitigate cross-media impacts, were summed to determine the volume of soil to be excavated in order to achieve the PRL goals under each of the land use objectives.

Step 5: Determine Incremental Soil Volume Requiring Excavation to Meet PRLs for Other COCs
Following the identification of soil to be excavated to achieve PRLs for uranium, the volume of additional soil requiring excavation to meet the PRLs for other COCs was estimated. RI characterization data for COCs other than uranium were mapped as overlays across the solid block model. Analytical results within each of the 100,000 blocks within the FEMP solid block model were compared against the PRLs for each COC. Where the contaminant concentration exceeded the PRL for that COC, the block was identified for excavation to meet the PRLs for other COCs.

Step 6: Estimate Additional Residual Soil from Other Operable Units Requiring Excavation to Meet Operable Unit 5 PRLs
The total quantity of contaminated residual soil to be obtained from the other operable units was estimated based upon calculations performed and reported in the FS Reports for those operable units. It is anticipated that Operable Unit 5 will receive additional contaminated soils from Operable Units 1, 2 and 4.

In accordance with the preferred alternative presented for Operable Unit 1, contaminated materials contained in the waste pits and the waste pit liners would be excavated and transported to an off-property commercial disposal facility. As part of the Operable Unit 1 remedy, the soil beneath the waste pits meeting preliminary waste acceptance criteria for capping would be left in place, subject to a follow-up evaluation by Operable Unit 5. If, under Operable Unit 5, this area were to be released for alternate land uses, an estimated 82,000 additional cubic yards of contaminated soil would require excavation beneath the waste pits. The area would then be backfilled with soil and revegetated. No capping would be required. The estimate was developed in the Operable Unit 1 FS on the basis of modeling projections of COCs residing in soil underlying the waste pits and the Clearwell. Lacking actual measurements, no attempt was made to segment excavated material according to land use objective. Instead, it was assumed that the entire 82,000 cubic yards of soil would be excavated regardless of the ultimate land use objective selected for Operable Unit 5.

Under Operable Unit 2, the contents of the waste units would be excavated and placed in a centralized, on-property disposal cell. Those materials not meeting the waste acceptance criteria for

the disposal cell would be disposed of at an off-property commercial disposal facility. Following excavation of the apparent waste materials by Operable Unit 2, residual contaminated soil would be evaluated using the area- and COC-specific PRLs for Operable Unit 5. Operable Unit 2 has evaluated impacts due to residual contamination for the two major COCs (i.e., uranium and neptunium-237). Operable Unit 5 would evaluate the soil and sediment for all COCs in the area if they are present. If required, additional soil removal actions would be performed to meet the Operable Unit 5 PRLs. An order-of-magnitude estimate of 20,000 cubic yards of contaminated soil and sediment was developed to represent the volume of material which may require removal to achieve the Operable Unit 5 PRLs. Following excavation, the areas would be backfilled with soil and vegetated.

Under Operable Unit 4, the contents of the silos will be disposed of off-property. Contaminated soil from Operable Unit 4 (i.e., berms and underlying soil) would be removed by Operable Unit 4 to the extent necessary to attain final remediation levels, defined in the Operable Unit 4 Record of Decision (ROD), for final disposition by Operable Unit 5. Additional excavations beyond those contemplated to comply with the Operable Unit 4 ROD may be required to attain Operable Unit 5 PRLs. On the basis of the volume estimates in the Operable Unit 4 FS Report and an examination of the Operable Unit 4 final remediation levels, a rough estimate of 30,000 cubic yards was established as the upper bound volume of soil from the Operable Unit 4 area which is required to be addressed by Operable Unit 5.

The above considerations yield a total of 132,000 cubic yards of contaminated soil from the other operable units which will be addressed under Operable Unit 5. This quantity was added to the volume of soil which will be dispositioned by Operable Unit 5.

Step 7: Estimate of Miscellaneous Soil Volumes Required to be Addressed by Operable Unit 5 Remedial Actions

Some contaminated soil from past on-property cleanup actions is not accounted for by either the solid block model or material estimates from other operable units. These materials include: boxes of contaminated soil stored at the FEMP, the Third Street dirt pile, stockpiles of dirt from Removal Action 17, and contaminated soil which may result from the excavation of underground piping. These soil volumes were estimated through summing container volumes, measurements of stock piles, and conservative estimates of that quantity of soil surrounding underground piping which may require disposal as contaminated material when excavated. Table 2-19 presents the sources and estimated quantities of miscellaneous soil volumes required to be addressed by Operable Unit 5.

TABLE 2-19

ESTIMATE OF MISCELLANEOUS SOIL VOLUMES TO BE ADDRESSED BY OPERABLE UNIT 5

Source	Volume of Soil (yd^3)
Boxes stored on-property	1500
Contaminated dirt piles	36000
Underground pipes	5000
Underground storage tanks	6500
Soil at Great Miami River outfall	2000
Total	51000

As discussed in Section 1.0 and Appendix A, a number of hazardous waste management units (HWMUs) are located at the FEMP. These HWMUs are designated as regulated units based upon the past or present management of listed and/or characteristic hazardous wastes. Current regulatory requirements and guidance provides that soil containing listed hazardous wastes or exhibiting the characteristics of a hazardous waste be managed as though they were hazardous waste. Consistent with this policy, the FEMP completed an estimate of the quantity of soil potentially containing listed wasted or exhibiting the characteristics of hazardous waste. This estimating process yielded 28,000 cubic yards of soil requiring potential management as hazardous waste. The assumptions used to derive this estimate and the strategy for managing these materials during remedial actions are presented in Section 4.1. This volume of soil does not constitute an incremental quantity of soil requiring remediation, but should be considered as a subset potentially necessitating an amended remedial approach to ensure compliance with existing environmental regulations.

Similarly an estimated 6500 cubic yards of soil (Table 2-19) contains petroleum products due to releases from underground storage tanks and includes both in situ soil and soil presently stored in stockpiles in the former production area. These volumes should be considered as incremental volumes for remediation by Operable Unit 5 as are the other soil volumes presented in Table 2-19.

Step 8: Estimate of Off-Property Soil Volumes Requiring Remediation under Operable Unit 5

Off-property soil data were manually interpolated based upon isoconcentration maps of off-property contamination taken from the Operable Unit 5 RI Report. Off-property contamination is the result of

air deposition, and is limited to surface soil as demonstrated by the RI Report. Exceptions to this mode of deposition include potentially contaminated soil located in the vicinity of the FEMP outfall line and soil and rubble on the banks of the Great Miami River at the location where the outfall line emerges. Estimated volumes of contaminated soil from these sources were accounted for in the previous section. Volume calculations were, therefore, based upon the assumed removal of 6 inches of surface soil from those off-property areas which exceed the PRLs associated with the target risk values.

Table 2-20 identifies the off-property soil volumes requiring remediation under each of the nine cases considered. Figures 2-6 and 2-7 show the areal extent of surface soil contamination to be remediated at off-property cleanup levels of 5 ppm (10^{-6} PRL) and 15 ppm (10^{-5} PRL) uranium, respectively. Achievement of the 50 ppm uranium PRL associated with cases 6, 7 and 9 is expected to require the excavation of less than 1000 cubic yards of surface soil in the immediate proximity of the FEMP east fence line to address areas of localized contamination. Because there is no general trend of off-property soil which exceeds 50 ppm uranium or which exceed PRLs for other COCs (i.e., such concentrations occur only at isolated locations along the fenceline), and because the entire 1000 cubic yard volume, which represents an estimate of the upper bound, would encompass fewer than four of the 125 feet x 125 feet grid cells in the solid block model, a map was not provided for off-property soil associated with Cases 6, 7 and 9.

Step 9: Estimate of Sediment Volume Requiring Remediation

The data set for sediment in on-property drainage ditches extends from 1987 to 1993. Elevated levels of COCs were identified at some point in nearly all of the on-property drainageways. Figure 2-8 shows FEMP on-property locations where sediment can be found. Due to the limited data set and high mobility of sediment, estimation of sediment volumes requiring remediation was performed in three steps. First, sediment data from on-property drainage ditches were included in the solid block model and kriged along with soil data. As presented in Section 2.5, the PRLs for sediment are less restrictive (i.e., higher) than the PRLs for soil. For conservatism, the concentrations of uranium in on-property sediment were compared against the more restrictive PRLs for soil to determine if sediment remediation was required.

Second, individual sediment sampling results were compared with ecological BTVs and with sediment PRLs. Locations of sediment data points exceeding PRLs were examined to separate isolated detections from overall trends and to establish the need for additional excavation in those areas not already identified for remediation from Step 1.

TABLE 2-20

OFF-PROPERTY SOIL VOLUMES REQUIRING REMEDIATION

Case	Cleanup Level (ppm uranium)	Estimated Soil Volume (yd^3)
1	5	5,200,000
2, 3, 4, 5, 8	15	400,000
6, 7, 9	50	1000

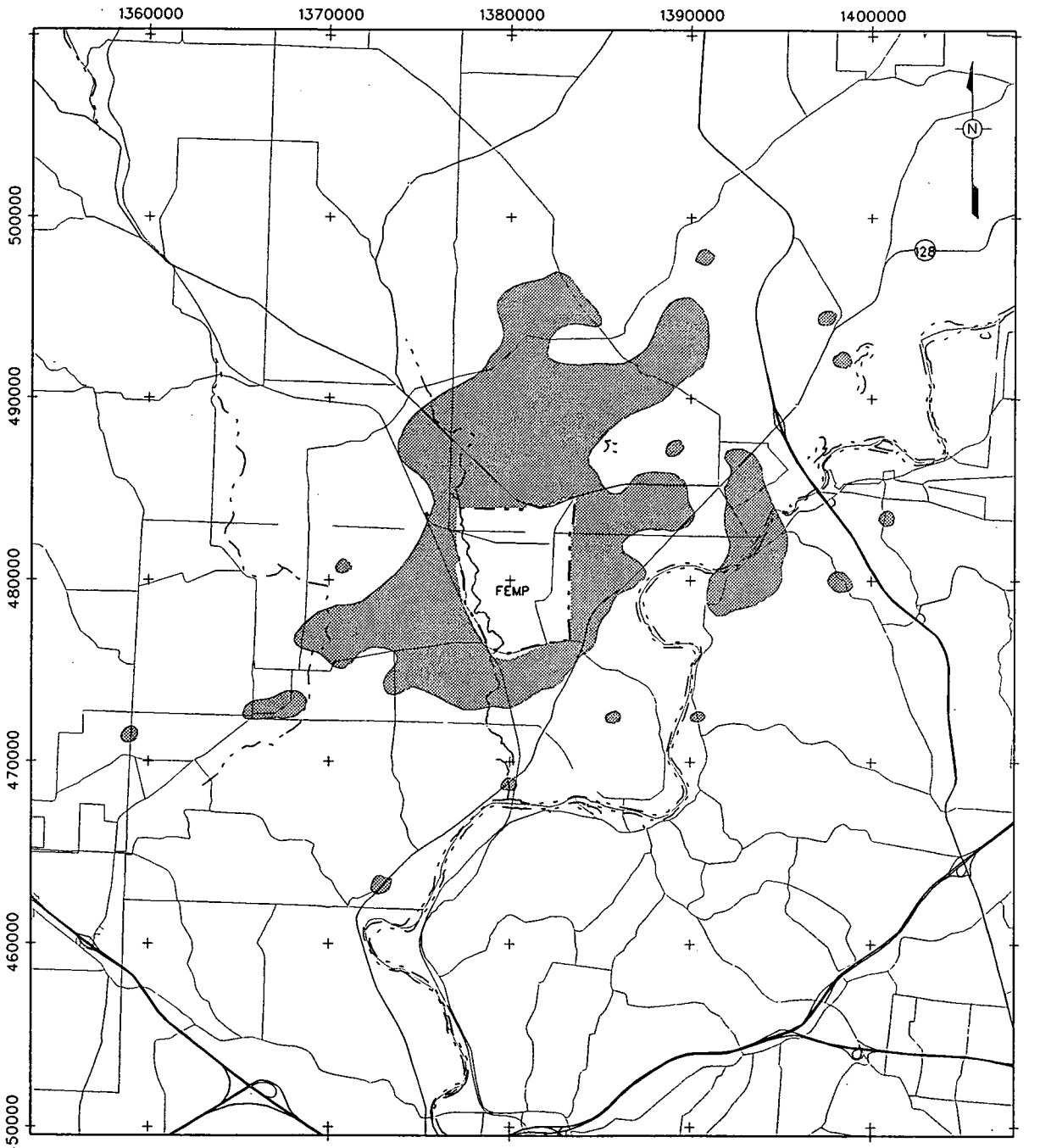
Third, for drainage ditches where the first two steps indicated that remediation was not required, but process knowledge indicated a high probability for contamination (e.g., the drainage ditch running from the pilot plant to Paddys Run), it was assumed that 6 inches of sediment would require removal along the entire course of the drainage ditch.

These volume estimates were developed to support evaluation of remedial action alternatives. Verification sampling will be performed along on-property ditches to identify the ultimate volume of sediment requiring remediation to achieve the final cleanup levels established in the ROD.

Several sets of sediment samples were collected from Paddys Run and the Great Miami River between 1986 and 1993. Although COCs above PRG or benchmark values were detected intermittently at some locations (see Figure 2-8), these data demonstrate no discernable trend of contamination to indicate that remediation of this sediment would be required. It is recognized, however, that sediment in Paddys Run and the Great Miami River is dynamic (i.e., conditions continually change, especially following a hard rain when sediment is washed out and replaced by new sediment material) and that the sediment data set is limited. Although no additional volume for Paddys Run or Great Miami River sediment was added to the volume estimates, verification sampling of sediment will be performed to ensure that remedial actions are not required. The verification sampling will be initiated near the completion of on-property soil remedial actions to preclude recontamination of remediated sediment due to surface water runoff from the FEMP during on-property remedial actions.

2.13.1.2 Volume Estimates

On the basis of the soil volume estimating methods presented herein, the alternatives considered for the FEMP would require the remediation of between 1,792,000 and 9,646,000 cubic yards of soil.



LEGEND:

10^{-6} RISK EXCAVATION FOOTPRINT

FEMP BOUNDARY

SCALE

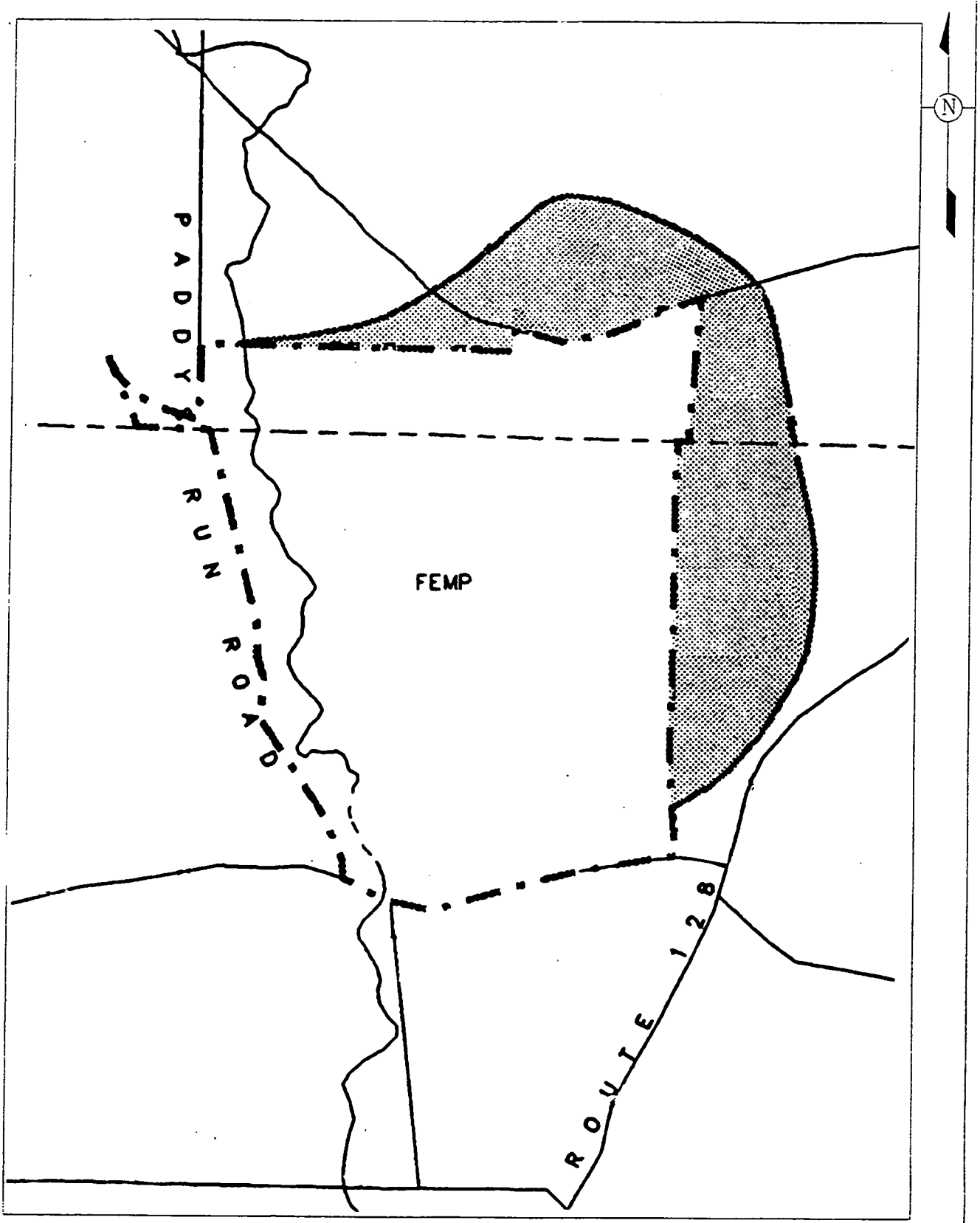
9000 4500 0 9000 FEET

/USR/ERMA1/LARRY/CFS004.DGN

FINAL

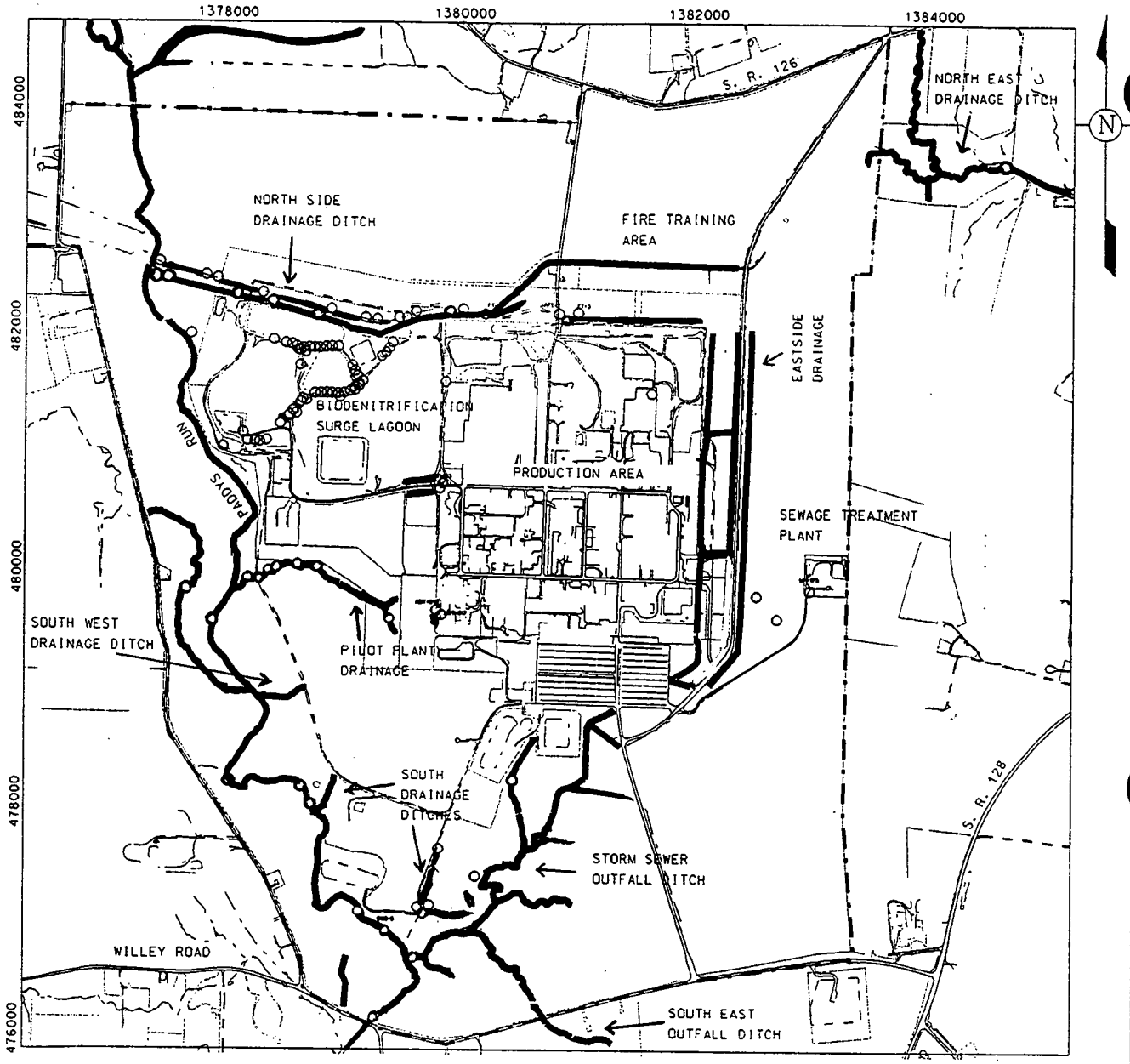
FIGURE 2-6. EXTENT OF REQUIRED OFF-PROPERTY REMEDIATION AT 10^{-6} RISK (TO 5 ppm URANIUM)

/USR/ERMA/CRU5/DGN/M.AP/HDR/DPTH/OFSITBX11.DGN FER OU5 11/8/94 STATE PLANAR COORDINATE SYSTEM 1927



FINAL

FIGURE 2-7. EXTENT OF REQUIRED OFF-PROPERTY SOIL REMEDIATION AT 10^{-5} RISK (TO 15 PPM URANIUM)



LEGEND:

- - - - - FEMP BOUNDARY

▬▬▬ DRAINAGEWAYS WHERE SEDMENT MAY ACCUMULATE

o LOCATIONS OF ELEVATED COC DETECTIONS IN SEDIMENT

FINAL

SCALE

1400 700 0 1400 FEET

/USR/ERMA3/5ARN1/CS00002.DGN FER OU5 RIDATA 11-9-94 STATE PLANAR COORDINATE SYSTEM 1927

FIGURE 2-8. AREAS OF POTENTIAL SEDIMENT DEPOSITION

The soil volume estimates generated for each case considered are presented in Table 2-21. For convenience, the target receptors and associated risk levels are included. The soil volume data for Cases 2 through 9 are presented graphically in Figure 2-9. Soil volumes for Case 1 were approximately four times the next highest case and, if presented in the same figure, made the visual comparison of data difficult.

As shown in Figure 2-9, the volume of soil requiring remediation to address cross-media impacts is constant across all cases with the exception of Cases 1 and 2. From this, it is clear that any remedial action alternative chosen for the FEMP will require the remediation of a minimum of 1,114,000 cubic yards of soil to ensure protection of the Great Miami Aquifer. The volume of soil requiring remediation to address potential cross-media impacts is higher for Cases 1 and 2 since they include an on-property resident farmer as a hypothetical receptor. Cases 1 and 2 therefore require that additional volumes of soil be remediated to address contaminated perched groundwater with a yield of 1 gpm or greater which could serve as a source of drinking water for the on-property resident farmer. Cases 3 through 9 did not contemplate the use of perched groundwater as a drinking water supply.

Another constant across all cases is the volume of soil to be received from other operable units. This volume also includes miscellaneous on-property material, such as contaminated soil from past removal actions, which must be addressed regardless of the alternative selected.

The soil volumes which vary from case-to-case include 1) soil that exceeds the uranium PRLs (in excess of soil already identified as requiring remediation to mitigate cross-media impacts), 2) soil in which the concentration of other COCs exceed the PRLs for those materials, and 3) off-property soil requiring remediation.

2.13.1.3 Footprints

Associated with each of the nine cases is a footprint showing the areal extent of land which would be disturbed as a result of the remedial actions associated with that case. The remedial action footprints for on-property areas are presented in Figures 2-10 through 2-16. Each of these figures is presented in three layers. The base map shows the areas disturbed by the excavation of the soil having a cross-media impact. The removal of this soil is essential to ensure the protection of the Great Miami Aquifer. Layer two shows the additional soil which would require remediation to ensure that the

PRLs for uranium are met at every location. The final layer shows the additional soil requiring remediation in order to ensure that the PRLs for other COCs are met.

Figures 2-6 and 2-7 show the off-property areas which would be disturbed in order to achieve the RAOs for each of the nine cases. Case 1 reflects a 10^{-6} ILCR to the off-property resident farmer.

TABLE 2-21

OPERABLE UNIT 5
SOIL VOLUME ESTIMATES

Case	On-Property Central Area Risk Target		On-Property Border Area Risk Target		Off-Property Risk Target	
	Risk Level	Receptor	Risk Level	Receptor	Risk Level	Receptor
			Land Use Objectives 1 and 2			
1	10^{-6}	Resident	10^{-6}	Resident	10^{-6}	Resident
2	10^{-5}	Resident	10^{-5}	Resident	10^{-5}	Resident
			Land Use Objective 3			
3	10^{-6}	Industrial	10^{-6}	Industrial	10^{-5}	Resident
4	10^{-6}	Dev. Park	10^{-6}	Dev. Park	10^{-5}	Resident
5	10^{-6}	Undev. Park	10^{-6}	Undev. Park	10^{-5}	Resident
6	10^{-6}	Undev. Park	10^{-6}	Undev. Park	3.5×10^{-5} HI = 1	Resident
7	10^{-6}	Undev. Park	ALARA[a]	Undev. Park	3.5×10^{-5} HI = 1	Resident
			Land Use Objective 4			
8	10^{-6}	Trespasser	10^{-6}	Trespasser	10^{-5}	Resident
9	10^{-6}	Trespasser	10^{-6}	Trespasser	3.5×10^{-5} HI=1	Resident

VOLUME OF SOIL REQUIRING ACTION

Case	Cross-Media Impacts (yd^3)	PRLs[b] (yd^3)	Other COCs (yd^3)	Other OUs and Misc. (yd^3)	Off-Site (yd^3)	Total (yd^3)
			Land Use Objectives 1 and 2			
1	3,102,000	1,145,000	16,000	183,000	5,200,000	9,646,000
2	1,503,000	482,000	176,000	183,000	400,000	2,744,000
			Land Use Objective 3			
3	1,114,000	487,000	204,000	183,000	400,000	2,388,000
4	1,114,000	226,000	274,000	183,000	400,000	2,197,000
5	1,114,000	178,000	316,000	183,000	400,000	2,191,000
6	1,114,000	178,000	316,000	183,000	1,000	1,792,000
7	1,114,000	216,000	283,000	183,000	1,000	1,797,000
			Land Use Objective 4			
8	1,114,000	175,000	319,000	183,000	400,000	2,191,000
9	1,114,000	175,000	319,000	183,000	1,000	1,792,000

[a] As low as reasonably achievable
[b] Includes estimated 175,000 cubic yards of gravel from former production area.

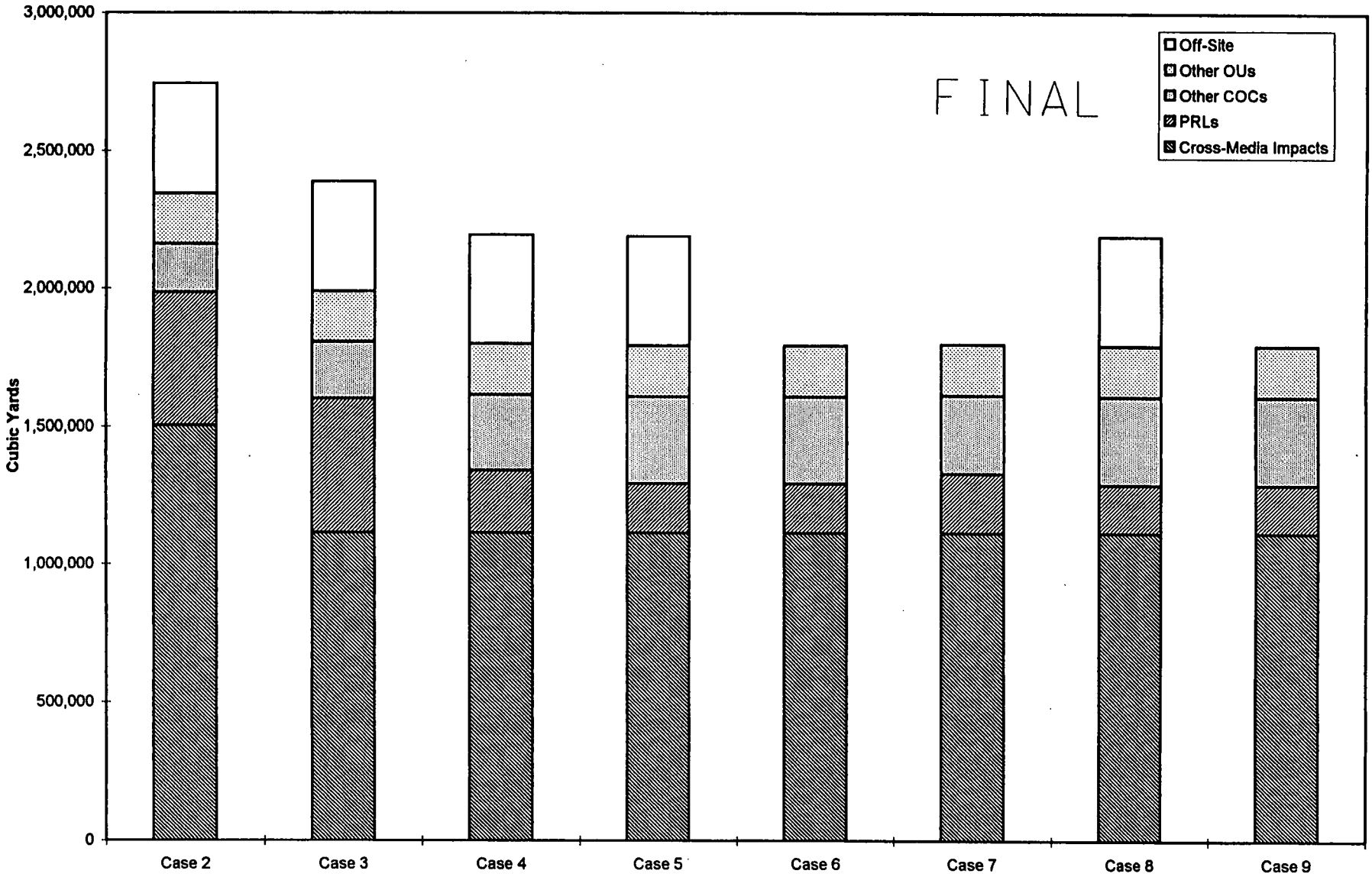


FIGURE 2-9. SOIL VOLUME ESTIMATES

000192

7069

+ OTHER COCs

+ URANIUM PRLs

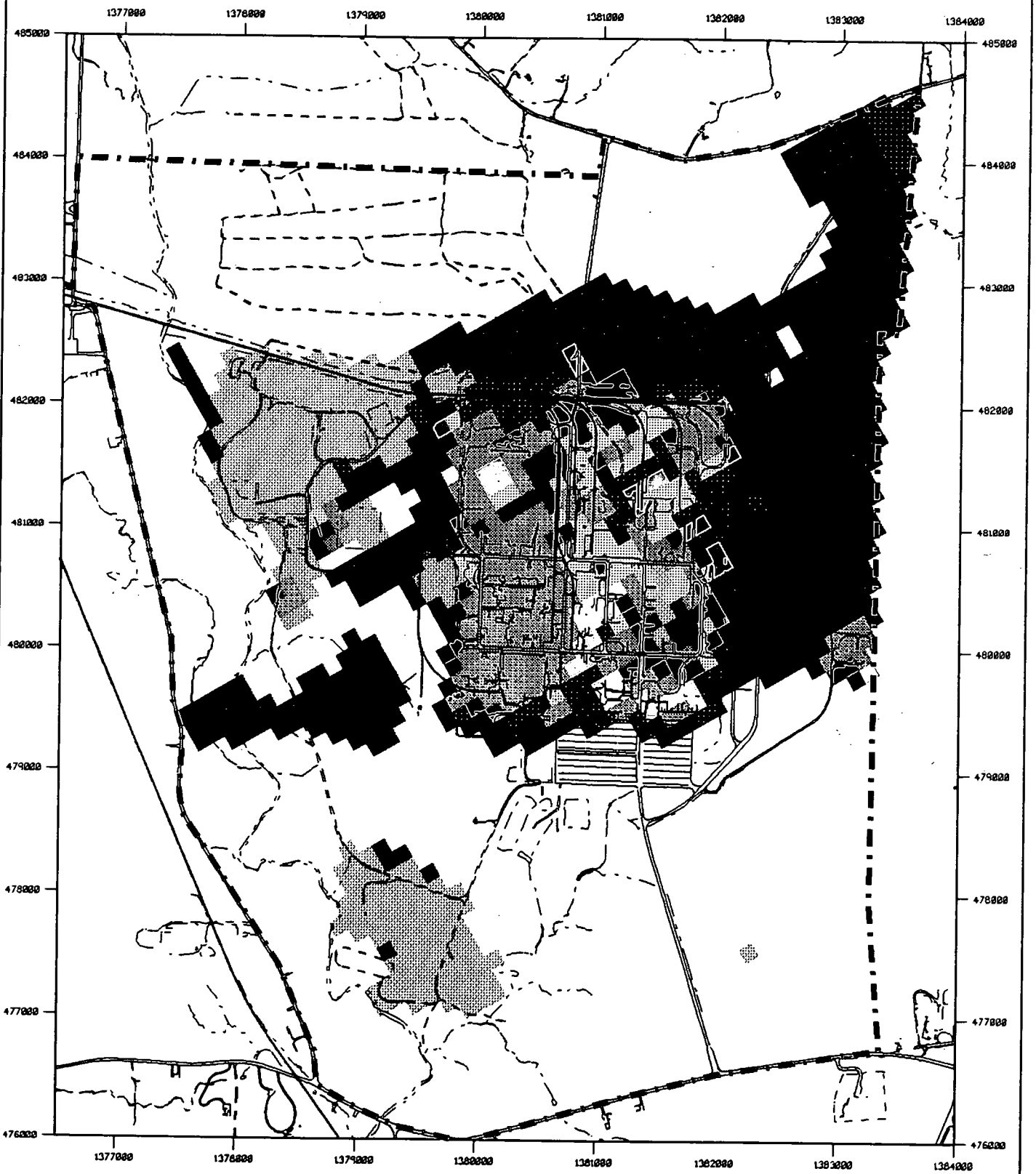


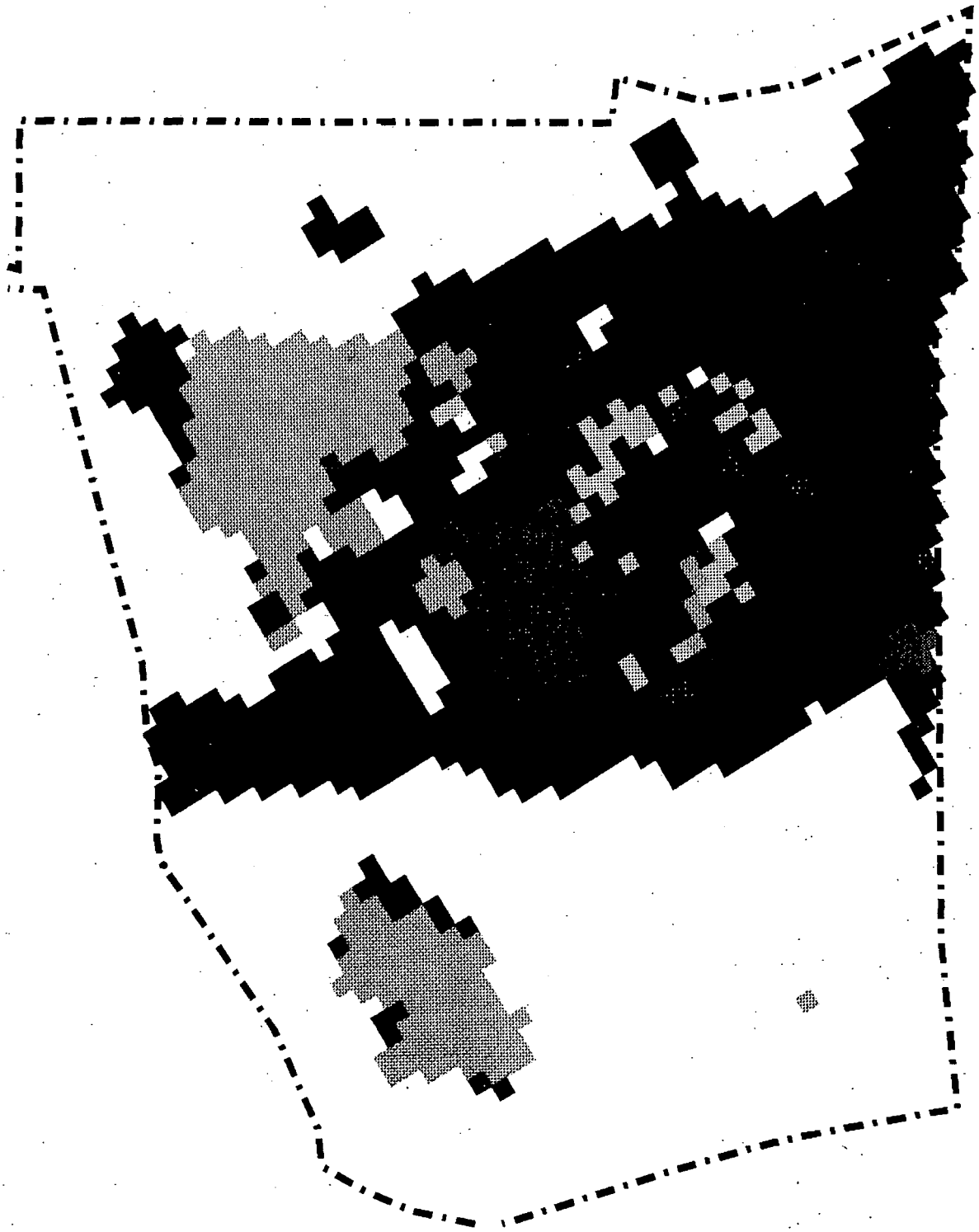
FIGURE 2-10. ON-PROPERTY SOIL EXCAVATION FOOTPRINT, LAND USE OBJECTIVES 1 AND 2, CASE 1

0 to 6' | 6' to 2.5' | 2.5 - 5' | 5 - 10' | 10 - 15' | > 15' | OTHER OU's

CROSS-MEDIA IMPACTS

FINAL

+ OTHER COCs



+ URANIUM PRLs

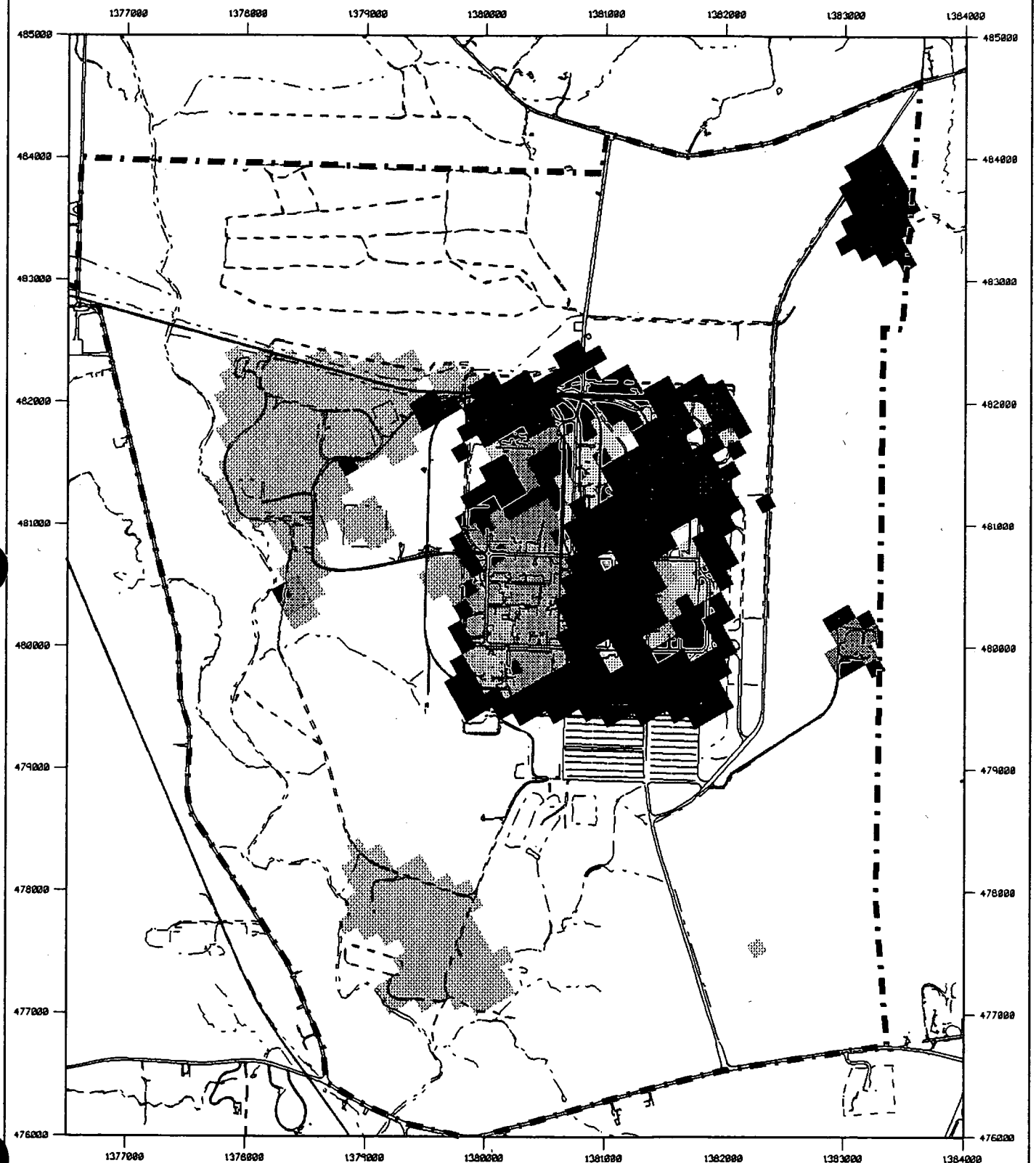


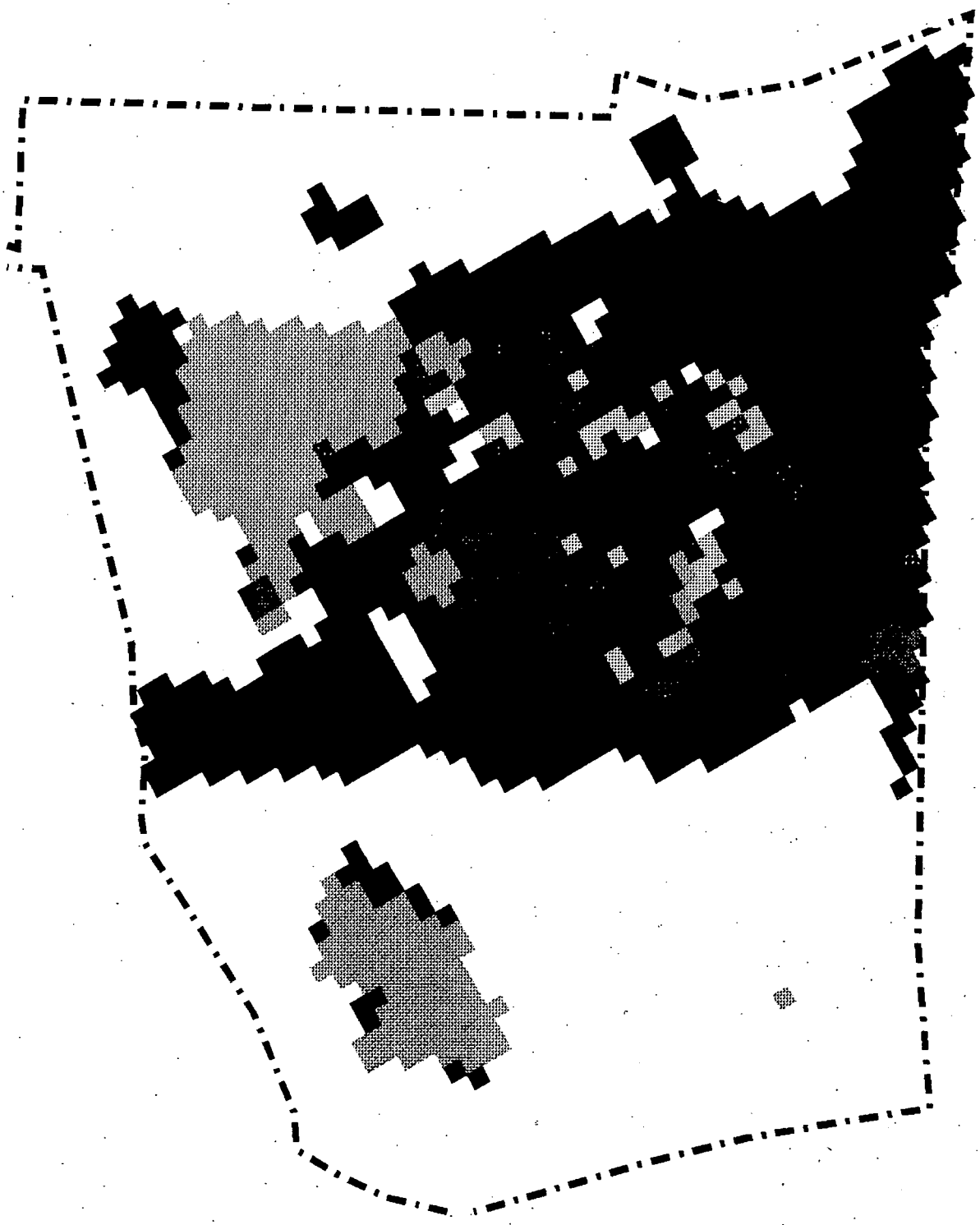
FIGURE 2-11. ON-PROPERTY SOIL EXCAVATION FOOTPRINT, LAND USE OBJECTIVES 1 AND 2, CASE 2

0 to 6' | 6' to 2.5' | 2.5 - 5' | 5 - 10' | 10 - 15' | > 15' | OTHER OU's

CROSS-MEDIA IMPACTS

FINAL

+ OTHER COCs



+ URANIUM PRLs

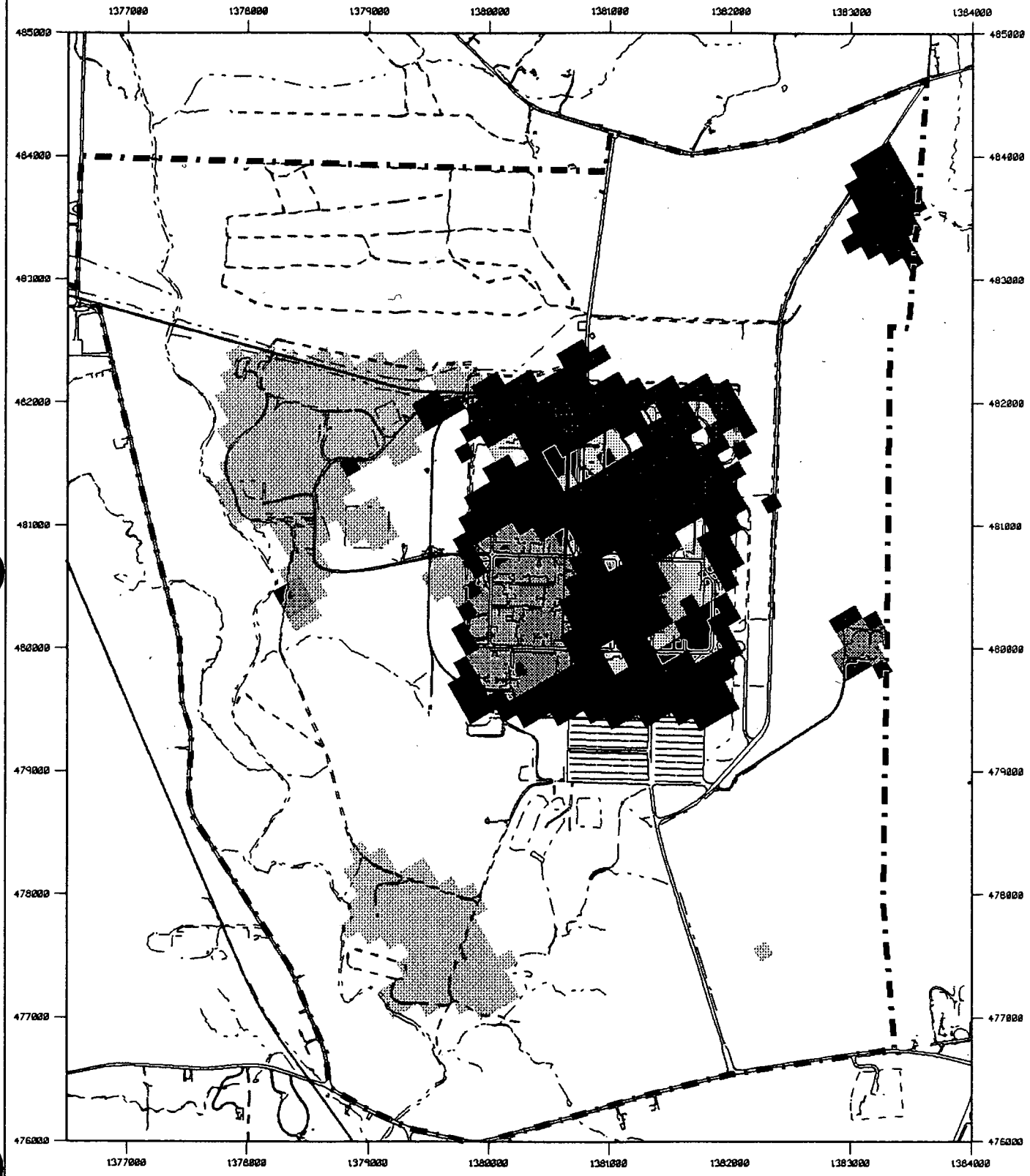


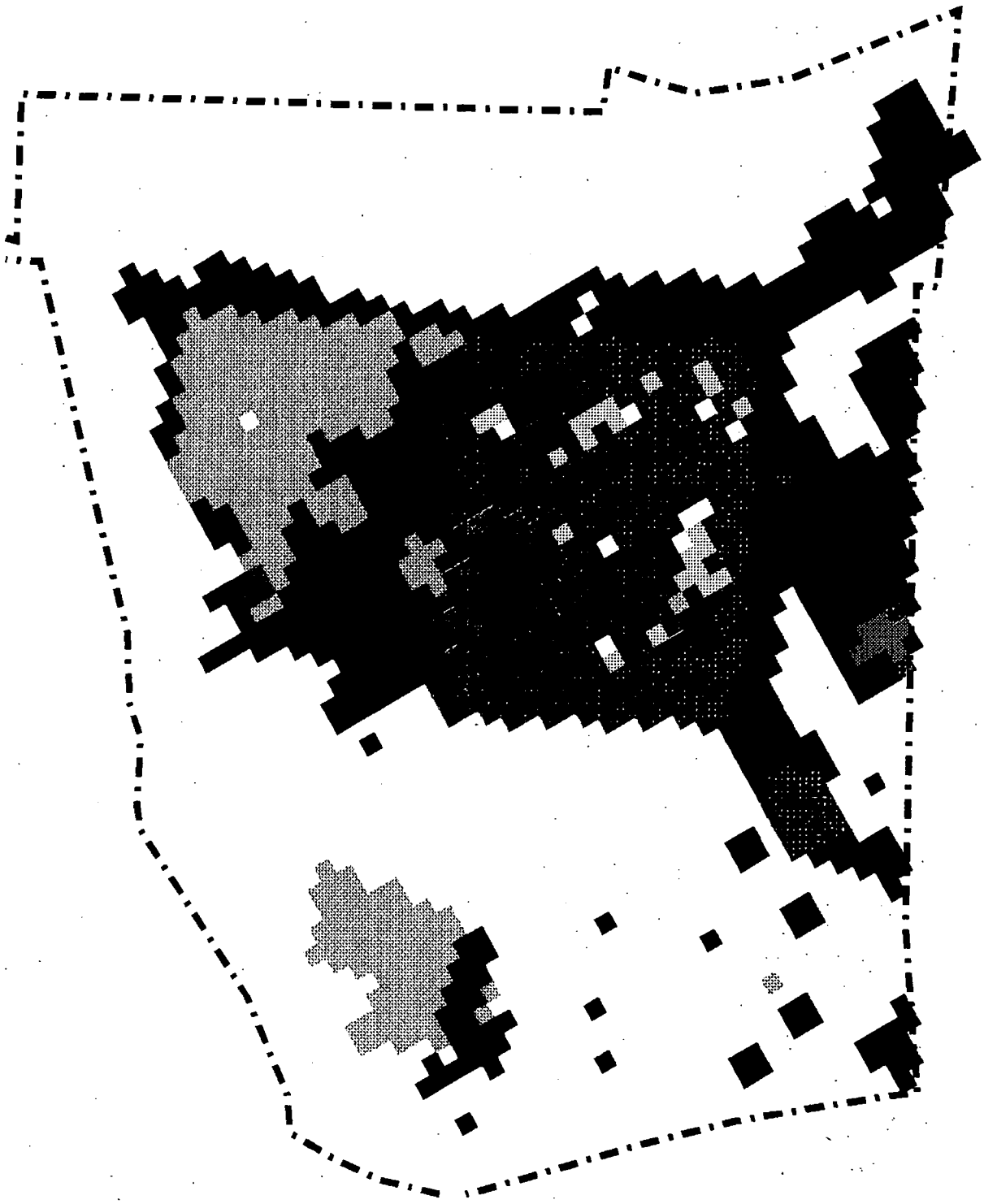
FIGURE 2-12. ON-PROPERTY SOIL EXCAVATION FOOTPRINT, LAND USE OBJECTIVE 3, CASE 3

0 to 6' | 6' to 2.5' | 2.5 - 5' | 5 - 10' | 10 - 15' | > 15' | OTHER OU's

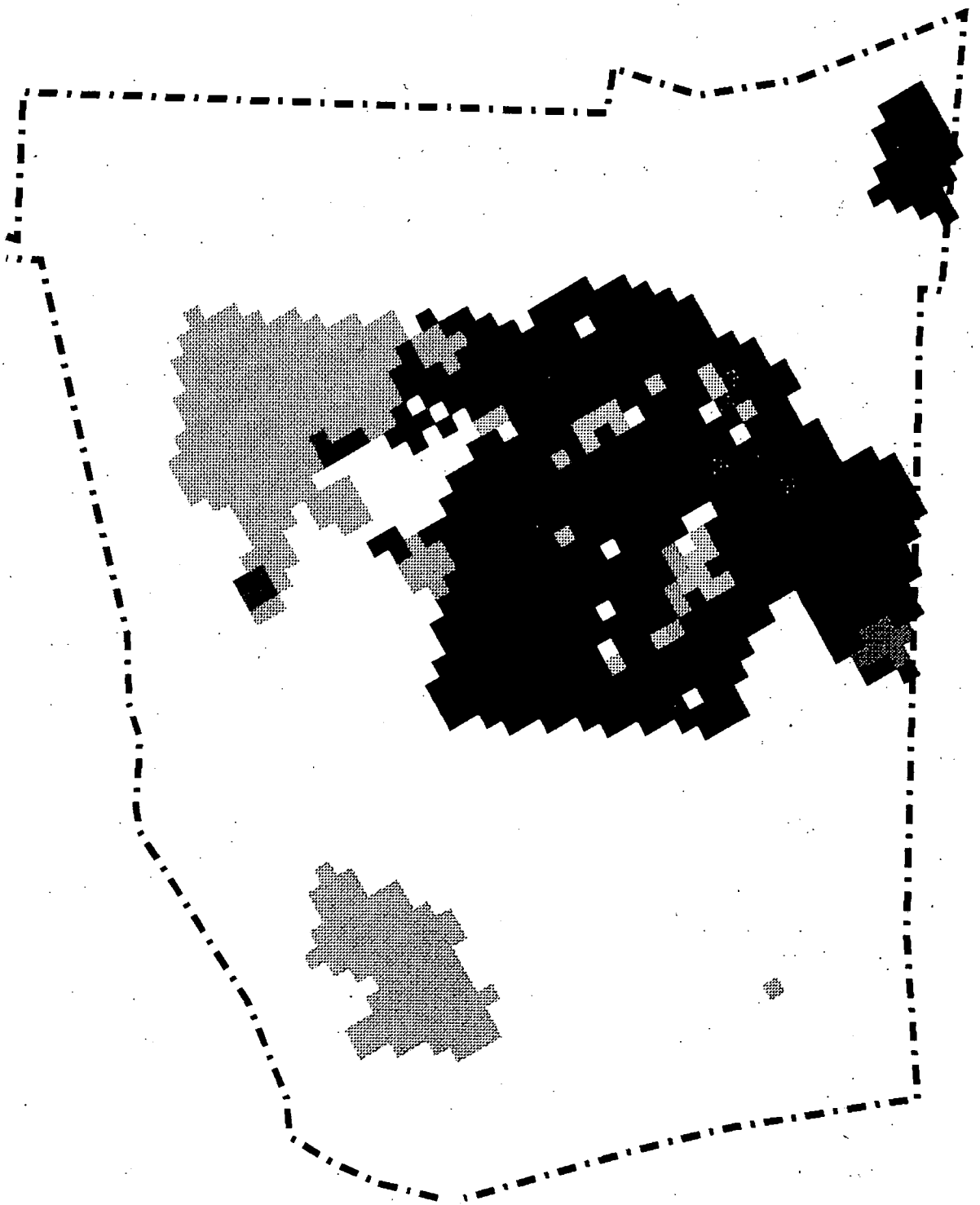
CROSS-MEDIA IMACTS

FINAL

CC0001



+ OTHER COCs



+ URANIUM PRLs

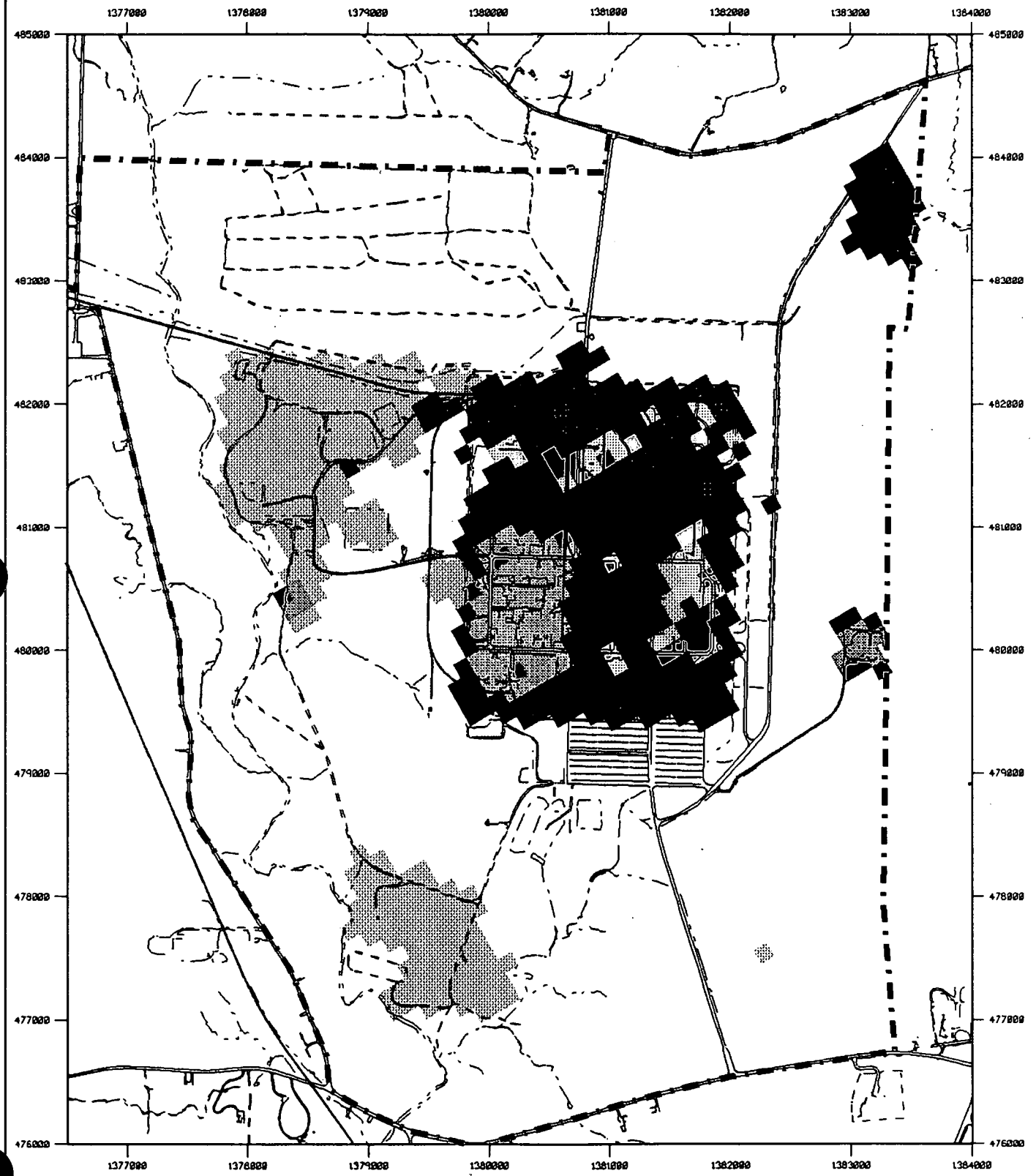


FIGURE 2-13. ON-PROPERTY SOIL EXCAVATION FOOTPRINT, LAND USE OBJECTIVE 3, CASE 4

0 to 6' | 6' to 2.5' | 2.5 - 5' | 5 - 10' | 10 - 15' | > 15' | OTHER OU's

CROSS-MEDIA IMPACTS

FINAL

+ OTHER COCs

+ URANIUM PRLs

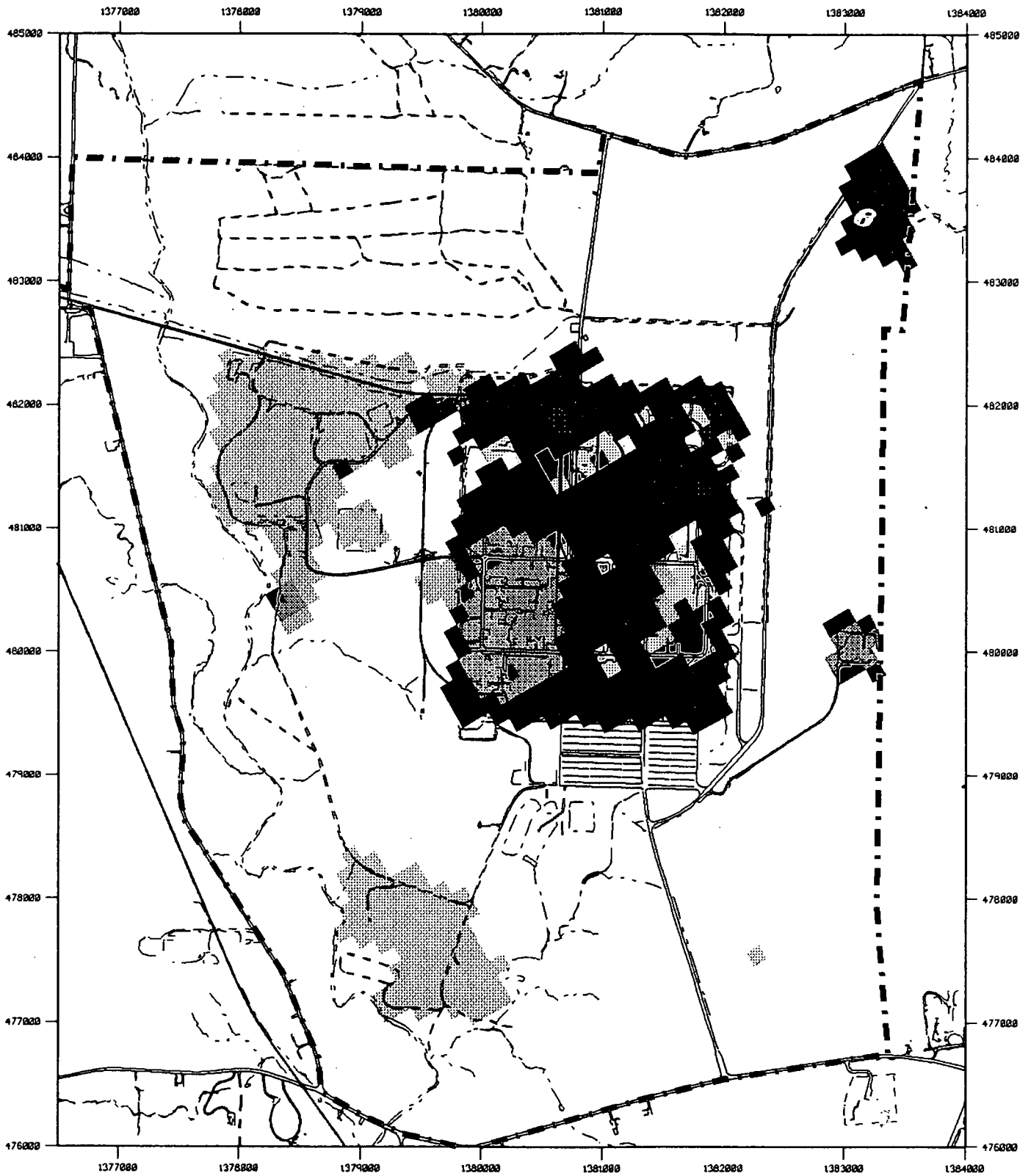


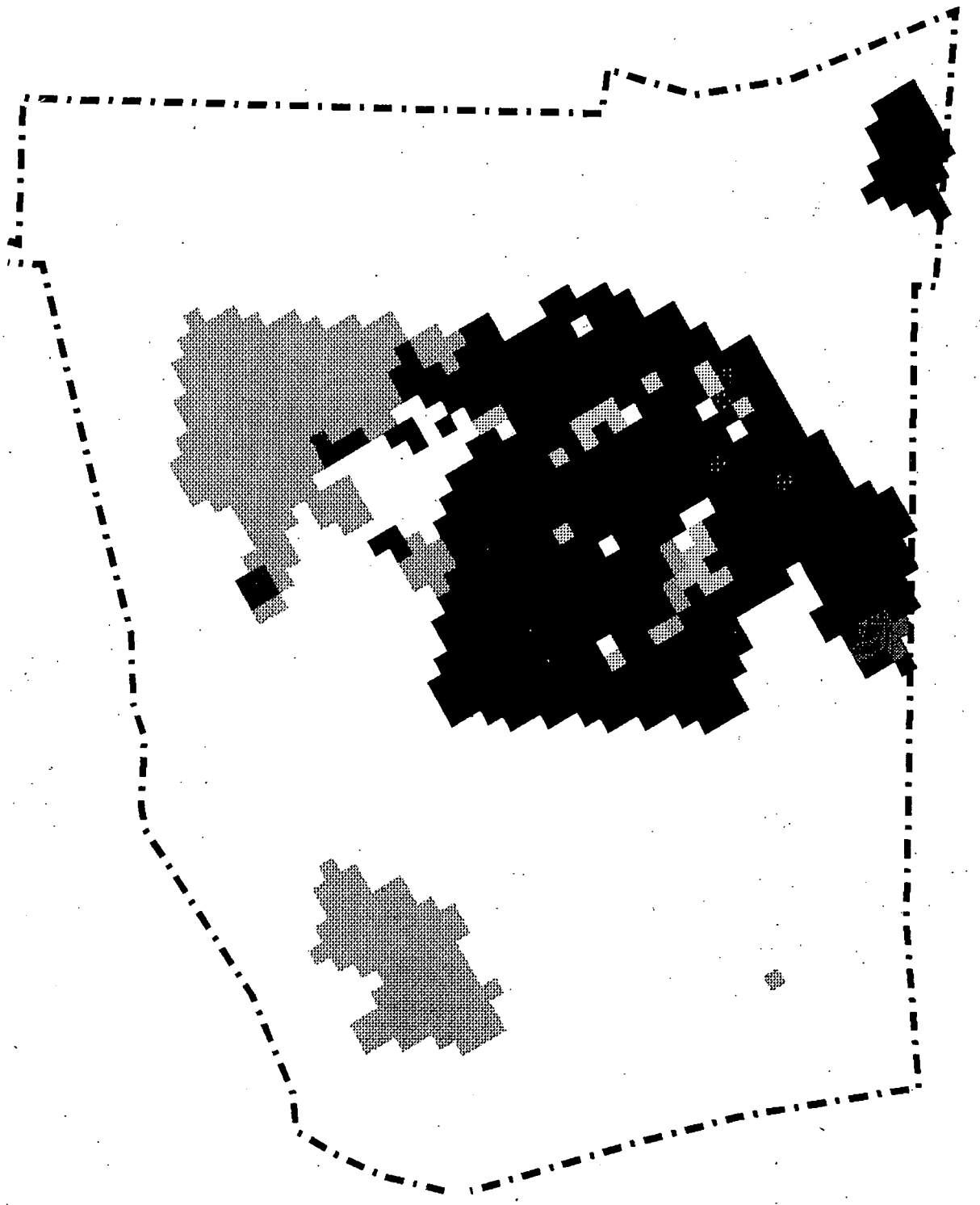
FIGURE 2-14. ON-PROPERTY SOIL EXCAVATION FOOTPRINT, LAND USE OBJECTIVE 3, CASES 5 AND 6

0 to 6' | 6' to 2.5' | 2.5 - 5' | 5 - 10' | 10 - 15' | > 15' | OTHER OU's

CROSS MEDIA IMPACTS

FINAL

+ OTHER COCs



+ URANIUM PRL.

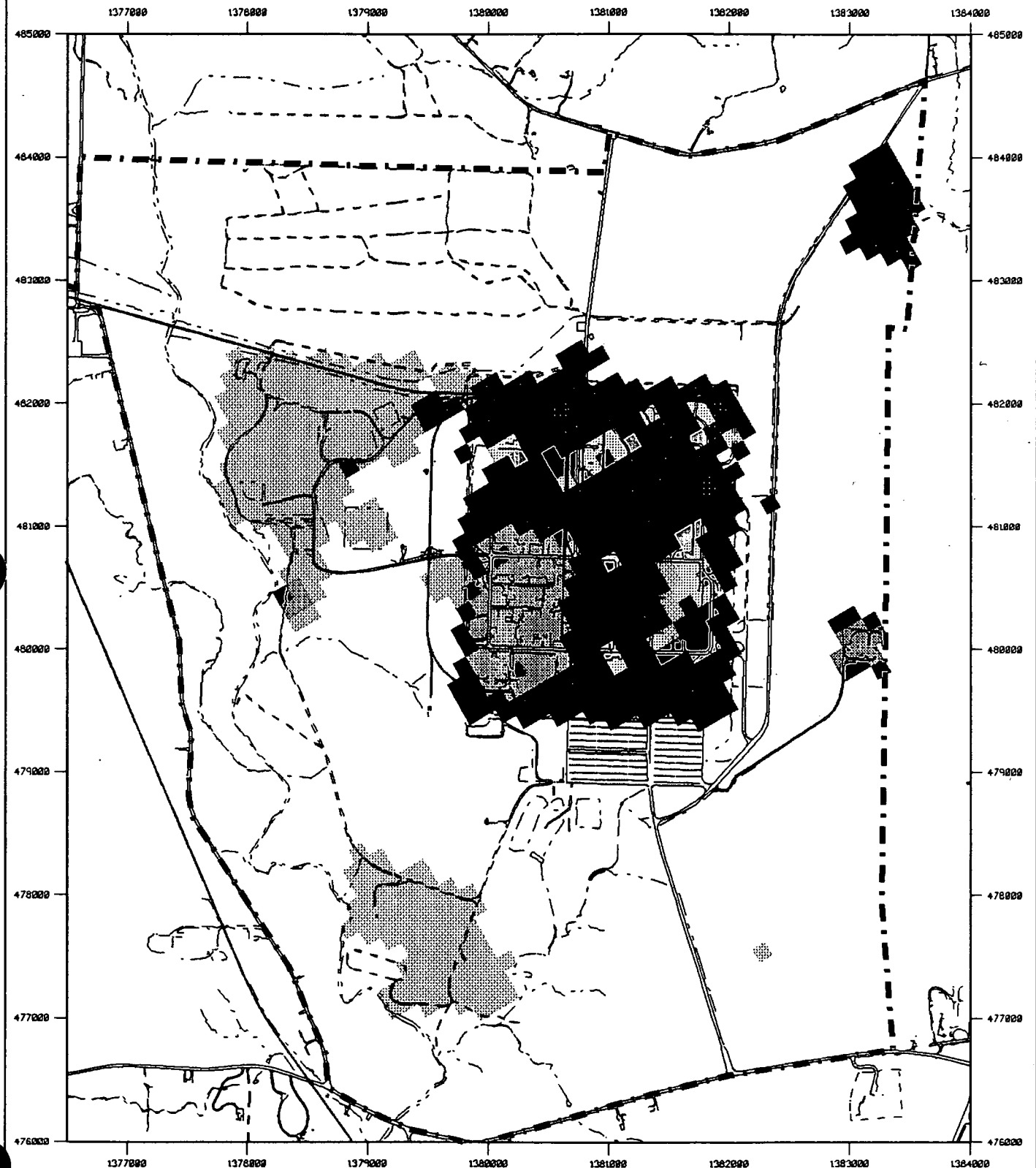


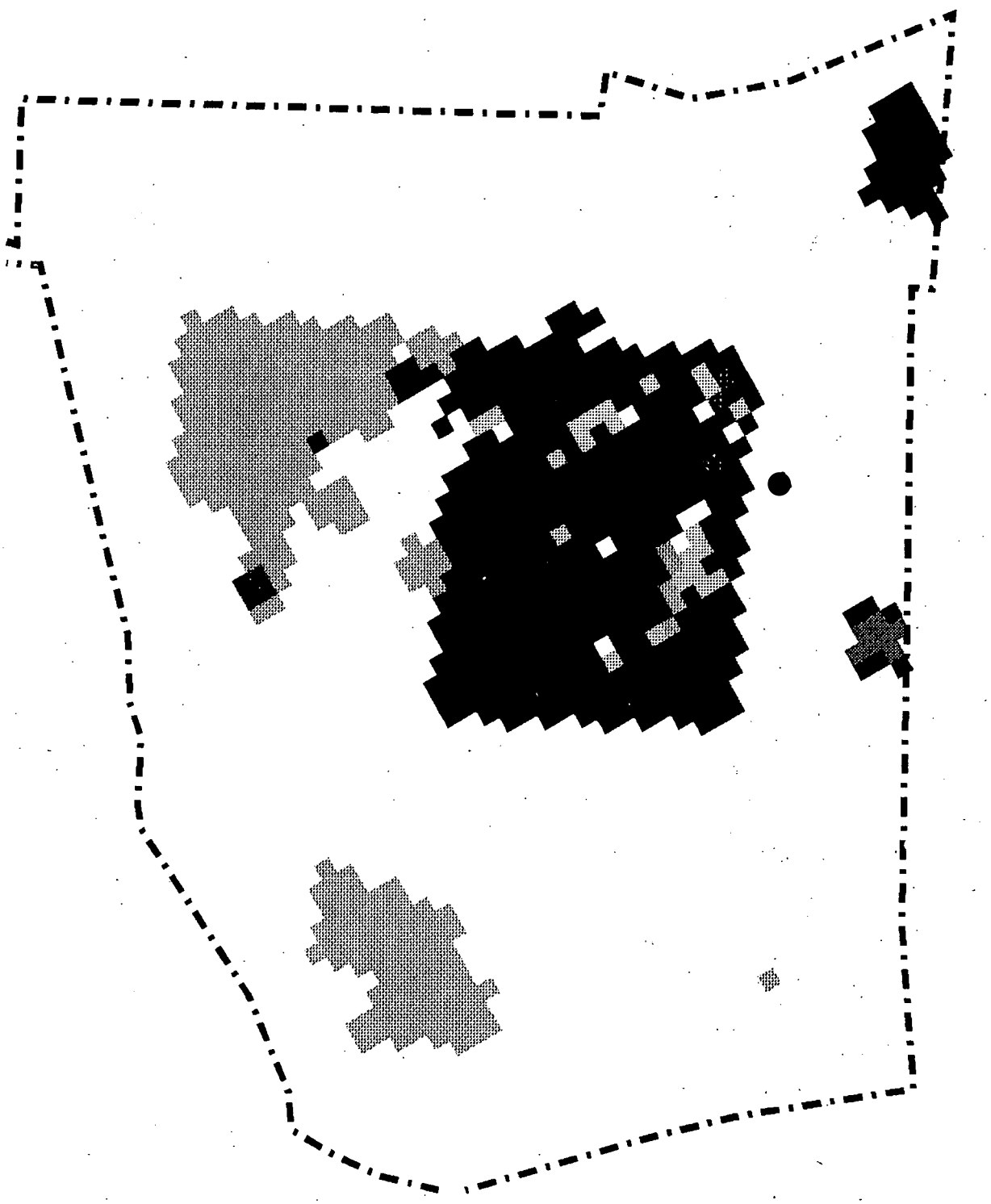
FIGURE 2-15. ON-PROPERTY SOIL EXCAVATION FOOTPRINT, LAND USE OBJECTIVE 3, CASE 7

0 to 6' | 6' to 2.5' | 2.5 - 5' | 5 - 10' | 10 - 15' | > 15' | OTHER OU's

CROSS-MEDIA IMPACTS

FINAL

+ OTHER COCs



+ URANIUM PRLs

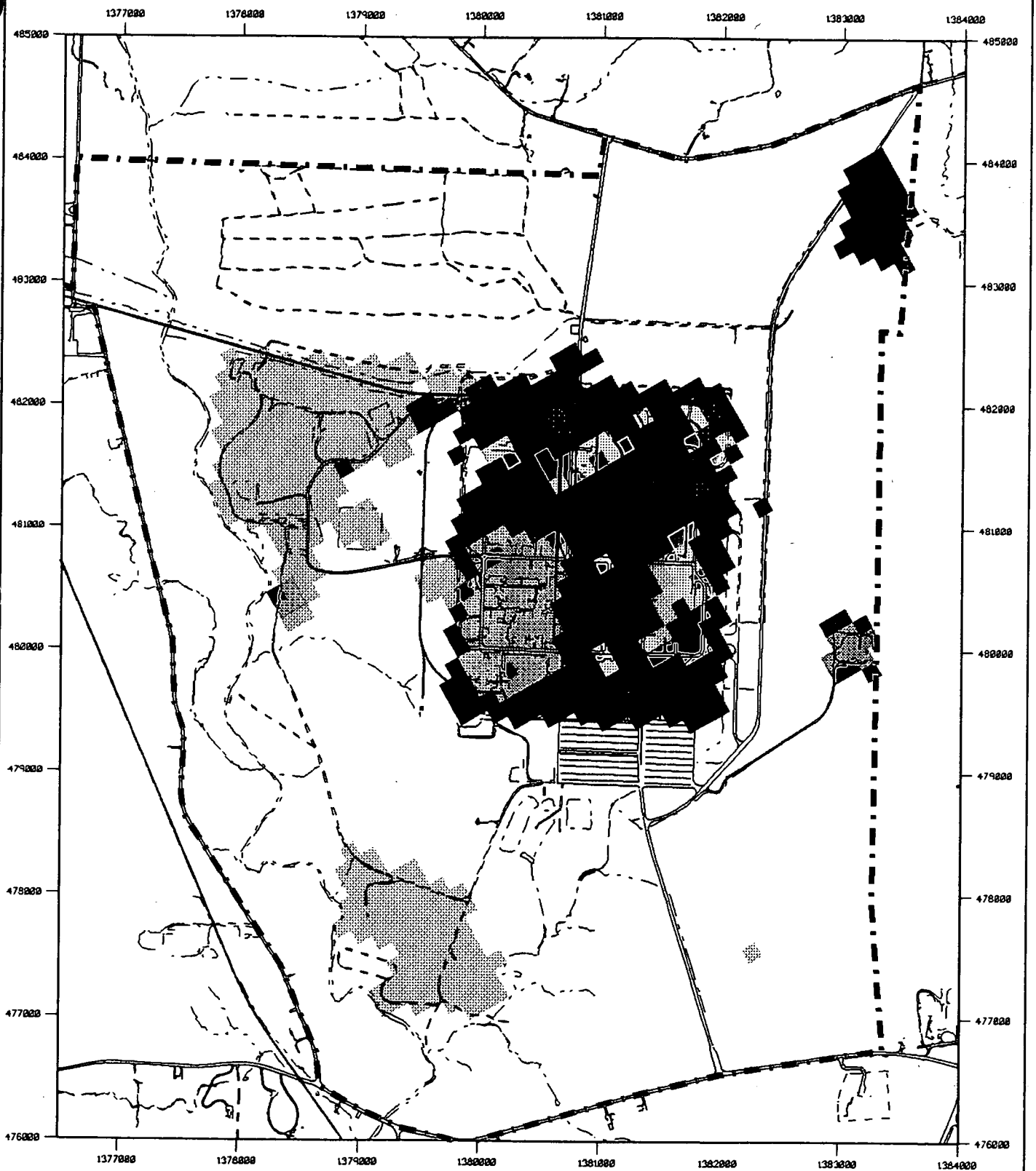


FIGURE 2-16. ON-PROPERTY SOIL EXCAVATION FOOTPRINT, LAND USE OBJECTIVE 4, CASES 8 AND 9

0 to 6" | 6" to 2.5' | 2.5 - 5' | 5 - 10' | 10 - 15' | > 15' | OTHER OU's

CROSS-MEDIA IMPACTS

FINAL

This corresponds to a uranium PRL of 5 ppm. The achievement of this objective would require the excavation of 10 square miles, shown in Figure 2-6, to a depth of 6 inches. This would result in the excavation of 5,200,000 cubic yards of soil.

Cases 2, 3, 4, 5, and 8 are designed to achieve an ILCR of 10^{-5} to the off-property resident farmer, which corresponds to a uranium PRL of 15 ppm. The achievement of this objective would require the excavation of 0.77 square miles (496 acres) of off-property soil, as shown in Figure 2-7, to a depth of 6 inches. This would result in the excavation of 400,000 cubic yards of soil.

Cases 6, 7, and 9 are designed to achieve an ILCR in the range of 10^{-5} to 10^{-4} with a HI of 1 to the off-property resident farmer. This corresponds to a uranium PRL of 50 ppm. The achievement of this objective would require the excavation of less than 1000 cubic yards of soil located in close proximity to the FEMP. For these and each of the other cases, verification sampling would be performed in order to more precisely identify those areas requiring excavation. Following excavation, certification sampling would be performed to ensure that the RAOs have been met.

2.13.2 Estimate of Perched Groundwater Requiring Remediation

A remedial action evaluation was performed to determine the most reasonable method for addressing contamination in perched groundwater and to provide a basis for cost estimating to support the development and evaluation of overall remedial action components for Operable Unit 5. This evaluation is discussed in more detail in Section 4.0 and Appendix F.

As part of the evaluation, groundwater modeling was performed to study the technical feasibility of the following remedial action components which might be used to contain or remove contaminated perched groundwater:

- Collection trenches
- Vertical pumping wells
- Excavation of contaminated perched groundwater zones.

The components were first assessed against three criteria designed to ensure the protection of potential future receptors. First, the remedial action must prevent consumption of perched groundwater containing contamination at levels above a PRL by a hypothetical resident farmer. Second, the remedial action must ensure that the Great Miami Aquifer is protected from the vertical migration of perched groundwater. Third, the remedial action must ensure that the Great Miami Aquifer is protected from the lateral migration of perched groundwater to the surface water and ultimate infiltration of surface water into the Great Miami Aquifer. Among the components evaluated, only the excavation component met all of the protection criteria.

Hydrologic modeling was used to define the perched groundwater zone requiring remediation based upon both lateral and vertical migration pathways. This modeling yielded three perched groundwater zones, shown in Figure 2-17, which would require excavation depending upon the case under consideration.

Excavation Footprint 1 represents the perched groundwater zone with constituent concentrations which, through the vertical and lateral migration pathway, would cause the contamination levels in the Great Miami Aquifer to exceed the PRLs associated with an ILCR of 10^{-5} to the off-property resident farmer. This perched groundwater zone would require excavation for all cases, 1 through 9.

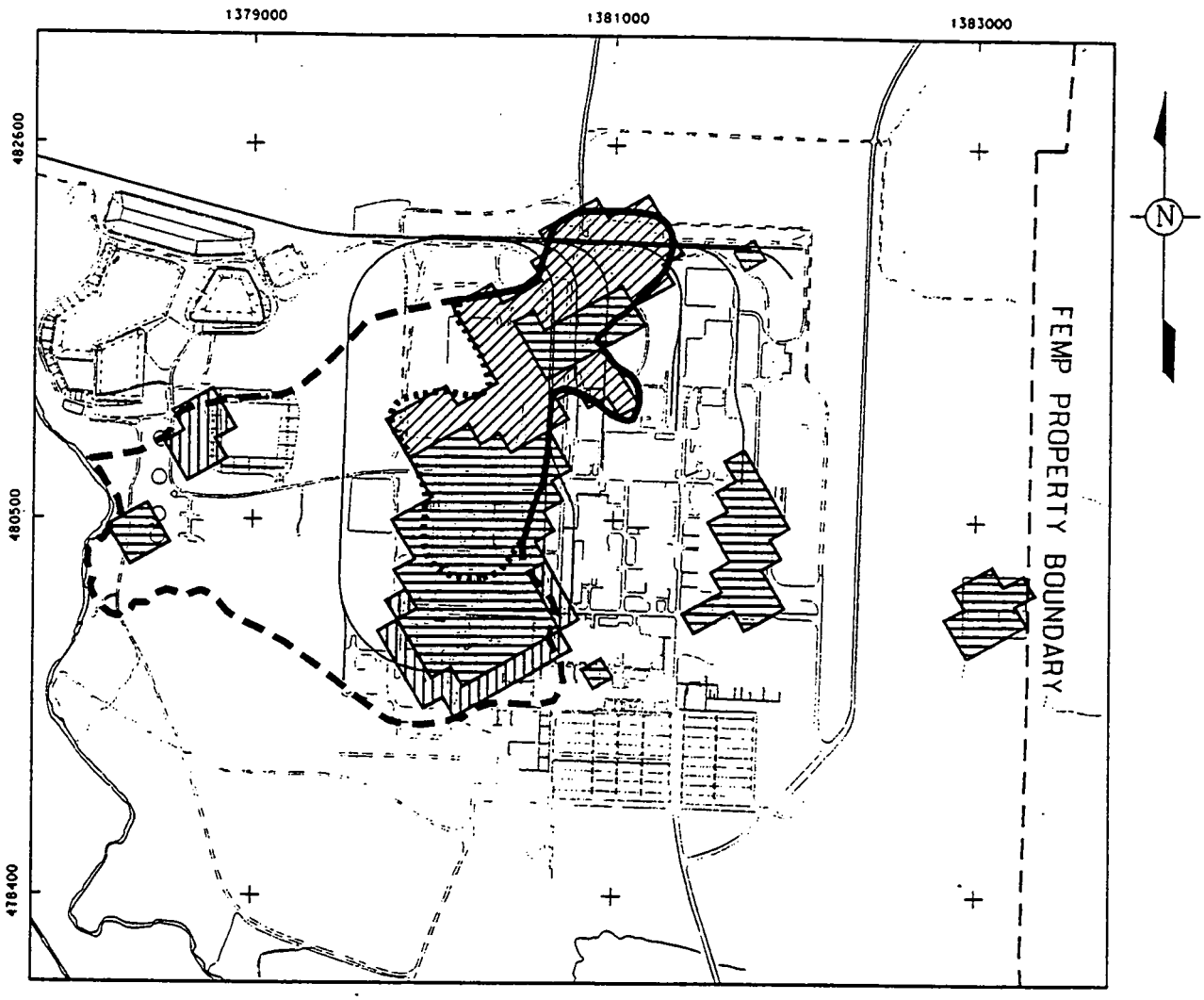
Excavation Footprint 2 represents the perched groundwater zone which yields greater than 1 gpm and which contains constituent concentrations which, if pumped and used as drinking water by an on-property resident farmer, would cause this target receptor to exceed an ILCR of 10^{-5}. This perched groundwater zone would require excavation for Cases 1 and 2 which contemplate an on-property resident farmer receptor.

Excavation Footprint 3 represents the perched groundwater zone with constituent concentrations which, through the vertical and lateral migration pathway, would cause the contamination levels in the Great Miami Aquifer to exceed the PRLs associated with an ILCR of 10^{-6} to the off-property resident farmer. This perched groundwater zone would require excavation for Case 1 which contemplates a risk level of 10^{-6} to the off-property resident farmer.

2.13.3 Great Miami Aquifer

As discussed in Section 4.1, all of the remedial action alternatives will incorporate remedial response measures to address the presence of groundwater contamination in the Great Miami Aquifer. As outlined in that section, active restoration of all on-property and off-property affected areas is the leading remedial strategy for the aquifer. Consistent with Operable Unit 5's risk-range approach for establishing remedial action areas, two proposed risk-based remedial action area footprints have been identified for the Great Miami Aquifer to assist decision makers in selection of appropriate groundwater cleanup levels:

- A risk-based footprint that corresponds to the 10^{-6} carcinogenic risk level (defined for planning purposes by the 3 ppb unfiltered total uranium contour interval in the aquifer)
- A risk-based footprint that corresponds to ARAR and TBC requirements (defined for planning purposes by the 20 ppb unfiltered total uranium contour interval in the aquifer).



LEGEND:

- INFILTRATION ZONE V BOUNDARY
- PRG ZONE BOUNDARY PROTECTIVE OF PERCHED WATER AS A DRINKING WATER SOURCE
- COMMON BOUNDARY OF INFILTRATION ZONE V BOUNDARY AND PRG ZONE BOUNDARY
- PERCHED WATER EXCAVATION FOOTPRINT 1
- PERCHED WATER EXCAVATION FOOTPRINT 2
- PERCHED WATER EXCAVATION FOOTPRINT 3

SCALE 0 250 500 1000FEET

FINAL

STATE PLANAR COORDINATE SYSTEM 1927

P0113/SKX03330.DGN

FIGURE 2-17. PERCHED WATER EXCAVATION FOOTPRINTS

The 20 ppb contour interval for the aquifer represents the proposed Safe Drinking Water Act MCL for uranium in drinking water, which has been adopted as a TBC. As indicated in the RI Report, all other site-related constituents that exceed their respective MCL concentrations fall within the footprint for uranium. Figure 2-18 displays the 3 ppb and 20 ppb contour intervals for the Great Miami Aquifer as indicated by the 1993 RI data set. These footprints were used as the basis for fate and transport modeling simulations (presented in Section F.7.0 of Appendix F) to develop the conceptual designs for the Great Miami Aquifer active restoration system.

Development of the remedial action area footprints for the Great Miami Aquifer has also considered the need to address programmatic boundaries created by the presence of the Paddys Run Road Site (PRRS) contaminant plume. For FS purposes, the southernmost boundary of the FEMP Operable Unit 5 plume has been set at the northern boundary of the PRRS plume. Remediation of the PRRS plume is the subject of a separate CERCLA response action currently under development between the State of Ohio and the PRRS responsible parties. DOE's role and involvement in the cleanup of the PRRS plume (if any) will be defined separately as part of the ongoing identification of PRRS response obligations and in accordance with the PRRS project schedule. The southern limit of groundwater capture created by the FEMP's South Plume Removal Action wells is used to denote the southern limit of the programmatic boundary for FS purposes; this boundary is also noted on Figure 2-18.

The 10^{-6} risk-based footprint (represented by 3 ppb uranium) will be used to define the corresponding Great Miami Aquifer remedial action area for all risk cases that contemplate restoration of the FEMP to allow residential farming at a 10^{-6} residual risk level (Cases 1 and 2). For the remaining risk cases that contemplate either higher remediation levels or nonfarming uses, the ARAR-based footprint (represented by 20 ppb uranium) will be used to define the corresponding action area.

The details of the remedial strategy for the Great Miami Aquifer, including all of the considerations used to develop the remedial action area footprints, are provided in Section 4.1.

2.13.4 Surface Water

With the exception of the Great Miami River, surface water acts as a pathway rather than a receptor. Thus, there are no estimates of total surface water requiring treatment in order to achieve remedial action objectives. The streambeds of the SSOD and Paddys Run south of the silo area are sitting directly on the Great Miami Aquifer sand and gravel sediment which have very high permeabilities. The majority of surface water contamination will quickly infiltrate through their streambeds into the Great Miami Aquifer. These two surface water bodies do not usually have standing or continuously flowing water. Therefore, no surface water in the Paddys Run and the SSOD can be effectively collected for treatment. Although surface water criteria for these surface water bodies and other drainage ditches for the meat and milk consumer were also considered when developing the soil and

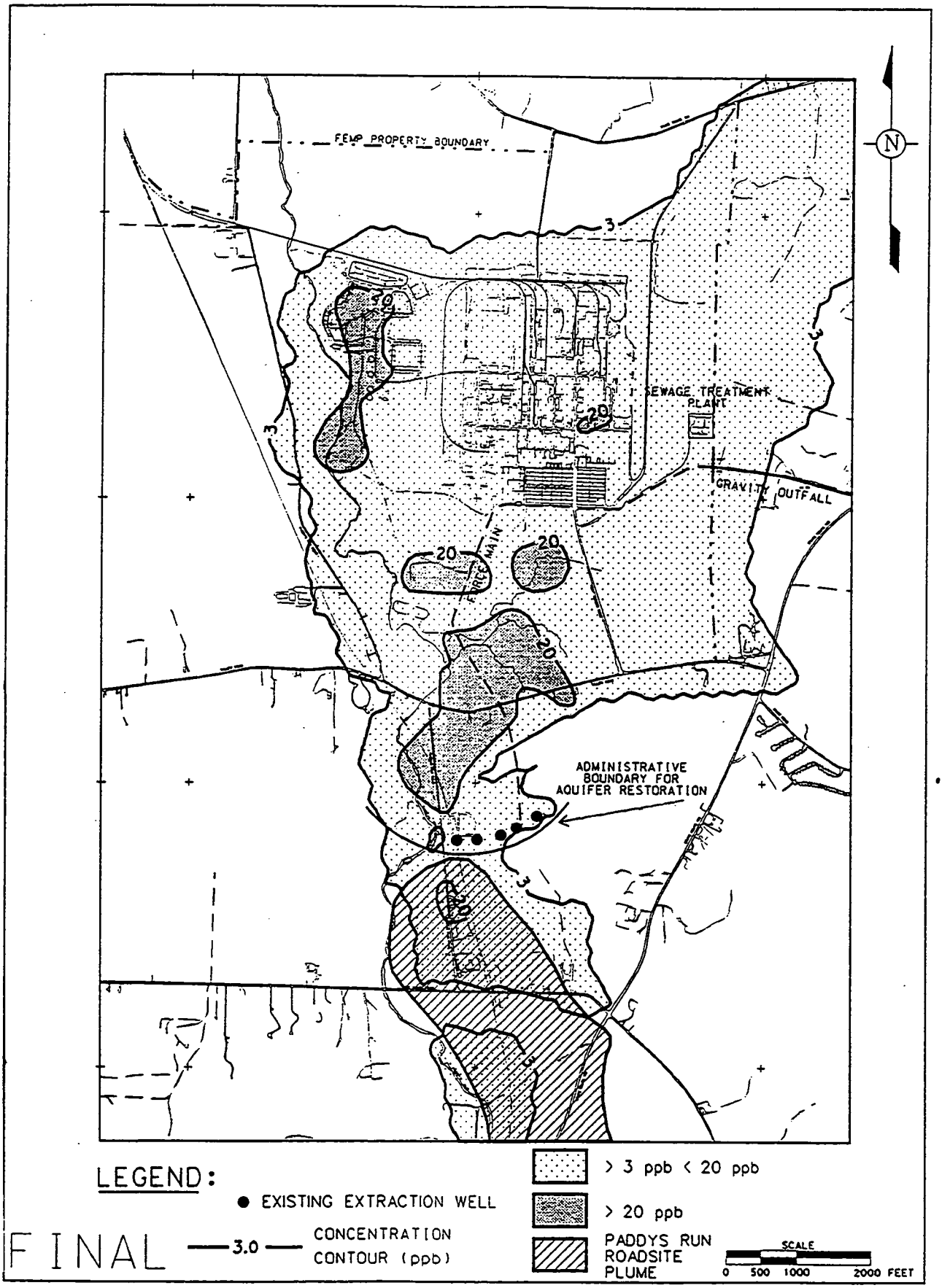


FIGURE 2-18. TARGET AREAS FOR GREAT MIAMI AQUIFER RESTORATION (3PPB AND 20 PPB URANIUM)

perched groundwater CPRGs, Paddys Run and the SSOD were generally considered as the pathway between contaminated surface runoff and the Great Miami Aquifer. Protective requirements for residual surface soil due to this contaminant migration pathway were developed in Appendix F.4.

Throughout the course of remedial actions, the FEMP will continue to process surface water and storm water runoff. Figure 2-19 illustrates the FEMP areas that are currently controlled for surface water and storm water runoff collection. Characteristics of the storm water runoff that will be treated by the advanced wastewater treatment (AWWT) facility are summarized in Table 2-22. As site areas are remediated, these influents will diminish, and the associated collection and treatment systems may be decommissioned or removed.

Additional wastewater from remedial actions performed in support of Operable Units 1 through 4 will be processed at the AWWT during this same period. A complete description of wastewater and its treatment is presented in Appendix L.

TABLE 2-22

CHARACTERISTICS OF COLLECTED SURFACE WATER

Parameter	Former Production Area & Parking Lots	Waste Pit Area & Perimeter
Flow rate	100 - 700 gpm	20 - 40 gpm
Total uranium	0.3 - 1.5 ppm	0.5 - 3.5 ppm
Other radionuclides	Low or trace	Low or trace
Heavy metals	Trace	Trace
Organics	Trace	Trace
Total suspended solids	20 - 300 ppm	20 - 300 ppm
pH	7 - 10	7 - 10

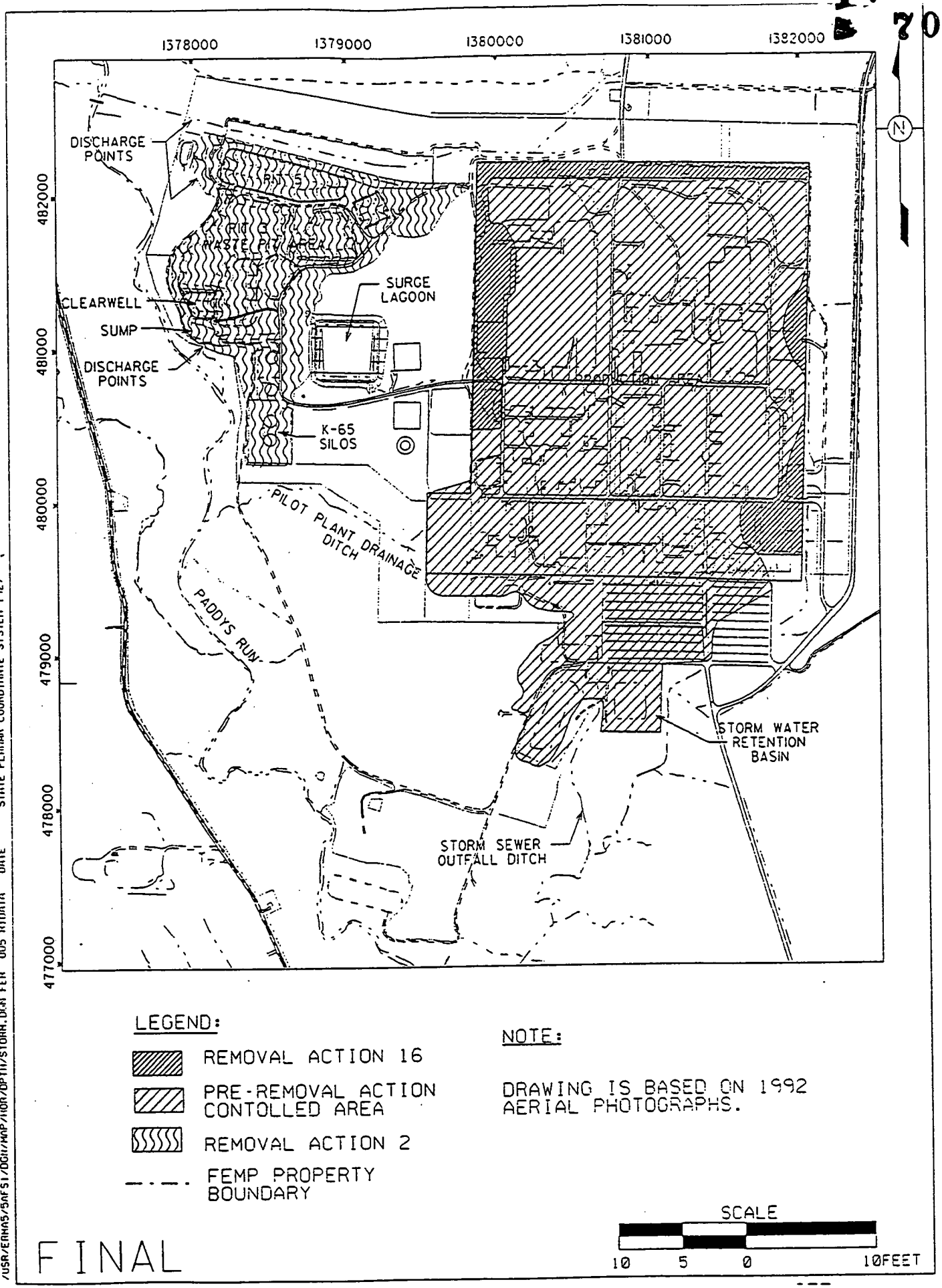


FIGURE 2-19. AREA OF CONTROLLED STORM WATER RUNOFF

2.14 FS STRATEGY TO ADDRESS RI DATA LIMITATIONS

The primary objective in characterizing the nature and extent of contamination in the RI was to collect data sufficient to:

- Perform the baseline and ecological risk assessments
- Support the development and evaluation of remedial alternatives under the FS for Operable Unit 5.

Characterization activities performed under the Operable Unit 5 RI focused on obtaining the quality and quantity of data necessary to meet the stated RI objectives. The process described throughout Section 2.0 produced estimates of media volumes and the areal extent of affected media which are of sufficient accuracy to support an unbiased comparison of remedial alternatives. Typically, there is significant uncertainty associated with such estimates, primarily attributable to the quantity and quality of available site characterization data. While the FEMP has conducted extensive sampling of the environmental media on and in the vicinity of the FEMP, uncertainty exists in the data set due to the large number of constituents considered and the relatively large area over which they are distributed.

Table 2-23 acknowledges these uncertainties and identifies the approach adopted within the FS to facilitate the fair comparison of alternatives. In all cases, conservative assumptions were consistently applied across all alternatives.

TABLE 2-23

STRATEGY OF THE FEASIBILITY STUDY (FS) TO ADDRESS DATA LIMITATIONS OF THE REMEDIAL INVESTIGATION (RI)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
Surface Water/Sediment	
Limited characterization of surface water and sediment at some locations in site drainage ditches, Paddys Run and the Great Miami River.	Data for sediment within on-property drainage ditches were included in the solid block model and kriged along with the soil data. The sediment data were compared against the more restrictive preliminary remediation levels (PRLs) for soil to determine the volume of sediments to be removed to achieve remedial action objectives. This is conservative since PRLs for soil are much more restrictive than the PRLs for sediment due to multiple pathways in the soil exposure scenarios versus the single pathway considered for sediments. It is recognized, however, that sediment in on-property drainage ditches, Paddys Run and the Great Miami River are dynamic (i.e., conditions continually change, especially following a hard rain when sediment is washed out and replaced by new sediment material) and that the sediment data set is limited. In on-property drainage ditches where kriged data indicated that excavation would not be required but process knowledge indicated a high probability for contamination (e.g., the drainage ditch running from the pilot plant to Paddys Run), it was assumed that 6 inches of sediment would require removal along the entire course of the drainage ditch. Sediment data from Paddys Run and the Great Miami River demonstrated no discernable trend of contamination to indicate that remediation in these streams is required. Although no additional volume for Paddys Run or Great Miami River sediment was added to the volume estimates performed herein, verification sampling of this sediment will be performed to ensure that remedial actions are not required. This verification sampling will be initiated near the completion of field activities performed to address on-property soils . The purpose of this sampling will be to confirm that sediment has not been contaminated (above final remedation goals as defined in the Operable Unit 5 Record of Decision [ROD]) as a result of surface water runoff during on-property remedial actions.
Surface Soil - Lateral Extent of Contamination	
Limited data are available to confirm the significance and extent of elevated concentrations of constituents detected in isolated soil samples outside the well-characterized 20 mg/kg total uranium in surface soil isopleth.	The extensive surface and subsurface soil data set provides a reliable delineation of the nature and extent of the constituents of concern (COCs) in areas on the Fernald Environmental Management Project (FEMP) property. The data set provides a sound foundation for the comparative analysis of the alternatives which may be considered for the remediation of soil. Outside the boundary of the extent of uranium contamination in soil, delineated by the 20 mg/kg isopleth, there are four areas which can be related to site activities. These are the trap range, the northern third of the fire training area, the area adjacent to the northwest corner of Operable Unit 1, and the area west of Operable Unit 4. In the trap range area remedial alternatives will likely be based principally on the removal of lead in soil rather than uranium. The northern third of the fire training area and the areas adjacent to Operable Units 1 and 4 may require the same treatment as areas within those units. Outside these areas there are constituents with concentrations above background which are unrelated to known source areas. The areas are isolated and could be due to sampling errors, laboratory errors, or the result of pre-FEMP

TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
	agricultural activities. The verification sampling program presented in Appendix L.1.1 defines how the final boundaries of the excavation areas will be determined. This verification sampling will ensure that areas adjacent to the excavation footprint that contain constituents above the final remediation levels as defined in the Operable Unit 5 ROD are included in the remediation program. For the scattered occurrences of constituents north of the production area and other on-property areas, the verification sampling program presented in Appendix L.1.1.2 will determine if constituents are present above the final remediation levels.
Surface Soil - Removal/Disturbance	
Surface soil over approximately 10 percent of the production area has been disturbed since the RI/FS characterization was initiated. An undetermined amount of this disturbed soil has been removed.	In excess of 10 percent of the production area surface soil was disturbed during the characterization of surface soil under the RI/FS. Surface soil was removed as part of removal actions, facility construction activities, and maintenance activities. The removed soil was boxed for disposal or stockpiled. Removed soil is located in inventory in containers and piles across the production area. This soil has been added to the volumes of soil requiring remedial actions under each remedial alternative. Estimates of in situ soil volumes requiring remedial action are presented on the basis of RI/FS data. The use of this data provides a conservative representation of existing site conditions. Actual field conditions will be verified before implementation of excavation operations. This verification sampling has been factored into the cost of each alternative.
Subsurface Soil - Vertical Extent of Contamination	
The density of data for parameters other than total uranium is significantly less than that of total uranium from 1.5 to 20 feet and below. The density of data available to characterize the vertical extent of subsurface soil contamination below 20 feet is significantly less than that to characterize the subsurface soil above 20 feet.	Type 2, 3 and 4 wells were installed within the FEMP production area as part of the RI/FS. During their installation, subsurface soil samples were collected at pre-established intervals along the entire depth of the well. In addition, more than 300 borings and more than 200 wells were installed in the former production area, as well as other suspect areas, as part of the Production and Additional Suspect Areas (PASA) Investigation Program. This program employed process knowledge regarding the types and volumes of material handled to guide intrusive sampling activities to areas suspected of unmonitored releases to the glacial overburden adjacent to or beneath the production facilities. Based on U.S. Environmental Protection Agency (EPA) comments, borings were installed to a maximum depth of 20 feet or until perched water was encountered to avoid compromising the barrier properties of the glacial till. The soil boring analytical results indicate that broad areas of the FEMP contain elevated concentrations of uranium at shallow depths (i.e., 0 - 1.5 feet). At a depth of 20 feet, contamination is localized and centers around areas where uranium levels are elevated and known or suspected releases of COCs occurred. It is therefore considered that the placement of the borings and the evaluation of the constituents in the collected samples were sufficiently broad to characterize FEMP production area source terms to the extent necessary to support the remedy selection process.

TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
	Data reported in the RI confirms that within the subsurface soil, uranium is the principle COC. Where other COCs which might require remediation were noted in subsurface soil, uranium concentrations were also above PRLs. The FS has developed remedial action volume estimates based on the results of kriging available uranium data. The location-specific depths of required excavation were established for purposes of the FS, on the basis of this kriging as refined by area-specific process knowledge. Following identification of the areas to be excavated based upon the kriging of uranium data, data for other COCs were evaluated to determine the need to expand excavation footprints. In general, subsurface soil data indicated that concentrations of other COCs which exceeded PRLs were well within the footprint already identified for excavation based upon the uranium data. Those additional areas identified for excavation in order to capture COCs other than uranium were generally surface soil where the COCs would have been deposited by air deposition. In addition to the above, each remedial action alternative specifies the completion of additional sampling during remedial design and remedial actions to validate the FS estimates of affected media. Moreover, certification sampling will be performed upon the completion of remedial action to ensure that remedial action objectives have been achieved.
<u>Off-Property Soil</u> The RI relies on the data set from the Litigation Study, conducted before the RI, to define the nature and extent of contamination in off-property surface soil. While this data set provides information from over 300 sampling points, the sampling density is less than that conducted on-property.	With the exception of surface water runoff through ditches to Paddys Run and the northeast drainage ditch, wastewater discharged to the Great Miami River, the outfall line, and riprap placed along the bank of the Great Miami River adjacent to the outfall pipeline to prevent erosion, the occurrence of above-background concentrations of FEMP constituents off-property would be attributable to air deposition. Under the RI/FS, limited random sampling was performed off property and systematic sampling was performed along the entire north and east boundaries of the FEMP property. This sampling was performed to: 1) demonstrate the usability of the Litigation Study data set; 2) develop a relationship between sampling performed under the RI/FS Quality Assurance Project Plan (QAPP) and that performed under the Litigation Study Quality Assurance Plan; and 3) verify the distribution of the COCs in areas subject to air deposition from FEMP operations. The data sets from the RI/FS and the Litigation Study were found to be consistent. The Litigation Study provided data adequate to define the relationship between constituent concentrations and distance from the FEMP. The data set from the Litigation Study was validated to the extent necessary to support on-going litigation at the FEMP in 1986 and 1987. As such, the data are considered sufficient to perform a risk assessment, evaluate remedial action alternatives and to derive final remedial action goals. All available off-property data was normalized to consistent concentration terms (ppm of uranium [U]). This data was then visually interpreted to establish the most reasonable representation of the off-property areas requiring excavation to attain risk-based cleanup levels. Each remedial alternative includes cost considerations associated with the implementation of a sampling program to verify the footprint of excavation during remedial design.

TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
Outfall Line	
Limited characterization data are available along the outfall line from the FEMP sewage treatment plant to the Great Miami River. Limited characterization data are available for the riprap placed along the banks of the Great Miami River near the discharge point of the FEMP outfall line.	Systematic borings were completed along the outfall line. Samples revealed slightly elevated concentrations of FEMP-related constituents, indicating potential leakage. The existing sampling program provides sufficient data to estimate the volume of affected media necessary to bound potential remedial actions which may be considered for the outfall line as part of the FS. Due to access limitations, additional characterization adjacent to or beneath the pipeline is impractical before removal of the line. Each remedial alternative assumes that up to 12 inches of soil underneath the length of this pipeline requires excavation to attain cleanup levels. Surface soil sampling and surface radiological measurements were completed at the location of the suspect riprap placed at the bank of the Great Miami River. Efforts were impeded by the characteristics of the material (i.e., large pieces of concrete surrounded by soil). Available characterization data coupled with information gained from interviews with long-term FEMP employees provide a sufficient basis to complete estimates of the volume of affected media. This volume has been included in the estimates of effects to media for each remedial alternative. Each remedial alternative cost estimate assumes additional characterization data will be collected during the implementation phase of remedial actions to guide excavation activities and to certify that cleanup objectives have been met.
Perched Groundwater - Lateral Extent of Contamination	
Limited data are available regarding the presence or absence of elevated concentrations of COCs in perched groundwater on and off property in areas of potential air deposition.	Available data from the RI, including COC concentrations, measured leachability and K_d values for site soil, establish a technical basis for estimating the existing and future concentrations of COCs in perched groundwater due to the vertical migration of surface soil contamination. This relationship, developed by direct measurement and predictive modeling, has been employed by the FS to support the establishment of cross-media impact preliminary remediation goals (PRGs).

TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
Perched Groundwater - Vertical Extent of Contamination	
The density of data available to characterize the vertical extent of contamination in the perched groundwater below 20 feet is significantly less than that to characterize the perched ground-water above a depth of 20 feet. The site investigations operated in most cases with a rule to stop drilling at the bottom of the first encountered water-bearing zone or 20 feet, whichever came first. As a consequence, most data at the FEMP was collected between 0 and 20 feet, and little data was collected between 20 feet and the base of the glacial overburden.	More than 200 wells were installed in the former production area, as well as other suspect areas, as part of the PASA Investigation Program. This program employed process knowledge regarding the types and volumes of material handled to guide intrusive sampling activities to areas suspected of unmonitored releases to the glacial overburden adjacent to or beneath the production facilities. Based on EPA comments, borings were installed to a maximum depth of 20 feet or until perched water was encountered to avoid compromising the barrier properties of the glacial till. Available data from the RI, including COC concentrations, measured leachability, and K_d values for site soil, establish a technical basis for estimating the existing and future concentrations of COCs in perched groundwater due to the vertical migration of surface and subsurface soil contamination. Each remedial alternative assumes the completion of a certification sampling program following the removal/ remediation of contaminated perched zones (as required) to ensure cleanup goals are attained.

TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
Great Miami Aquifer - Sporadic/Isolated Detections of Uranium	
Limited data are available to confirm the significance of sporadic/isolated detections of uranium in wells outside of well-characterized (5 ppb total uranium) Great Miami Aquifer groundwater isopleths. With the exception of Well 2098, these isolated detections cannot be explained on the basis of laboratory uncertainties or by process/site knowledge. The occurrences include Well Locations 2092, 2098, 2733, and 2555.	The extensive Great Miami Aquifer data set provides a reliable delineation of the nature and extent of constituents of potential concern in areas downgradient of known or suspected sources. This data set provides a sound foundation for a comparative analysis of the limited range of remedial action alternatives which may be considered for the Great Miami Aquifer. Outside the delineated boundary of these areas (typically represented by the 5 ppb total U isopleth) there are wells which yield elevated concentrations of uranium which are unrelated to previously known source areas. The areas appear to be isolated and could be the result of: 1) anomalous laboratory data; 2) natural causes (e.g., localized concentrations of constituents due to infiltration of surface deposition which was the result of causes other than the FEMP); 3) FEMP constituents transported to the area via multiple pathways which are not connected to the primary Aquifer plumes (e.g., air deposition which is first concentrated through surface water runoff to drainage ditches which then infiltrate to the Great Miami Aquifer); or 4) cross contamination of the wells during installation or sampling. A more thorough discussion of this issue is presented in Section 3. Because these areas are isolated and will not impact the selection of overall remedial actions selected for primary regions of elevated concentration, each remedial alternative assumes that investigations to confirm the presence or absence of isolated areas of elevated concentration would occur during remedy design or implementation. In the event an additional area requiring remedial action was identified, the capture zone of any installed recovery well would be designed to accommodate the finding.
Great Miami Aquifer Near Confluence of Paddys Run and Great Miami River	
Limited groundwater characterization data are available in the region near the confluence of Paddys Run and the Great Miami River.	As part of the RI/FS, the FEMP completed the systematic installation of monitoring wells along the entire length of Paddys Run from north of the FEMP production area to the confluence of Paddys Run with the Great Miami River. Samples were analyzed for a full suite of radiological, Hazardous Substance List inorganic and general water quality parameters. In addition, home owner's wells along Paddys Run and in the vicinity of the confluence of Paddys Run with the Great Miami River were sampled and analyzed for total uranium. Alternate water supplies have been offered to people whose wells yield a uranium concentration in excess of 2.7 ppb. Existing sampling data in the vicinity of the confluence of Paddys Run with the Great Miami River is sufficient to estimate the volume of impacted

TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
	groundwater, thereby supporting the evaluation and selection of remedial action alternatives from among a limited list of alternatives which may be considered as part of the FS. Verification data may be collected as part of remedial design activities, as necessary, to ensure the adequacy of proposed actions, and during the implementation phase of remedial actions to guide groundwater recovery and treatment activities and to certify that cleanup objectives have been met.
Fate and Transport Modeling	
Limited information was available regarding K_l for uranium-contaminated soil in the glacial overburden outside of the former production area and other operable units. The RI assumed the uranium is less soluble (K_l value of 222) in these areas.	Sampling to support the FS was conducted in areas outside the former production area (where air deposition is the only known source) in the summer of 1994. The uranium batch leaching test results from this program have been incorporated into the Operable Unit 5 FS as Attachment F.2.I of Appendix F. These results indicate that the residual uranium contamination is contained in the surface soil and supports the decision to use a high uranium K_l of 325 L/kg in the area outside the former production area. The data for other constituents from the study is expected in late November 1994 and will be evaluated and summarized in a stand-alone report.
Modeling - Colloidal Transport	
Specific investigations regarding the role of colloidal migration mechanisms in the transport of site contaminants in groundwater have not been conducted.	The nature and extent of uranium in both the perched zones and the Great Miami Aquifer (i.e., plume definition) are defined by groundwater monitoring data. Analyses of filtered and unfiltered groundwater samples were performed for radiological and inorganic contaminants. The extent of groundwater contamination associated with colloidal uranium, if present, would be bounded by these analyses. Furthermore, the higher of filtered/unfiltered analyses for a particular well have been used to support fate and transport modeling. There is no well-developed and verified approach for modeling the rate of transport of colloidal particles. The presence or absence of colloidal transport, which might or might not be faster than the transport of soluble species, is one of numerous parameters with a degree of uncertainty that must be factored into any transport model. The transport model accommodates these uncertainties by conservatively estimating input parameters such as K_d. All groundwater treatment systems will be capable of addressing colloidal uranium, if present. An ion exchange system has been adopted as the representative treatment system for uranium removal at the FEMP. A filtration system is contemplated to be placed ahead of the ion exchange columns for protection against plugging. The combination of filtration followed by ion exchange has proven to be more than adequate to remove all forms of uranium. Also, colloidal uranium, if present, should not affect the performance of groundwater extraction and conveyance systems. Therefore, additional information regarding colloidal transport is not required for the evaluation of groundwater remedial alternatives in the FS.

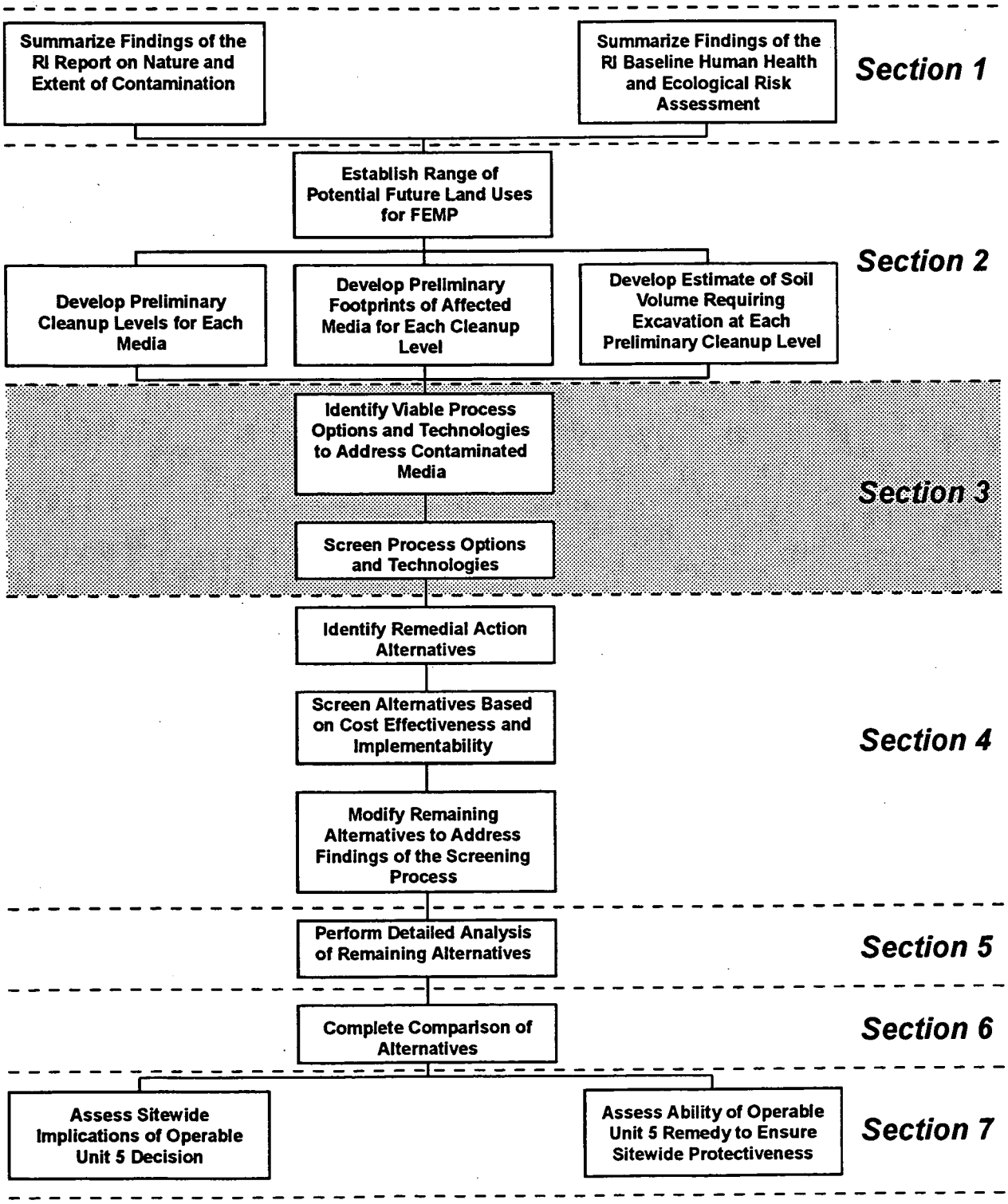
TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
Hazardous Waste Management Units	
Limited characterization data is available surrounding select units regulated under the Resource Conservation and Recovery Act and non-clean-closed underground petroleum product storage tanks.	Each of the regulated units with limited data sets lie within the study area defined by the PASA Investigation. This investigation employed process knowledge regarding the types of constituents handled and activities performed at the FEMP to guide intrusive sampling activities to areas suspected of potential releases to the glacial overburden adjacent to or beneath the production facilities. The program involved completion of approximately 300 borings and installation of more than 200 wells across the former production area. Initial samples were collected under the PASA program during the period 1988 to 1992. A subsequent program was implemented in 1993 to fulfill the complete data needs of the RI/FS. Placement of the borings and constituents evaluated in samples collected during the PASA and 1993 investigations were sufficiently broad to characterize FEMP production area source terms to the extent necessary to support the alternatives assessment under the FS. To ensure continued visibility of those media potentially containing listed hazardous wastes or petroleum derivatives, care has been taken to ensure that these constituents are not screened from consideration in the FS. Contamination from these units is contained within the limits of soil excavation for all remedial alternatives. Estimates of media volumes containing listed constituents or petroleum products have been developed for the FS based upon the results of the previously mentioned investigation and unit-specific process knowledge. Appropriate alternatives will be developed and evaluated to ensure that media containing listed constituents and petroleum products are adequately addressed. Each remedial alternative assumes that additional sampling would be performed during remedial design to validate the volume estimates of soil to be excavated.
Threatened and Endangered Species	
The Site-Wide Characterization Report (DOE 1993e) identified habitat potential for several state/federal threatened and endangered species at the FEMP. However, much of this data is inconclusive.	Available information provides a relative indication of the presence/absence of both threatened and endangered species which may be present in the region of the FEMP. Additional threatened and endangered species surveys were conducted during 1994 to confirm the presence/absence of these species. The surveys performed included: Spring Coral Root Indiana Bat Cave Salamander Mountain Bindweed Slender Finger Grass Sloan's Crayfish Running Buffalo Clover These surveys provide additional information regarding potential impacts various remedial action alternatives may have on these species.

TABLE 2-23 (Continued)

RI Data Limitation	Strategy Adopted in FS to Address Limitation
Ecological Risk	
Site-specific data regarding the occurrence and impact of contaminants on biological resources are limited.	During the course of RI sampling related to ecological receptors, the focus was on the media that potentially affects the receptors rather than the receptors themselves. Therefore, limited data are available regarding concentrations of contaminants in the receptors. The ecological risk assessment has relied on conservative uptake factors for both flora and fauna to determine conservative estimates of risk to these receptors. Benchmark criteria were defined during the RI for environmental media to establish concentration-based thresholds for discrete contaminants which were suspected of impacting ecological receptors. These benchmark values have not been factored into the development of PRLs. However, constituents with PRLs exceeding these benchmark values were identified for consideration during remediation. Hence, if actual post-remedial concentrations exceed these benchmark values, further ecological investigations may be necessary. A management plan will be developed to protect natural resources, including ecological receptors, to the extent practicable during remediation of the site.

Section 3.0


Summarize Findings of the RI Report on Nature and Extent of Contamination
Summarize Findings of the RI Baseline Human Health and Ecological Risk Assessment
Section 1
Establish Range of Potential Future Land Uses for FEMP
Develop Preliminary Cleanup Levels for Each Media
Develop Preliminary Footprints of Affected Media for Each Cleanup Level
Develop Estimate of Soil Volume Requiring Excavation at Each Preliminary Cleanup Level
Section 2
Identify Viable Process Options and Technologies to Address Contaminated Media
Screen Process Options and Technologies
Section 3
Identify Remedial Action Alternatives
Screen Alternatives Based on Cost Effectiveness and Implementability
Modify Remaining Alternatives to Address Findings of the Screening Process
Section 4
Perform Detailed Analysis of Remaining Alternatives
Section 5
Complete Comparison of Alternatives
Section 6
Assess Sitewide Implications of Operable Unit 5 Decision
Assess Ability of Operable Unit 5 Remedy to Ensure Sitewide Protectiveness
Section 7

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

Identification, screening, and evaluation of potentially applicable technology types and process options are key steps in the feasibility study (FS) process. The primary objective of this phase of the Operable Unit 5 FS is to identify an appropriate range of remedial technologies and process options to be developed into preliminary remedial alternatives.

Section 3.0 discusses the identification, development, and screening of applicable technologies and process options that will be used to assemble the remedial action alternatives for Operable Unit 5. The basis for technology identification and screening actually began in Section 2.0 with a series of discussions that included the following:

- Identification of applicable or relevant and appropriate requirements (ARARs)
- Development of remedial action objectives (RAOs)
- Identification of volumes or areas of media of concern.

Technology screening is completed and technology evaluation is performed in this section with the completion of the following analytical steps:

- Identification of general response actions
- Identification and screening of remedial technologies and process options
- Evaluation and selection of representative process options.

Appendix M describes in greater detail the identification, initial screening, and evaluation procedure for the universe of technologies and process options that were considered in the development of remedial alternatives for Operable Unit 5. Sections M.2.0 and M.3.0 describe the initial screening process for the full range of potential technologies and associated process options related to groundwater and soil and sediment, respectively. In Sections M.4.0 and M.5.0, technologies and process options which passed the initial screening procedures are evaluated against the criteria of effectiveness, implementability, and cost to select representative options for incorporation into preliminary remedial alternatives. As with Appendix M, the information in Section 3.0 is presented in a format consistent with EPA RI/FS guidance (EPA 1988a). Section 3.1 identifies the general response actions that will potentially meet the RAOs which were identified in Section 2.0. Section 3.2 summarizes the initial screening of technologies and process options within these general response actions, while Section 3.3 summarizes the evaluation of technologies and process options.

3.1 GENERAL RESPONSE ACTIONS

General response actions (GRAs) describe categories of actions that could be implemented to satisfy or address a component of a RAO for the site. Typically, the formation of remedial action

alternatives represents the combining of GRAs to fully address remedial action objectives. When implemented, the combined GRAs are capable of achieving the RAOs which have been generated for each contaminated medium at the site. For Operable Unit 5, the contaminated media of concern include groundwater, which encompasses both the Great Miami Aquifer groundwater and perched groundwater, and soil, which includes on-property and off-property soil and sediment.

The GRAs developed for all groundwater media are common in Operable Unit 5, as are the soil and sediment GRAs. Groundwater and soil and sediment GRAs are described in Sections 3.1.1 and 3.1.2, respectively.

3.1.1 Groundwater General Response Actions

The groundwater GRAs include:

- No Action - The no-action response is retained throughout the FS process as required by the National Contingency Plan (NCP) [40 CFR 300.430(e)(6)] to provide a comparative baseline against which other alternatives can be evaluated. Under this response, no remedial action will be taken. The contaminated media are considered to be left "as is," without the implementation of any institutional controls, containment, removal, treatment, or other mitigating actions. The no-action alternative does not provide for the monitoring of groundwater or for the implementation of access controls to reduce the potential for exposure (e.g., alternate water supply, physical barriers, deed restrictions).

- Institutional Controls - These involve the application of various access controls and/or deed restrictions to reduce or eliminate pathways of exposure to hazardous substances at the site, and could involve the use of groundwater monitoring networks and/or groundwater use restrictions and access controls. The volume, mobility, and toxicity of the contaminants are not reduced through the singular application of institutional controls.

- Containment - This GRA involves the application of physical measures to reduce the potential for contaminant migration. To reduce the migration of contaminants, the contaminated media must be isolated from the primary transport mechanisms, such as wind, erosion, surface water and groundwater. Contaminated media may be isolated by installing surface and subsurface barriers that either block or divert any transport media (i.e., groundwater, wind, etc.) from the contaminants. Pumping wells used for gradient control can provide a type of barrier to contain the migration of contaminated groundwater plumes.

- Removal - Under this GRA, the contaminated media are moved from their present location in order to be treated and/or disposed of elsewhere. Removal process options are combined with treatment and/or disposal process options to develop alternatives, and could involve the installation of extraction wells or collection trenches to remove contaminated groundwater.

- Treatment - The treatment response action includes both in situ and ex situ treatment process options, and could include physical, chemical, biological and/or the advanced wastewater treatment (AWWT) facility as measures designed to reduce the toxicity,

mobility, and/or volume of the contaminants present. Ex situ treatment process options are used with removal and disposal process options to develop alternatives.

- Disposal/Discharge - The disposal/discharge process options are used with removal options and possibly treatment options to develop alternatives. The toxicity, mobility, or volume of the contaminants is not reduced through the singular application of disposal/discharge. This response action includes discharge/release of untreated or treated groundwater.

3.1.2 Soil and Sediment General Response Actions

The soil and sediment GRAs include:

- No Action - The no-action response is retained throughout the FS process as required by the NCP [40 CFR 300.430(e)(6)] to provide a comparative baseline against which other alternatives can be evaluated. Under this response, no remedial action will be taken. In the no-action alternative, the contaminated media are considered to be left "as is," without the implementation of any institutional controls, containment, removal, treatment, storage, or other mitigating actions. The no-action alternative does not provide for monitoring or for the implementation of access controls to reduce the potential for exposure (e.g., physical barriers, security guards, deed restrictions).

- Institutional Controls - These involve the application of various access controls and/or deed restrictions to reduce or eliminate pathways of exposure to hazardous substances at the site. The volume, mobility, and toxicity of the contaminants are not reduced through the singular application of institutional controls.

- Containment - This GRA applies physical measures to minimize the potential for contaminant migration. To reduce the migration of contaminants, the contaminated media must be isolated from the primary transport mechanisms, such as wind, erosion, surface water and groundwater. Contaminated media may be isolated by installing surface and subsurface barriers that either block or divert any transport media (i.e., groundwater, wind, etc.), from the contaminants.

- Removal - Under this GRA, the contaminated media are moved from their present location in order to be treated and/or disposed of elsewhere. Removal process options are combined with treatment and/or storage/disposal process options to develop alternatives and could involve excavation and material handling/processing of contaminated soil and sediment.

- Treatment - The treatment response action covers both in situ and ex situ treatment process options, and could include physical, chemical, solidification and/or thermal measures designed to reduce the toxicity, mobility, and/or volume of the contaminants present. Ex situ treatment process options are used with removal and disposal process options to develop alternatives.

- Storage - Under this response action, contaminated media are temporarily stored until they are treated and/or disposed of.

- Disposal - Disposal technologies include placement of removed or treated materials in an on-property or an off-site permanent disposal facility. The disposal process options are

used with removal options and possibly treatment options to develop alternatives. The toxicity, mobility, or volume of the contaminants is not reduced through the singular application of disposal. This response action will reduce or eliminate exposure pathways related to direct human contact with contaminated material.

3.2 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

3.2.1 Criteria for Identification and Screening of Technologies and Process Options

The criteria for identifying potentially applicable technologies are provided in the U.S. Environmental Protection Agency's (EPA's) remedial investigation/feasibility study (RI/FS) guidance (EPA 1988a) and in the NCP (EPA 1990). The final remedy must protect human health and the environment and comply with ARARs.

Remedial action alternatives for Operable Unit 5 were developed by identifying remedial technologies and process options within these technologies that may be applied to the various contaminated media at the site (groundwater and perched groundwater, and on- and off-property soil and sediment). The identification and screening of technologies and process options have been conducted in consideration of these two major media types. Due to the similarity in nature of concentrations and types of contaminants, technologies and process options to address collected storm water and process wastewaters generated during remedial actions have been included, where appropriate, in the discussions addressing perched groundwater. In addition, the technologies and process options applicable to nonrecoverable debris and to the residual materials resulting from the treatment of the Great Miami Aquifer groundwater, perched groundwater, collected storm water, and process wastewaters have been included, when appropriate, in the discussions addressing soil and sediment.

Technologies considered in selecting remedial action alternatives for these media include those identified in 40 CFR 300, relevant EPA guidance, the Operable Unit 5 Initial Screening of Alternatives Report and FSs for other Fernald Environmental Management Project (FEMP) operable units. Additional technologies were considered based on experience and information gained through remedial action planning and implementation at similar sites.

Based upon available information, media-specific remedial technologies and process options were identified for each of the general response actions. Each process option was initially screened for technical implementability. When no viable process option remained from a technology family, the technology was also screened. The screening process reduces the variety of possible process options for a given technology family to a smaller, more manageable number of options that are considered appropriate for the various media. In this step, both technologies and process options could be eliminated based on technical implementability criteria. Information such as site conditions and types and concentrations of contaminants were used to eliminate various technologies and process options

that would not apply or could not be technically implemented at the site. In Sections M.2.0 and M.3.0 of Appendix M, the range of available technology types and process options were initially screened for applicability to the FEMP site in accordance with EPA guidance (EPA 1988a).

3.2.2 Summary of Screening of Technologies and Process Options for Groundwater

The identification and initial screening of technologies and process options applicable to groundwater are presented in Table 3-1. This table summarizes the general response actions, remedial technologies, and process options associated with the Great Miami Aquifer and perched groundwater media and presents the results of the initial screening process. Unshaded areas in this table represent those technologies/process options which passed initial screening procedures.

Table 3-2 presents the technologies and process options for groundwater, process wastewater, and storm water that have passed the initial screening process, and are retained for further evaluation.

3.2.3 Summary of Screening of Technologies and Process Options for Soil and Sediment

The identification and initial screening of technologies and process options applicable to soil and sediment are presented in Table 3-3. This table summarizes the GRAs, remedial technologies, and process options associated with soil and sediment and presents the results of the initial screening process. Unshaded areas in this table represent those technologies/process options which passed initial screening procedures. Operable Unit 5 will continue to support the development of environmentally acceptable technologies that have cost-effective potential for achieving volume reduction through waste minimization.

Table 3-4 presents the technologies and process options for soil and sediment that have passed the initial screening process and have been retained for further evaluation with regard to effectiveness, implementability, and cost.

3.3 EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS

3.3.1 Criteria for Evaluating Technologies and Process Options

The technologies and process options which have passed the initial screening are considered for further evaluation. The purpose of the evaluation is to obtain a reasonable number of process options to combine into remedial alternatives in Section 4.0. This evaluation will compare similar process options from within a specific remedial technology group and will not compare process options between different technology types. Process options which pass the evaluation step will be classified by type as either "primary" or "support" processes. Then representative process options, those which will be incorporated into remedial alternatives, will be selected from the acceptable primary and support processes remaining. Selecting representative process options is done to minimize the

TABLE 3-1

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

(Unshaded items indicate passing initial screening process)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No activities conducted at site to address contamination.	Required by NCP
Institutional Controls	Monitoring	Groundwater Monitoring	Sampling of newly installed or existing wells to assess contaminant migration in groundwater.	Potentially applicable to GMA and perched groundwater
		Leachate Monitoring	Sampling and analysis of leachate collection systems.	Potentially applicable to perched groundwater
		Surface Water Monitoring	Sampling and analysis of storm water runoff or treated groundwater discharged to surface streams.	Potentially applicable to GMA and perched groundwater.
	Access/Use Restrictions	Alternate Water Supply	Replacement of contaminated groundwater source with alternative water supply for end user.	Potentially applicable to GMA.
		Physical Barriers	Barrier used to restrict site access (e.g., fencing, security, etc.)	Potentially applicable to GMA and perched groundwater.
		Deed Restrictions	Administrative action using property deeds to restrict future site activities.	Potentially applicable to GMA and perched groundwater.
		Continued Federal Ownership	Continued property ownership of all or part of the FEMP site to restrict future site activities through ownership rights.	Potentially applicable to GMA and perched groundwater.
Containment	Capping	Single Layer Cap	Low-permeability cap over an area of contamination; low permeability materials include concrete, asphalt, soil, clay, synthetic membrane, etc.	Not applicable. Does not meet the design life criteria.
		Multilayer Cap	Cap formed with multiple layers including topsoil, clay, synthetic membrane, sand/gravel, etc.	Potentially applicable to GMA and perched groundwater.
	Subsurface Water Control	Vertical Slurry Wall	Vertical slurry barrier used to restrict lateral migration of groundwater and isolate contaminants.	Potentially applicable to perched groundwater
		Horizontal Slurry Barrier	Horizontal slurry barrier used to restrict vertical migration of contaminated groundwater.	Potentially applicable to perched groundwater
		Grout Curtain	Use of pressure-injected cement to restrict lateral migration of groundwater; typically used in porous or fractured bedrock.	Not applicable. No confining geologic layer available to key into.

TABLE 3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Subsurface Water Control (continued)	Subsurface Drains	Gravity flow French drain type collection system used to contain shallow groundwater.	Potentially applicable to perched groundwater
		Sheet Piling	Sheet piling joined and driven into ground to prevent horizontal migration of contaminated groundwater.	Potentially applicable to perched groundwater
		Pumping Wells	Injection or extraction wells used to contain and/or redirect contaminated groundwater flow by altering hydraulic gradient.	Potentially applicable to GMA and perched groundwater.
Removal	Subsurface Water Extraction	Vertical Extraction Wells	Discrete conventional pumping wells used to remove contaminated groundwater.	Potentially applicable to GMA and perched groundwater.
		Directional Extraction Wells	Discrete pumping wells, directionally drilled at an angle, used to remove contaminated groundwater.	Potentially applicable to GMA and perched groundwater.
		Wellpoint System	Numerous closely spaced extraction wells which use a common header and suction pumps to remove shallow contaminated groundwater.	Not applicable. Applied to shallow groundwater; GMA and most perched groundwater zones are too deep.
		Collection Trench/French Drain	A permeable trench used to collect, convey or divert surface water, groundwater or leachate flow.	Potentially applicable to perched groundwater
		Excavation	Use of conventional earthmoving equipment and pumping to access and remove contaminated groundwater during contaminated soil excavation.	Potentially applicable to perched groundwater
		Electroosmosis	Application of an electrical field to induce groundwater flow through soil.	Potentially applicable to perched groundwater
		Bedrock Fracturing	Blasting or hydrofracturing of bedrock to promote access to contaminated groundwater located in bedrock formations.	Not applicable. Amount of contaminated groundwater in bedrock formations insignificant
Treatment	In Situ	Chemically Induced Soil Flushing	Inject chemicals into the soil to enhance the contaminants solubility and mobility in the groundwater.	Not applicable. Varied subsurface conditions would result in channeling and poor contact times.
		Vapor Sparging	Injecting air or CO_2 into the groundwater to increase the solubility and mobility of contaminants.	Potentially applicable to GMA and perched groundwater.
		Bioremediation	Enhancement of biodegradation of organic contaminants by the addition of oxygen, microorganisms, and/or nutrients to the groundwater.	Not applicable. Majority of contaminants are not amenable to biodegradation.

TABLE 3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Physical	Equalization	Dampening of flow and/or contaminant concentration variation in a large basin or tank to promote constant discharge rate and water quality before further processing.	Potentially applicable to GMA and perched groundwater.
		Sedimentation/ Clarification	Gravity settling of suspended solids from water in a basin or clarifier.	Potentially applicable to GMA and perched groundwater.
		Ultrafiltration	Removal of dissolved high molecular weight contaminants and fine suspended or colloidal particles from water by forcing the contaminated liquid through filter membranes.	Potentially applicable to GMA and perched groundwater.
		Multimedia Filtration	Separation of suspended matter from water via flow through a bed of sand, anthracite, etc.	Potentially applicable to GMA and perched groundwater.
		Flotation	Separation of oils and suspended matter less dense than water via gravity separation, or dissolved or indirect air flotation.	Not applicable. Free oil and fine suspended particulates are not major concerns.
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials, including organics and inorganics from water.	Potentially applicable to GMA and perched groundwater.
		Volatilization	Contact of water with gas stream to remove volatile compounds; air stripping or steam stripping methods are typically employed.	Potentially applicable to GMA and perched groundwater.
		Adsorption	Adsorption of contaminants onto a substrate media such as activated carbon, resins or activated alumina.	Potentially applicable to GMA and perched groundwater.
		Evaporation	Change water from liquid to gaseous state at temperature to separate suspended and dissolved contaminants.	Not applicable. Not feasible for low contaminant levels.
		Distillation	Heat used to separate organic contaminants from water based on the difference in boiling points.	Not applicable due to low organic concentrations.
		Crystallization	Refrigeration used to separate contaminants from water based on the difference in freezing points.	Not applicable. Not feasible for low contaminant levels.

TABLE 3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical	Ion Exchange	Process in which noncontaminant ions, held by electrostatic forces to charged functional groups on the ion exchange resin surface, are exchanged for contaminant ions of similar charge in a water stream.	Potentially applicable to GMA and perched groundwater.
		Solvent Extraction (Liquid/Liquid)	Separation of contaminants from water by contact with an immiscible solvent with a higher affinity for the contaminants of concern.	Not applicable due to low organic concentrations.
		Electrodialysis Reversal	Recovery of anions or cations using special membranes under the influence of an electrical current.	Potentially applicable to GMA and perched groundwater.
		Electrolytic Recovery	Passage of an electric current through water with resultant ion recovery on positive and negative electrodes.	Not applicable. Not feasible for low contaminant levels.
		Coagulation/ Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Potentially applicable to GMA and perched groundwater.
		Polymerization	Chemical catalysts used to promote the combining of monomers to form long chained polymers removable by filtration or settling.	Not applicable. No organic monomer contaminants present in groundwater.
		Dehalogenation	Use of chemicals to remove halogen atoms from organic compounds in water.	Not applicable due to low organic concentrations.
		Neutralization (pH Adjustment)	Use of acids or bases to neutralize high or low pHs or to adjust pH to satisfy the requirements of a given process.	Potentially applicable to GMA and perched groundwater.
		Chemical Precipitation	Use of reagents to convert soluble contaminants into insoluble state to be removed by filtration or settling.	Potentially applicable to GMA and perched groundwater.
		Hydrolysis	Lime or caustic used to decompose organic contaminants in a reaction which generates water.	Not applicable due to low organic concentrations.
		Enhanced Oxidation	Use of strong oxidizers such as ultraviolet light, ozone, peroxide, chlorine, or permanganate to chemically oxidize materials; typically hydrogen peroxide (and/or ozone) with UV light is used for groundwater remediation.	Potentially applicable to GMA and perched groundwater.
		Chemical Reduction	Use of strong reducing reagents such as sulfur dioxide, sulfite, or ferrous iron to chemically reduce the oxidation state of contaminants, thus making them more amenable to removal from a liquid stream.	Potentially applicable to GMA and perched groundwater.

TABLE 3-1
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Physical/ Chemical	Treatment by Advanced Waste Water Treatement (AWWT) Facility	Treatment of perched groundwater, storm water and process wastewater by AWWT system using equalization, pH adjustment, chemical precipitation, clarification, filtration, carbon adsorption and ion exchange.	Potentially applicable to perched groundwater
	Thermal	Wet Air Oxidation	Treatment of groundwater with air at high temperature and pressure to enhance oxidation of organic contaminants.	Not applicable due to low organic concentrations.
	Biological	Aerobic Detoxification	Suspended growth or fixed film process employing aeration and biomass recycle to decompose organic contaminants.	Not applicable due to low organic concentrations.
		Aerobic/ Anaerobic Detoxification	Suspended growth facultative process in pond or basin employing long detention times and aerobic/ anaerobic biomass to decompose organic contaminants.	Not applicable due to low organic concentrations.
		Anaerobic Detoxification	Suspended growth or fixed film process employing anaerobic biomass to decompose organic contaminants.	Not applicable due to low organic concentrations.
		Biosorption	Use of an algae-based ion exchange resin to remove heavy metals and radionuclides from groundwater	Potentially applicable to GMA and perched groundwater.
		Denitrification	Use of bacteria to reduce nitrates and nitrites to molecular nitrogen.	Not applicable. Nitrogen compounds are not of concern.
Disposal/ Discharge	On-Property	Beneficial Reuse	Reuse of treated groundwater, as necessary, for site process water.	Potentially applicable to GMA and perched groundwater.
		Direct Discharge to Surface Water	Discharge of treated groundwater to Paddys Run.	Potentially applicable to GMA and perched groundwater.
	On-Property/ Off-Property	Surface / Subsurface Discharge	Use of reinjection wells or spray irrigation to discharge treated groundwater to underground.	Potentially applicable to GMA.
	Off-Property	Indirect Discharge to POTW	Discharge of untreated water to a publicly owned treatment works (POTW).	Not applicable. Volume of removed groundwater is too great.
		Indirect Discharge to Permitted Facility	Discharge of untreated water to a permitted commercial treatment facility.	Not applicable. Volume of removed groundwater is too great.
		Direct Discharge to Surface Water	Discharge of treated groundwater to the Great Miami River	Potentially applicable to GMA and perched groundwater.

TABLE 3-2
GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR FURTHER EVALUATION

General Response Action Components	Technology	Process Option
No Action	None	Not applicable (G,P)
Institutional Controls	Monitoring	Groundwater monitoring (G,P) Leachate monitoring (P) Surface water monitoring (G,P)
	Access/Use Restrictions	Alternate water supply (G) Physical barriers (G,P) Deed restrictions (G,P) Continued Federal ownership (G,P)
Containment	Capping	Multilayer cap (G,P)
	Subsurface Water Control	Vertical slurry wall (P) Horizontal slurry barrier (P) Subsurface drains (P) Sheet piling (P) Pumping wells (G)
Removal	Subsurface Water Extraction	Vertical extraction wells (G,P) Directional extraction wells (G,P) Collection trench/French drain (P) Excavation (P) Electroosmosis (P)
Treatment	In Situ	Vapor sparging (G,P)
	Physical	Equalization (G,P) Sedimentation/clarification (G,P) Ultrafiltration (G,P) Multimedia filtration (G,P) Reverse osmosis (G,P) Volatilization (G,P) Adsorption (G,P)
	Chemical	Ion Exchange (G,P) Electrodialysis reversal (G,P) Coagulation/flocculation (G,P) Neutralization (pH adjustment) (G,P) Chemical precipitation (G,P) Enhanced oxidation (G,P) Chemical reduction (G,P)
	Physical/Chemical	Treatment by AWWT facility (P)
	Biological	Biosorption (G,P)
Disposal/Discharge	On-Property	Beneficial reuse (G,P) Direct discharge to Paddys Run (G,P)
	On-Property/Off-Property	Surface/subsurface discharge (G)
	Off-Property	Discharge to Great Miami River (G,P)

(G) Potentially Applicable to Great Miami Aquifer Groundwater
(P) Potentially Applicable to Perched Groundwater

TABLE 3-3
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL AND SEDIMENT
(Unshaded items indicate passing initial screening process)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No activities conducted at site to address contamination.	Required by NCP.
Institutional Controls	Monitoring	Surface Water Monitoring	Sampling and analysis of surface water and storm water ditches to assess contamination.	Potentially applicable.
		Groundwater Monitoring	Sampling of newly installed or existing wells to assess contaminant migration.	Potentially applicable.
		Leachate Monitoring	Sampling and analysis of leachate collection systems.	Potentially applicable.
	Access/Use Restrictions	Physical Barriers	Fencing, markers, and/or warning signs to restrict site access.	Potentially applicable.
		Security Guards	Supplement physical barriers by monitoring for breaches and trespassers.	Potentially applicable
		Deed Restrictions	Administrative action using property deeds to restrict future site activities.	Potentially applicable.
		Continued Federal Ownership	Continued property ownership of all or part of the FEMP site to restrict future site activities through ownership rights.	Potentially applicable.
Containment	Capping	Single Layer Cap	Low permeability cap over an area of contamination; low permeability materials include concrete, asphalt, soil, clay, synthetic membrane, etc.)	Not applicable. Insufficient life expectancy.
		Multilayer Cap	Cap formed with multiple layers including topsoil, clay, synthetic membrane, etc.	Potentially applicable.
	Surface Water Control	Diversion/ Collection	Dikes, berms, channels, chutes, and ditches to control run-on, runoff, erosion, and infiltration.	Potentially applicable as a support action.
		Grading	Recontour the land surface to limit run-on, runoff, erosion, and infiltration.	Potentially applicable as a support action.
		Revegetation (Earthen Cover)	Vegetative cover to stabilize soil.	Potentially applicable as a support action.
		Channel Relocation	Relocate on-site stream to expose clean sediment and/or allow covering of contaminated sediment.	Not applicable. Site conditions make stream deposition control unnecessary.
		Channel Modification	Modify stream to control sediment deposition or resuspension.	Not applicable. Site conditions make stream deposition control unnecessary.

TABLE 3-3
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Removal	Excavation	Excavation	Removal of soil and sediment using conventional earthmoving equipment.	Potentially applicable.
		Dredging	Mechanical or hydraulic dredging of sediment and soil below the groundwater table.	Not applicable; conventional excavation methods can be used.
		Sorting/ Separation	Visually sort large debris using mechanical excavation equipment. Use gamma or phtoionization detectors in field to identify radiologically and organic contaminated material.	Potentially applicable as a support action during excavation.
Treatment	Biological	In Situ Aerobic Bioremediation	In situ degradation of organics using microorganisms in an aerobic environment. Oxygen and nutrients would be injected into the subsurface to promote biological activity.	Not applicable to metals and radionuclides found in soil at the site.
		In Situ Anaerobic Bioremediation	In situ degradation of organics using microorganisms in an anaerobic environment. Nutrients and other supplements would be injected into the subsurface to promote biological activity.	Not applicable to metals and radionuclides found in soil at the site.
		Plant Harvesting	Plants are seeded in contaminated area to remove contaminants by root and plant uptake.	Not applicable; may introduce contaminants into food chain.
		Soil Aeration	Air is tilled or injected into soil to promote microbial degradation of organics and to strip volatile organics.	Not applicable to metals and radionuclides found in soil at the site.
		Land Farming	Isolation of contaminated media on a containment pad and supplemented with oxygen and nutrients to enhance biological degradation.	Not applicable to metals and radionuclides found in soil at the site.
	Physical	Dewatering / Drying	Gravity or mechanical dewatering of soil, sludges, and residues.	Potentially applicable as a support action.
		Soil Vapor Extraction	System of air injection and extraction wells to promote transfer of volatile organics to the air.	Not applicable to metals and radionuclides found in soil at the site.
	Physical/ Chemical	Soil Washing	Ex situ extraction of contaminants using an agent such as water, acid, solvent, or chelating agents, possibly incorporating the use of phosphates for stabilizing uranium mobility.	Potentially applicable.
		Soil Flushing	In situ flushing of contaminants using injection/extraction well system and a flushing solution.	Not applicable due to insufficient contact time caused by varied subsurface conditions.

TABLE 3-3
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Physical/ Chemical (continued)	Dehalogenation	Use of alkaline reagents such as potassium polyethylene glycolate to chemically strip halogen atoms from organics in contaminated soil.	Not applicable to metals and radionuclides found in soil at the site.
		Physical Separation	Ex situ process to minimize waste through volume reduction by physically separating out size fractions of soil or sediment containing minimal contamination.	Potentially applicable.
	Solidification/ Stabilization	Cement- /Pozzolan-Based Solidification	Cement, lime, or other pozzolanic materials are mixed with soil to immobilize contaminants.	Potentially applicable.
		Thermoplastic Solidification	Soil is mixed with asphalt, bitumen, paraffin, or polyethylene and heated to form a stable solid.	Potentially applicable.
		Organic Polymer Stabilization	Soil is mixed with a polymer and catalyst to form a stable solid.	Potentially applicable.
		Vitrification	Contaminated soil is mixed with molten glass to form a stable solid.	Potentially applicable.
		In Situ (Cement-Based) Solidification	Cement, quicklime, or other grouting materials are mixed in situ with soil to immobilize contaminants.	Not applicable due to inadequate mixing caused by varied subsurface conditions.
		In Situ Vitrification	High current electricity passed through area of contamination in situ to melt the material into a glass-like solid matrix.	Not applicable due to large size and associated energy requirements.
		Soil Compaction	Utilizes standard brickmaking equipment and practices for achieving volume reduction through densification.	Potentially applicable.
	Thermal	Thermal Desorption	Application of heat at relatively low temperature to remove organics from excavated soil by volatilization. Vapor phase is treated by incineration or carbon adsorption.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Rotary Kiln Incineration	Rotary kiln used to destroy organic contaminants by high temperature incineration.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.

TABLE 3-3
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Thermal (continued)	Fluidized Bed Combustion	Destruction of organic contaminants in a vessel containing a bed of hot, inert granular particles into which waste is injected.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Circulating Bed Combustion	Similar to fluidized bed combustion, except air is added to increase turbulence and operating temperatures are lower.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Radio Frequency Heating	Soils is heated in situ using electrodes placed in the ground. Organics are vaporized and collected at the surface for treatment.	Not applicable. Major COCs are not volatile; following treatment in situ for volatile organics, soil would require excavation to treat radionuclides and inorganics.
		Infrared Incineration	Employs an intense flux of near infrared radiation to initiate and sustain pyrolysis of the feed materials and to destroy organics.	Potentially applicable as support process to remove low levels of organics; additional treatment for metals and radionuclides required.
		Plasma Centrifugal Furnace	Soil is detoxified by the use of heat from a plasma torch to vaporize organic contaminants and immobilize metals and radionuclides in a nonleachable glass-like matrix.	Potentially applicable.
Storage	Intermediate Storage	Central Storage Facility	Short term storage for staging and packaging of contaminated soil and sediment, residuals, and nonrecoverable debris before shipment to appropriate disposal facility.	Potentially applicable.
Disposal	On-Property	Backfilling	Disposal of treated soil by using it as backfill in on-site excavations.	Potentially applicable.
		Engineered Disposal Facility	Disposal of soil and/or residuals in an on-property disposal facility.	Potentially applicable.
		Consolidation	Consolidating slightly contaminated soil at a central location with grading and cover or capping.	Potentially applicable

TABLE 3-3
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Disposal (continued)	Off-Site	Nevada Test Site (NTS)	Disposal of contaminated soil at NTS.	Potentially applicable.
		Permitted Commercial Facility	Disposal of contaminated soil at a permitted commercial facility.	Potentially applicable.
	Waste Transportation	Truck Transport	Use of trucks for transporting waste from areas of contamination to disposal areas on the site or for off-site disposal.	Potentially applicable as a support action.
		Rail Transport	Use of rail transportation to transport waste off site for disposal.	Potentially applicable as a support action.

TABLE 3-4
SOIL AND SEDIMENT TECHNOLOGIES AND PROCESS OPTIONS RETAINED FOR FURTHER EVALUATION

General Response Action Component	Technology	Process Option
No Action	None	Not applicable
Institutional Controls	Monitoring	Surface water monitoring Groundwater monitoring Leachate monitoring
	Access/Use Restrictions	Physical barriers Security guards Deed restrictions Continued Federal ownership
Containment	Capping	Multilayer cap
	Surface Water Control	Diversion/collection Grading Revegetation (Earthen Cover)
Removal	Excavation	Excavation Sorting/separation
Treatment	Physical	Dewatering/drying
	Physical/Chemical	Soil washing Physical separation
	Solidification/ Stabilization	Cement-/Pozzolan-based solidification Thermoplastic solidification Organic polymer stabilization Vitrification Soil Compaction
	Thermal	Thermal desorption Rotary kiln incineration Fluidized bed combustion Circulating bed combustion Infrared incineration Plasma centrifugal furnace
Storage	Intermediate Storage	Central storage facility
Disposal	On-Property Disposal	Backfilling Engineered disposal facility Consolidation
	Off-Site Disposal	Nevada Test Site Permitted commercial facility
	Waste Transportation	Truck transport Rail transport

generation of large numbers of similar remedial alternatives. Selecting a representative process option does not preclude the use of the other acceptable process options in the remedial design.

The evaluation of technologies and process options uses three criteria: effectiveness, implementability, and relative cost. The CERCLA RI/FS guidance document suggests that this evaluation focus on the effectiveness criterion, with less emphasis directed at implementability and relative cost. Following are brief definitions of effectiveness, implementability, and relative cost as they apply to the screening process. The evaluation process itself is discussed in greater detail in Sections M.4.0 and M.5.0 of Appendix M.

3.3.1.1 Effectiveness Evaluation

This criterion focuses on the potential effectiveness of process options in handling the estimated volume of media and meeting the remediation goals, the potential impacts to human health and the environment during construction and implementation, and how proven and reliable the process is with respect to the contaminants and conditions at the site.

3.3.1.2 Implementability Evaluation

The implementability evaluation encompasses both the technical and institutional feasibility of implementing a process. Since technical implementability was used as an initial screening criterion of technology types and process options to eliminate those that are clearly ineffective or unworkable at the site, the implementability evaluation will provide a more detailed analysis of the technical aspects of process options. It will also place an emphasis on the institutional aspects of implementability, such as regulatory agency acceptance, availability of treatment, storage, and disposal services, and availability of necessary equipment and resources.

3.3.1.3 Cost Evaluation

Cost plays a limited role in this screening. The cost analysis is based on engineering judgment, and each process is evaluated as to whether costs are high, medium, or low relative to the other options in the same technology type. If there is only one process option, costs are compared to those of process options in other candidate technologies. Both capital cost and operation and maintenance (O&M) costs are considered.

3.3.2 Summary of Evaluation of Technologies and Process Options for Groundwater

The technologies and process options remaining after the initial screening for perched and Great Miami Aquifer groundwater were evaluated based on effectiveness, implementability, and cost. The process options within each technology type were then compared, and preferred or representative process options were selected for incorporation into remedial action alternatives. (See Section M.4.0 of Appendix M for a detailed description of the entire evaluation process.)

Based on effectiveness, implementability, and relative cost, Table 3-5 summarizes the results of the evaluation of technologies and process options for perched and Great Miami Aquifer groundwater. Tables 3-6 and 3-7 present the technologies and process options that will be retained for consideration in the development of the remedial alternatives for perched groundwater and Great Miami Aquifer groundwater, respectively. In these tables, the technologies are organized according to the GRAs developed in Section 3.1. Retained process options are listed by type (primary or support) and status (representative) with respect to incorporation into remedial alternatives.

3.3.3 Summary of Evaluation of Technologies and Process Options for Soil and Sediment

The technologies and process options remaining after the initial screening for soil and sediment were evaluated based on effectiveness, implementability, and relative cost. The process options within each technology type were then compared and the preferred or representative process options were selected for incorporation into remedial action alternatives. (See Section M.5.0 of Appendix M for a detailed description of the entire evaluation process.)

Based on effectiveness, implementability, and relative cost, Table 3-8 presents a summary of the results of the evaluation of technologies and process options for soil and sediment. Table 3-9 presents the technologies and process options that will be retained for incorporation into remedial alternatives for soil and sediment. In this table, the technologies are organized according to the general response actions developed in Section 3.1. Retained process options are listed by type (primary or support) and status (representative) with respect to incorporation into remedial alternatives.

Although considerable time and effort were spent in treatability studies to evaluate soil washing processes using various chemical extraction techniques (Appendix D), this technology was not retained as a primary process option to be incorporated into a remedial alternative. The hybrid soil washing, which currently appears to be the most promising of the chemical extraction process options, was evaluated versus the screening criteria (Appendix M) and was not retained as a primary remedial alternative for detailed analysis in Section 5.0. Overall, the hybrid sulfuric acid/sodium carbonate physicochemical treatment process is an unattractive option from every aspect of the screening criteria. Component operating costs are extremely high at $592 per cubic yard; uranium removal is only marginally acceptable at the 1×10^{-5} risk assessment level and mobility remains an issue of concern; and implementation requires the construction and operation of a large chemical treatment plant around the clock for 22 years. Soil washing was retained as a representative support option because of the potential of the phosphate amendment for stabilizing uranium mobility in FEMP soils. As a support option, it also allows a means for introducing innovative waste minimization technologies that are likely to emerge during the 22-year period of soil remediation. Several of these technologies are identified and briefly discussed in Appendix M.

TABLE 3-5
SUMMARY OF EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
(Shaded process options and/or technologies have been eliminated from further consideration)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
No Action	None	Not Applicable	G,P	Not effective in protection of public health or the environment.	No actions would be implemented.	None	None
Institutional Controls	Monitoring	Groundwater Monitoring	G,P	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of groundwater recovery system.	Readily implementable.	Low; new wells may need to be installed.	Low; includes maintenance, sampling and analysis.
		Leachate Monitoring	P	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of perched water remedial actions.	Readily implementable.	Low; new collection sumps may need to be constructed.	Low; includes sampling and analysis.
		Surface Water Monitoring	G,P	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of water treatment system.	Readily implementable.	Low; includes installation of automated monitoring system.	Low; includes sampling and analysis.
	Access/Use Restrictions	Alternate Water Supply	G	Indirectly meets human health objectives by limiting exposure; does not meet environmental objectives since contaminants are left in place.	Extension of existing distribution system is readily implementable and in progress.	Moderate; includes pump stations, trunk and distribution lines.	Low to moderate; includes well and line maintenance and water monitoring.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

000251
132000

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Institutional Controls (continued)	Access/Use Restrictions (continued)	Physical Barriers	G,P	Indirectly meets human health objectives by limiting access; does not meet environmental objectives since contaminants are left in place.	Readily implementable.	Low; includes materials and installation, and is dependent on the extent of area to be enclosed.	Negligible.
		Deed Restrictions	G,P	Indirectly meets human health objectives by reducing exposure; does not meet environmental objectives since contaminants are left in place.	Readily implementable within property; not implementable for off property restrictions.	Negligible.	Negligible.
		Continued Federal Ownership	G,P	Indirectly meets human health objectives by reducing exposure; does not meet environmental objectives since contaminants are left in place.	Readily implementable; maintains status quo.	Negligible.	Negligible.
Containment	Capping	Multilayer Cap	G,P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for migration by limiting infiltration and erosion.	Materials, equipment, and skilled labor are readily available.	Moderate; includes materials and installation, and depends upon area to be enclosed.	Low; includes periodic inspections, maintenance and repairs.
	Subsurface Water Control	Vertical Slurry Walls	P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for lateral migration.	Materials, equipment, and labor are readily available; more difficult at depths greater than 75 feet.	Moderate; includes trench construction, backfilling, and depends upon length and depth required.	Low; includes periodic inspections and repairs.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Containment (continued)	Subsurface Water Control (continued)	Horizontal Slurry Barrier	P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for vertical migration; difficult to determine integrity.	Construction involves special techniques and equipment; limited number of vendors.	High; includes slurry injection into predrilled holes, special equipment mobilization; depends on depth and area of barrier.	Low; includes periodic repairs of the barrier and monitoring its performance.
		Subsurface Drains	P	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for lateral migration.	Constructing drain systems beneath contaminated soil can be difficult; materials and equipment are readily available.	Low to moderate; includes installation of conduit, pumps, and leachate collection tanks or sumps.	Low; includes pump maintenance and monitoring costs.
		Sheet Piling	P	Does not reduce toxicity, mobility or volume of contaminants; potential for reducing lateral migration is questionable.	Materials, equipment and labor are readily available.	Low; includes materials and installation, and depends on length and depth of piling required.	Negligible.
		Pumping Wells	G	Does not reduce toxicity or mobility of contaminants; reduces contaminant volume and potential for migration.	Construction simple; materials and equipment are readily available.	Low to moderate; includes construction of new pumping wells.	Low to moderate; includes operation and maintenance.
Removal	Subsurface Water Extraction	Vertical Extraction Wells	G,P	Does not reduce toxicity or mobility of contaminants, but does reduce volume and potential for migration.	Equipment and materials are readily available.	Low to moderate; includes installation of new wells and pumps.	Low to moderate; includes electricity and maintenance of wells, pumps and other equipment.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Removal (continued)	Subsurface Water Extraction (continued)	Directional Extraction Wells	G,P	Does not reduce toxicity or mobility of contaminants, but does reduce the potential for migration.	Equipment and materials are readily available; more difficult to construct than vertical extraction wells.	Moderate; more costly than vertical wells; includes installation of new wells and pumps.	Moderate; includes electricity plus maintenance of wells, pumps and other equipment.
		Collection Trench/French Drain	P	Effective in removing contaminated media so it is no longer a threat to human health and the environment; decrease in effectiveness when depths exceed 40 feet.	Equipment and materials are readily available; skilled labor required as trenching depths approach 40 feet.	Moderate; includes construction of trenches and associated collection sumps.	Low; includes maintenance and periodic inspections.
		Excavation	P	Effective in removing contaminated media so it is no longer a threat to human health and the environment.	Equipment and materials are readily available; conventional techniques readily implementable.	Low; includes skilled labor and equipment.	Negligible.
		Electroosmosis	P	May be effective in removing inorganic constituents of concern; very limited application at hazardous waste sites.	Equipment and materials are readily available; however, skilled labor required; tanks, buildings or utilities would interfere with process.	Moderate; includes installation of system and construction of associated collection sumps.	High; includes maintenance, inspections, plus possible excessive electrical costs.
Treatment	In Situ	Vapor Sparging	G	Questionable effectiveness issues; reliability of process at required depths and ability of natural carbonates to mobilize uranium.	Materials, equipment and labor are readily available; injection permit may be difficult to obtain.	Moderate; includes air injection fans, ducts and additional injection wells if required.	Moderate; includes electricity, monitoring, bulk CO_3 and equipment maintenance.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

000255

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Physical	Equalization	G,P	Effective support process option for most treatment processes.	Materials and equipment are readily available.	Low; includes installation of tanks, sumps, and mixers.	Low; includes mixer maintenance and electricity.
		Sedimentation/ Clarification	G,P	Effective support process for chemical precipitation; improves removal of inorganics and radionuclides.	Materials and equipment are readily available; thickened sludges must be dewatered before off-site disposal.	Moderate; includes installation of clarifier/thickener system.	Low; includes electricity and maintenance for pumps and agitators.
		Ultrafiltration	G,P	Emerging technology in regard to wastewater applications; not as reliable as multimedia filtration for the removal of suspended solids.	Materials and specialized equipment are readily available; skilled labor required to implement.	High; includes pilot studies, and design and construction of the system.	High; includes equipment maintenance, membrane replacement, chemical additions and electricity.
		Multimedia Filtration	G,P	Effective support option for many treatment processes such as reverse osmosis, ion exchange, carbon adsorption; removes only suspended contaminants in water media.	Materials and equipment are readily available.	Low; includes equipment and filtration media.	Low; includes filter maintenance and occasional replacement of filter media.
		Reverse Osmosis	G,P	Reliable treatment process for dissolved organics, inorganics and metals; pH adjustment, filtration, and removal of certain organics are required pretreatment steps.	Materials and specialized equipment are readily available; membranes are subject to deterioration; disposal of sizable liquid reject stream is difficult.	High; includes pilot studies, and design and construction of the system.	High; includes membrane replacement, chemical additions, handling of reject stream and electricity.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Physical (continued)	Volatilization	G,P	Reliable treatment process for removal of volatile organics in wastewater; off-gas requires treatment.	Materials and equipment are readily available; pretreatment of solids, iron and certain salts is needed to prevent packing material from clogging.	Moderate; includes the cost of packing material, and installation of the system.	Low to moderate; depends on contaminant loadings, degree of removal and type of off-gas treatment required.
		Adsorption	G,P	Reliable treatment process for removal of low level organics in wastewater; low carbon consumption expected.	Materials and equipment are readily available; spent carbon must be disposed of; regeneration not practiced because of adsorbed radioactivity.	Moderate; includes activated carbon cost, plus design and construction of the system.	Moderate; depends on carbon usage rate which is a function of contaminant loadings.
	Chemical	Ion Exchange	G,P	Reliable treatment process for removal of low level ionic contaminant species such as metals, inorganics and radionuclides.	Materials and equipment are readily available; spent resin may be reused after regeneration or disposed of.	Moderate; includes initial resin cost plus design and installation of the system.	Moderate; includes cost of replacement resin and regeneration chemicals.
		Electrodialysis Reversal	G,P	Has not been proven to be effective in the treatment of uranium and radionuclides; would require treatability study to verify applicability.	Materials and equipment are available; disposal of sizable brine reject stream is difficult.	High; includes extensive studies, and design and installation of the system.	High; includes cost of membrane replacement, electricity and handling of brine reject stream.
		Coagulation/ Flocculation	G,P	Effective treatment process for the removal of metals, inorganics and radionuclides in the form of small colloidal particles.	Materials, chemicals and equipment are readily available.	Low; includes feed tanks, pumps and mixers.	Low; includes maintenance of equipment, and depends on types of chemicals used.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

000257

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Chemical (continued)	Neutralization/ pH Adjustment	G,P	A proven and reliable means of balancing or changing the pH in a water media; often used as a pretreatment step for many treatment options.	Materials, chemicals and equipment are readily available.	Low; includes feed tanks, pumps and mixers.	Low; includes equipment maintenance and replacement chemicals.
		Chemical Precipitation	P	A proven and reliable means of removing insoluble metals and radionuclides from wastewater through the use of coagulants.	Materials, chemicals and equipment are readily available.	Low; includes feed tanks, pumps and mixers.	Moderate; includes maintenance of equipment, and depends on types of chemicals used.
		Enhanced Oxidation	G,P	Innovative technology that is contaminant specific in its effectiveness; would require treatability study to verify applicability.	Implementable, however, equipment is not readily available; pretreatment by filtration required to prevent lamp fouling; controls needed to prevent peroxide releases.	High; includes extensive studies, and design and installation of the system.	Moderate to high; depends on flow rate and contaminant loadings; very high energy requirements.
		Chemical Reduction	G,P	Typically most effective for wastewater containing heavy metal concentrations; most common application converts hexavalent chromium to the trivalent state.	Materials, chemicals and equipment are readily available; however, processes which eliminate pH reduction step are more difficult to implement.	Moderate; includes feed tanks, pumps and mixers plus installation of the system.	Low to moderate; includes maintenance of equipment, and depends on types of chemicals used.
	Physical/ Chemical	Treatment by Advanced Wastewater Treatment Facility (AWWT)	P	Reliable treatment processes for removal of organics, metals, uranium and other radionuclides.	Readily implementable as it is currently in operation.	Negligible; since system is already designed and in operation.	High; includes resin, filter media, chemical replacement and disposal of process residues.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Biological	Biosorption	G,P	Innovative technology that removes metals, uranium and other radionuclides from wastewater; modification of the ion exchange process.	Difficult to implement as it is a proprietary technique; availability of equipment and skilled workers could be limited.	High; includes pilot studies, and design and installation of the system.	High; includes cost of replacement resin and disposal of residuals.
Disposal/ Discharge	On-Property	Beneficial Reuse	G,P	Effective if treated to the necessary process standards; reduces volume of groundwater needed to be disposed of by other options.	Readily implementable.	Low; requires a make up tank, pumps, and a distribution line to be installed.	Low; includes equipment maintenance and line inspections.
		Discharge to Paddys Run	G,P	Imposed discharge limits would be protective of human health and the environment; capacity of Paddys Run may be limited.	Implementable; would require construction of treated effluent discharge line; Paddys Run limits more stringent than those for the Great Miami River.	Low; includes the construction of a discharge line from the treatment facilities to Paddys Run.	Low; includes maintenance and monitoring costs.
	On-Property/ Off-Property	Surface/ Subsurface Discharge	G	Imposed discharge limits would be protective of human health and the environment; effective in reducing remediation time in a pump and treat system by increasing flow through the aquifer.	May be difficult to achieve a closed system; difficult to obtain permission to inject into a sole source drinking water aquifer; limits more stringent than those for surface water discharge.	Moderate; includes installation of new injection wells and pumps; would cost more than surface water discharge.	Moderate; includes maintenance of wells and pumps, electricity and sampling and analysis.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

000259

TABLE 3-5
(Continued)

General Response Action	Remedial Technology	Process Option	Media[a]	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Disposal/ Discharge (continued)	Off-Property	Discharge to Great Miami River	G,P	Imposed discharge limits would be protective of human health and the environment.	Easily implementable; construction of enclosed pipeline to Great Miami River is completed; need to connect effluent lines from treatment plants.	Low; includes connecting treatment discharge lines to enclosed pipeline.	Low; includes maintenance and monitoring costs.

[a]G - Great Miami Aquifer groundwater; P - perched groundwater

TABLE 3-6
SUMMARY OF RETAINED PERCHED GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Primary	Support	Representative Process Option[a]
No Action	None	Not applicable	X		
Institutional Controls	Monitoring	Groundwater monitoring		X	X
		Leachate monitoring		X	X
		Surface water monitoring		X	X
	Access/Use Restrictions	Physical barriers		X	X
		Deed restrictions		X	X
		Continued Federal ownership		X	X
Containment	Capping	Multilayer cap	X		X
	Subsurface Water Control	Vertical slurry walls		X	
Removal	Subsurface Water Extraction	Vertical extraction wells		X	
		Directional extraction wells		X	
		Collection trench/ French drain			
		Excavation	X		X
Treatment	Physical	Equalization		X	
		Sedimentation/clarification		X	
		Multimedia filtration		X	
		Adsorption	X		
	Chemical	Ion exchange	X		
		Coagulation/flocculation		X	
		Neutralization (pH adjustment)		X	
		Chemical precipitation	X		
	Physical/Chemical	Treatment by Advanced Wastewater Treatment Facility (AWWT)	X		X
Disposal/ Discharge	On-Property	Beneficial reuse		X	X
	Off-Property	Discharge to the Great Miami River	X		X

[a] The representative primary process options have been selected for incorporation into the remedial alternatives. Their selection does not preclude the use of the other retained process options in the remedial design.

TABLE 3-7
SUMMARY OF RETAINED GREAT MIAMI AQUIFER GROUNDWATER TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Primary	Support	Representative Process Option[a]
No Action	None	Not applicable	X		
Institutional Controls	Monitoring	Groundwater monitoring		X	X
		Surface water monitoring		X	X
	Access/Use Restrictions	Alternate water supply		X	X
		Physical barriers		X	X
		Deed restrictions		X	X
		Continued Federal ownership		X	X
Containment	Capping	Multilayer cap	X		X
Removal	Subsurface Water Extraction	Vertical extraction wells	X		X
		Directional extraction wells		X	
Treatment	In Situ	Vapor sparging		X	
	Physical	Equalization		X	X
		Sedimentation/clarification		X	X
		Multimedia filtration		X	X
		Adsorption	X		X
	Chemical	Ion exchange	X		X
		Coagulation/flocculation		X	X
		Neutralization (pH adjustment)		X	X
Disposal/ Discharge	On-Property	Beneficial reuse		X	X
	On-Property/ Off-Property	Surface/subsurface discharge		X	
	Off-Property	Discharge to the Great Miami River	X		X

[a] The representative primary process options have been selected for incorporation into the remedial alternatives. Their selection does not preclude the use of the other retained process options in the remedial design.

TABLE 3-8
SUMMARY OF EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL AND SEDIMENT
(Shaded process options and/or technologies have been eliminated from further consideration)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
No Action	None	Not Applicable	Not effective in protecting public health or the environment.	No actions would be implemented.	None.	None.
Institutional Controls	Monitoring	Surface Water Monitoring	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of water treatment system.	Readily implementable.	Low; includes installation of automated monitoring system.	Low; includes sampling and analyses.
		Groundwater Monitoring	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of groundwater recovery system.	Readily implementable.	Low; new wells may need to be installed.	Low; includes maintenance, sampling, and analyses.
		Leachate Monitoring	Does not reduce toxicity, mobility or volume of contaminants; indicates effectiveness of remedial actions.	Readily implementable.	Low; new collection sumps may need to be installed.	Low; includes sampling, and analyses.
	Access/Use Restrictions	Physical Barriers	Indirectly achieves human health objectives by preventing access; does not meet environmental objectives since contaminants are left in place.	Readily implementable.	Low; includes materials and installation and is dependent on the extent of the area to be enclosed.	Negligible.
		Security Guards	Indirectly achieves human health objectives by limiting allowable site activities; does not meet environmental objectives since contaminants are left in place.	Readily implementable; physical barriers required for long term implementation.	Negligible.	Low; salaries for security personnel and administrative costs.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Institutional Controls (continued)	Access/Use Restrictions (continued)	Deed Restrictions	Indirectly achieves human health objectives by limiting allowable site activities; does not meet environmental objectives since contaminants are left in place.	Readily implementable within facility boundary; not implementable for off-site property.	Negligible.	Negligible.
		Continued Federal Ownership	Indirectly achieves human health objectives by limiting allowable site activities; does not meet environmental objectives since contaminants are left in place.	Readily implementable; maintains status quo.	Negligible.	Negligible.
Containment	Capping	Multilayer Cap	Does not reduce toxicity, mobility or volume of contaminants; reduces the potential for migration by limiting infiltration and erosion.	Materials, equipment, and skilled labor are readily available.	Moderate; includes costs for material and installation and is dependent on the extent of the area to be capped.	Low; limited to inspections, repairs, and maintenance.
	Surface Water Control	Diversion/ Collection	Would minimize run-on, run-off, erosion, infiltration and, therefore, contaminant migration.	Readily implementable.	Moderate; includes materials and labor.	Low; minimal maintenance.
		Grading	Would be effective in contouring the surface to prevent run-on and run-off and to minimize infiltration, and, therefore, contaminant migration.	Readily implementable.	Moderate; includes materials and labor.	Low; minimal maintenance.

7069

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Containment (continued)	Surface Water Control (continued)	Revegetation (Earthen Cover)	Would be effective in minimizing erosion by wind and water and, therefore, contaminant migration.	Readily implementable.	Low; includes labor and materials.	Low; minimal maintenance.
Removal	Excavation	Excavation	Effective in removing contaminated media so it no longer is a threat to human health and the environment.	Conventional techniques are readily implementable; equipment and materials are readily available.	Low; includes equipment and labor.	Negligible.
		Sorting/Separation	Would be effective in segregating contaminated soil from noncontaminated soil.	Implementable, although low contaminant levels may be difficult to detect with hand-held instruments.	Moderate; includes instruments for analysis.	Low; includes sampling and analysis, and monitoring.
Treatment	Physical	Dewatering/Drying	Would be effective in reducing moisture content of solids (soil and treatment residuals).	Readily implementable.	Moderate; includes equipment, labor and utility costs.	Negligible.
	Physical/ Chemical	Soil Washing	Has proven effective in removing soil contamination (uranium) in pilot plant testing; emerging technology; additional treatability studies required.	Required equipment readily available; would require a large compliment of operators and large quantities of chemicals.	High; includes equipment, power, operators, treatment chemicals, and material and residual handling.	Low, includes long-term monitoring of treated soil.
		Physical Separation	Achieve waste minimization through volume reduction; emerging technology; additional treatability studies required	Required equipment readily available; minimum number of operators required to run the system	Low; includes equipment, power, operators, and material and residual handling	Low; includes long-term monitoring of treated soil.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (Continued)	Solidification/ Stabilization	Cement-/Pozzolan-Based Solidification	Effective in immobilizing radionuclides and inorganics; effectiveness for organics depends on concentration and mobility of compounds.	Uses commonly available techniques and equipment.	High; includes equipment, reagents, labor, and power usage.	Low; includes long-term monitoring and maintenance of solidified area.
		Thermoplastic Solidification	Has not been applied to radioactive waste; long-term stability and leachability are uncertain.	Requires special equipment and highly trained operators.	High; includes specialized equipment and reagents, trained operators, and power.	Low; includes long-term monitoring of stabilized materials.
		Organic Polymer Stabilization	Questionable effectiveness; used more for ease of waste handling rather than long-term security of wastes.	Requires special equipment and highly trained operators.	High; includes specialized equipment and reagents, trained operators, and power.	Low; includes long-term monitoring of stabilized materials.
		Vitrification	Effective in treating hazardous waste and immobilizing radionuclides. Developed specifically for application to radioactive waste sites.	Most techniques not commercially available, but can be made available for DOE sites. Requires special equipment and highly trained operators.	High; includes equipment, utility costs, and operators.	Low; includes long-term monitoring of stabilized materials.
		Soil Compaction	Capable of 30-50% volume reduction through densification by mechanical compaction.	Uses standard brickmaking equipment and practices.	Low; uses standard low-cost equipment and auxiliaries.	Low; includes long-term monitoring of stabilized materials.

002265

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (Continued)	Thermal	Thermal Desorption	Effective for removal of organics. Not effective in removal of inorganics or radionuclide constituents of concern (COCs).	This process is both technically and administratively feasible and readily implementable. Mobile units are available.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.
		Rotary Kiln Incineration	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs. Effective in both long-term and short-term.	This process is both technically and administratively feasible and readily implementable. Mobile units are available.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.
		Fluidized Bed Combustion	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs. Low throughput capacity.	This process is both technically and administratively feasible. Not widely used on hazardous wastes.	High; includes equipment, labor, and utility costs.	Low; includes maintenance and monitoring.
		Circulating Bed Combustion	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs.	This process is both technically and administratively feasible and readily implementable. Not widely used on hazardous wastes.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.
		Infrared Incineration	Effective for removal of organics. Not effective in removal of inorganics or radionuclide COCs.	This process is both technically and administratively feasible and readily implementable. Mobile units are available.	High; includes equipment, labor and utility costs.	Low; includes maintenance and monitoring.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Treatment (continued)	Thermal (continued)	Plasma Centrifugal Furnace	Effective for treating organics, metals, and radionuclides; most appropriate for highly concentrated wastes.	Process is in research & development stage; problems encountered with emission controls, short electrode life, and volatilization of metals.	High; includes equipment and utility costs.	Low; includes maintenance and monitoring.
Storage	Intermediate	Central Storage Facility	Effective in isolating contaminants; not a permanent solution; dependant on continued maintenance.	Design and construction is readily implementable.	Moderate; includes structure, pad, secondary containment and drain system.	Moderate; includes monitoring, maintenance, and security.
Disposal	On-Property	Backfilling	Contingent upon the backfill material meeting the required soil remediation goals.	Equipment, labor and on-property disposal sites are readily available.	Low; includes earthmoving and handling equipment and labor.	Low; includes maintenance and monitoring.
		Engineered Disposal Facility	Effective in isolating contaminated materials so that direct contact threats and contaminant migration are reduced.	Disposal cell design and construction widely practiced; siting will require regulatory approval.	High; cost dependant on volume of material to be landfilled.	Moderate; includes monitoring and maintenance.
		Consolidation	Contingent upon the consolidated material meeting the waste acceptance criteria	Equipment, labor and on-property consolidation sites are readily available.	Low; includes earth moving and handling equipment and labor	Low; includes monitoring and maintenance.
	Off-Site	Nevada Test Site	Radionuclide COCs would be permanently removed from the site; mixed waste (hazardous and radioactive) will not be accepted.	Administratively easy to implement, logistically more difficult; waste must be containerized; no rail line into site.	High; due to disposal fees and packaging costs.	Negligible.

000267

TABLE 3-8
(Continued)

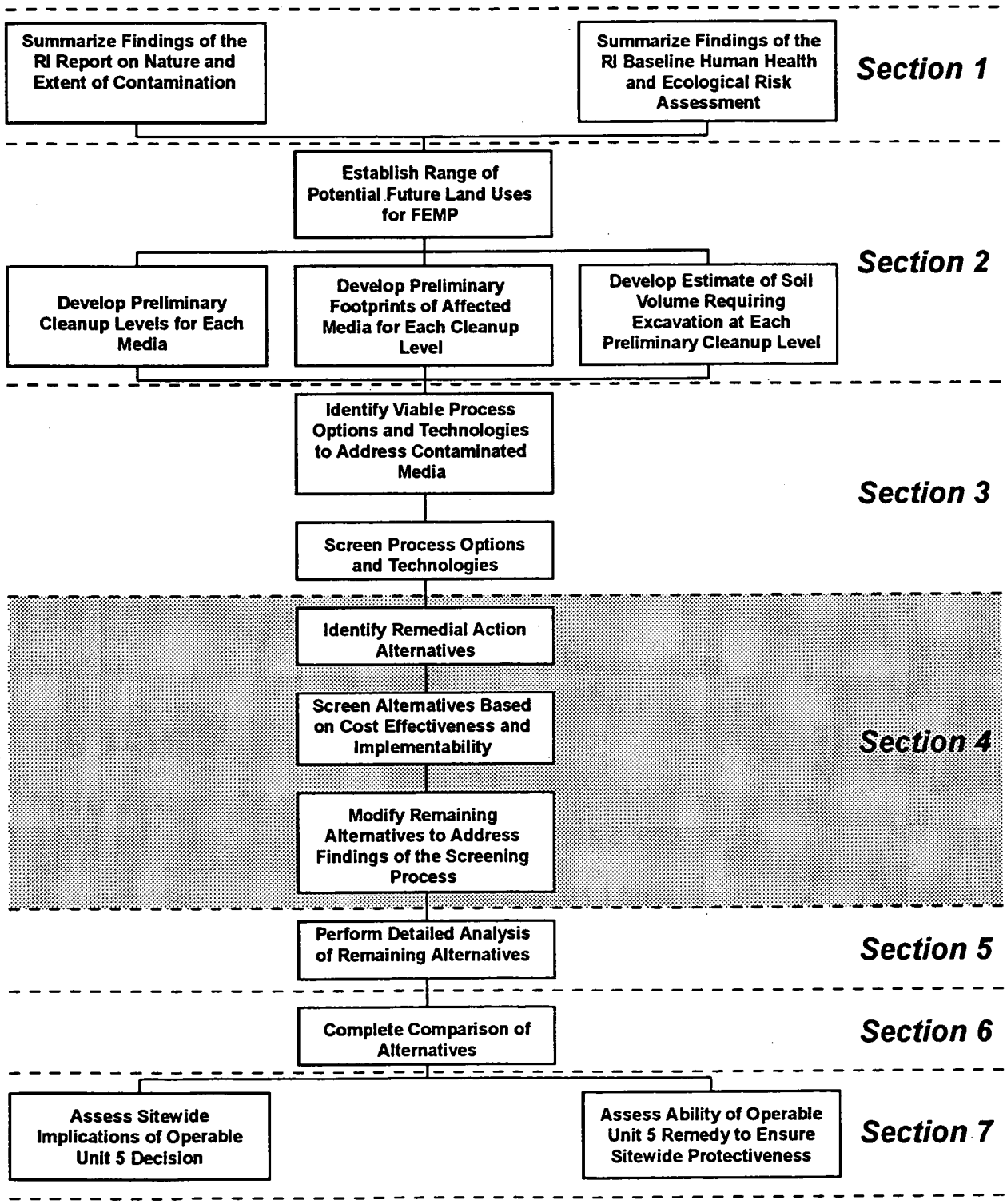
General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Capital Cost	Operation & Maintenance Cost
Disposal (continued)	Off-Site (continued)	Permitted Commercial Facility	Radionuclide, organic and inorganic COCs would be permanently removed from the site; mixed wastes would be accepted.	Waste disposal is readily implemented; waste can be received in bulk shipments; a rail line runs directly to the facility.	Moderate; due to disposal fees, no packaging costs required.	Negligible.
	Waste Transportation	Truck Transport	Effective in transporting contaminated material on site and off site; provides portal to portal service to sites without rail spurs.	Truck transport is moderately difficult for long distances; notification of regulatory agencies would be required.	Moderate, compared to rail transport; includes construction of access roads.	Moderate; includes fees, maintenance of access roads, loading areas.
		Rail Transport	Effective in transporting contaminated material off site; will require the additional use of truck transport if rail spur not available to disposal site.	Rail transport is readily implemented, some rail upgrades may be required; highly reliable and safe.	High, compared to truck transport; includes upgrading on-site rail spur and loading areas.	Low; includes rail fees.

TABLE 3-9
SUMMARY OF RETAINED SOIL AND SEDIMENT TECHNOLOGIES AND PROCESS OPTIONS

General Response Action	Remedial Technology	Process Option	Primary	Support	Representative Process Option[a]
No Action	None	Not applicable	X		
Institutional Controls	Monitoring	Surface water monitoring		X	X
		Groundwater monitoring		X	X
		Leachate monitoring		X	X
	Access/Use Restrictions	Physical barriers		X	X
		Security guards		X	X
		Deed restrictions		X	X
		Continued federal ownership		X	X
Containment	Capping	Multilayer cap	X		X
	Surface Water Controls	Diversion collection		X	X
		Grading		X	X
		Revegetation (earthen cover)		X	X
Removal	Excavation	Excavation	X		X
		Sorting/separation		X	X
Treatment	Physical	Dewatering/drying		X	X
	Physical/Chemical	Soil washing		X	X
		Physical separation		X	X
	Solidification/ Stabilization	Cement/pozzolan-based solidification		X	X
		Vitrification		X	X
		Soil compaction		X	X
	Thermal	Thermal desorption		X	X
		Rotary kiln incineration		X	
		Infrared incineration		X	
Storage	Intermediate Storage	Central storage facility		X	X
Disposal	On-Property	Backfilling	X		X
		Engineered disposal facility	X		X
		Consolidation	X		X
	Off-Site	Nevada Test Site	X		
		Commercial disposal facility	X		X
	Waste Transportation	Truck transport		X	X
		Rail transport		X	X

[a] The representative primary process options have been selected for incorporation into the remedial alternatives. Their selection does not preclude the use of other retained process options in the remedial design.

Section 4.0


Summarize Findings of the RI Report on Nature and Extent of Contamination
Summarize Findings of the RI Baseline Human Health and Ecological Risk Assessment
Section 1
Establish Range of Potential Future Land Uses for FEMP
Develop Preliminary Cleanup Levels for Each Media
Develop Preliminary Footprints of Affected Media for Each Cleanup Level
Develop Estimate of Soil Volume Requiring Excavation at Each Preliminary Cleanup Level
Section 2
Identify Viable Process Options and Technologies to Address Contaminated Media
Screen Process Options and Technologies
Section 3
Identify Remedial Action Alternatives
Screen Alternatives Based on Cost Effectiveness and Implementability
Modify Remaining Alternatives to Address Findings of the Screening Process
Section 4
Perform Detailed Analysis of Remaining Alternatives
Section 5
Complete Comparison of Alternatives
Section 6
Assess Sitewide Implications of Operable Unit 5 Decision
Assess Ability of Operable Unit 5 Remedy to Ensure Sitewide Protectiveness
Section 7

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section presents the development and screening of remedial alternatives assembled from combinations of technologies and associated process options evaluated in Section 3.0. Section 4.1 provides an overview of the framework and key considerations used to develop a range of alternatives based on the general response actions discussed in Section 3.1. Section 4.1 additionally outlines the response action strategies for each of the principal affected environmental media present at the site: perched groundwater, the Great Miami Aquifer groundwater, and soil and sediment. The strategies include the considerations necessary to address flora, fauna, and cultural resource values that may be affected during remedy implementation. Other subsections outline the strategies for designating and addressing Operable Unit 5's principal threat materials (consistent with National Contingency Plan [NCP] requirements) and the management approach for addressing Resource Conservation and Recovery Act (RCRA)-regulated constituents present within Operable Unit 5's affected environmental media. Section 4.2 presents a summary of the land use objectives discussed in Section 2.0, and a summary description of the alternatives. Section 4.3 presents a more detailed description of each alternative, and Section 4.4 offers the initial screening of alternatives evaluated against the broad Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) initial screening criteria of effectiveness, implementability, and cost. Section 4.5 summarizes the results of the initial screening process. Section 4.6 discusses considerations that may, over time, affect the desirability of optimizing the configuration of remedial alternatives before design and implementation.

The purpose of the Feasibility Study (FS) and the overall remedy selection process is to implement remedial actions that eliminate, reduce, or control risks to human health and the environment (40 CFR 300). The national program goal for the FS process, as defined in the NCP, is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste. The criteria for identifying potentially applicable technologies to achieve these goals are provided in U.S. Environmental Protection Agency (EPA) guidance (EPA 1988a) and in the NCP (EPA 1990). A strong statutory preference for remedies that will result in a permanent and significant decrease in toxicity, mobility, or volume and provide long-term protection is identified in Section 121 of CERCLA, as amended. The primary requirements for the final remedy are that it be both protective of human health and the environment and comply with ARARs. Alternative screening, therefore, focuses on these criteria.

Section 4.0 develops potential remedial alternatives by assembling groups of process options selected from those process options passing the screening and evaluation procedures conducted in Section 3.0. The process options are selected so that those included in a remedial alternative collectively respond to the objectives of a particular land use objective. The resulting potential remedial alternatives are evaluated in Section 4.4 with respect to effectiveness, implementability and cost to determine the

relative advantages and disadvantages of each alternative. Through that process, the reader gains an insight into the relative desirability of each of the potential alternatives.

In addition to the above objectives, the NCP defines certain expectations in developing and screening remedial action alternatives, as follows:

- The expectation to use treatment to address the principal threats posed by a site, wherever practical.
- The expectation to use engineering controls, such as containment, for waste that poses a relatively low long-term threat and for which treatment is impractical.
- The expectation to use a combination of methods, as appropriate, to achieve protection of human health and the environment. In appropriate site situations, treatment of principal threats will be combined with engineering controls (such as containment) and institutional actions for treatment residuals and untreated waste.
- The expectation to use institutional actions, such as water use controls and deed restrictions, to supplement engineering controls for short- and long-term management to prevent or limit exposures to hazardous substance, pollutants, or contaminants
- The expectation to consider using innovative technology when such technology offers the potential for comparable or superior treatment performance or implementability, fewer or less adverse impacts than other available approaches, or lower costs for similar levels of performance than demonstrated technologies.
- The expectation to return environmental media such as groundwater to their beneficial uses, wherever practical, within a time frame that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not practical, EPA expects to prevent further migration of the plume and prevent exposures to contaminated groundwater.

These expectations have been applied in the development, description, and screening of alternatives as presented in Sections 4.3 and 4.4.

The concept of principal threat is discussed in Section 4.1.6.1. As discussed in that section, this Operable Unit 5 FS categorizes contaminated media into principal threat (i.e., higher contaminant concentrations) and secondary threat (i.e., lower contaminant concentrations) materials based on a comparison of contaminant concentrations to the waste acceptance criteria for a given potential remedial alternative. That is, materials with contaminant concentrations less than the waste acceptance criteria can be disposed of on property and are categorized as secondary threat material, whereas material with contaminant concentrations greater than the waste acceptance criteria must be disposed of off site and are termed principal threat material. As a consequence, the potential remedial alternatives described in Section 4.3 each provide for both an on-property and an off-site disposal option for contaminated media.

For Operable Unit 5, there are three primary categories of environmental media for which general response actions are being developed and assembled:

- Soil and sediment
- Perched groundwater
- Great Miami Aquifer groundwater.

The individual response actions identified for each type of media are combined into comprehensive remedial alternatives which address all affected media associated with Operable Unit 5. As part of the comprehensive alternative development process, additional measures (if any) that are needed to address flora, fauna and cultural resource remedial requirements are also factored into the formulation of the alternatives.

4.1 DEVELOPMENT OF PRELIMINARY ALTERNATIVES

4.1.1 Criteria for Developing Preliminary Alternatives

The technologies and process options screening conducted in Section 3.0 established a set of building blocks for assembling preliminary remedial alternatives. Initially, these building blocks were developed separately for soil and sediment, perched groundwater and the Great Miami Aquifer groundwater. Subsequently, the technology and process options for each media were combined into alternatives, each of which addressed all affected Operable Unit 5 media.

Early in the development of Section 3.0, it was recognized that assembling preliminary remedial alternatives by employing all technologies and process options passing the screening process would result in an unwieldy quantity of potential remedial options, and would succeed only in confusing the development of a succinct set of remedial alternatives. That point was demonstrated when a list of nearly 2000 possible alternatives resulted from the assembly of all possible combinations of technologies and process options for addressing soil and sediment alone. To arrive at a more manageable quantity of potential remedial alternatives while continuing to cover the full range of possibilities from no action to complete removal, a decision tree similar to that shown in Figure 4-1 was developed as a tool for focusing the development of alternatives for soil. With the aid of that tool, the quantity of potential remedial alternatives addressing soil was reduced to 33. To avoid expanding the initial list of alternatives as other environmental media were factored into the mix of possible remedial activities, options for addressing perched groundwater and the Great Miami Aquifer groundwater were examined on the basis of process options (see Section 3.0) using the results of computer simulations described in Appendix F. To further refine the list of alternatives, three considerations were factored into the alternatives development process.

The three considerations were: 1) the judicious application of professional judgment that eliminated alternatives that were not viable (e.g., full remediation of groundwater with no control of the source

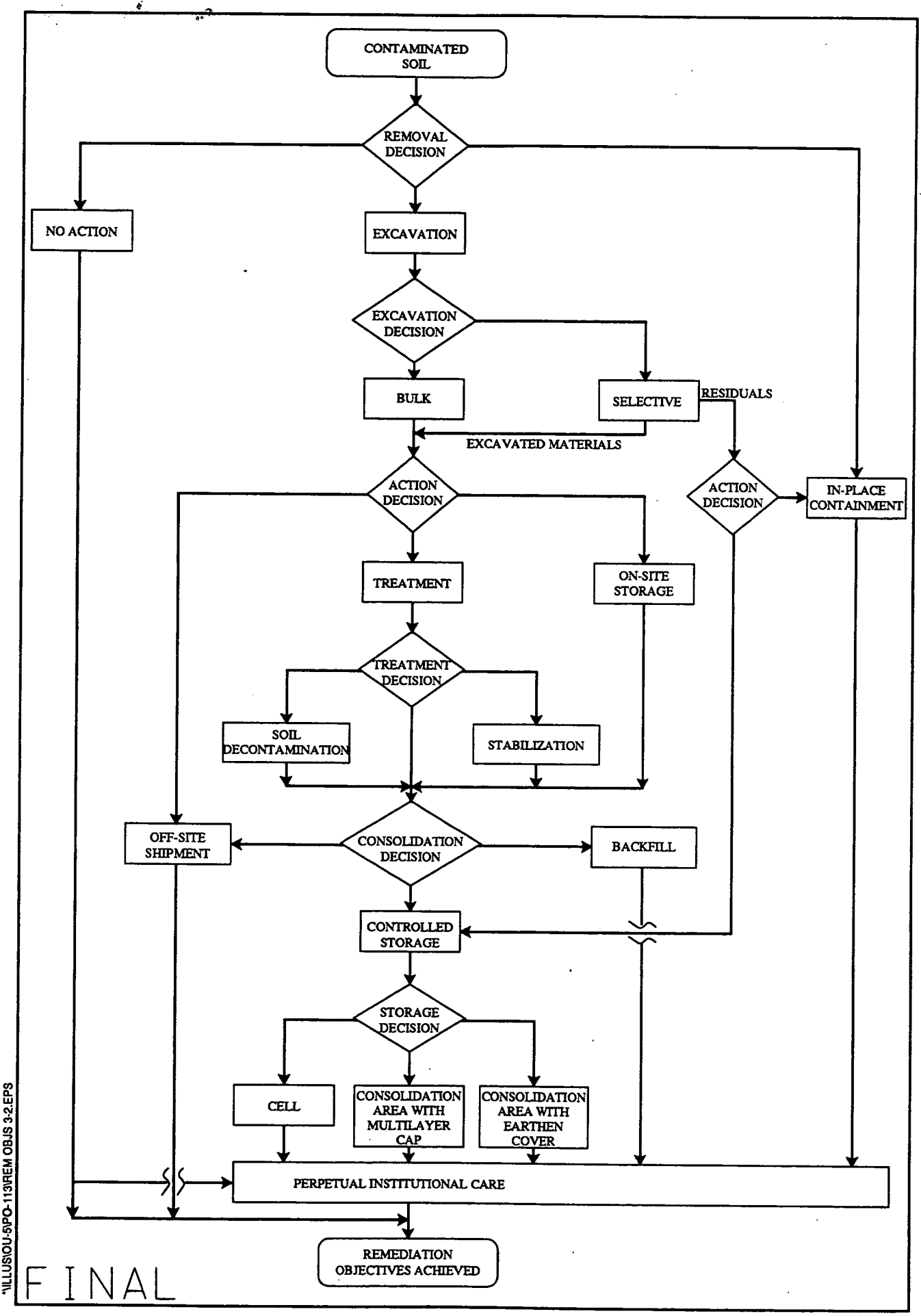


FIGURE 4-1. DEVELOPMENT LOGIC FOR PRELIMINARY ALTERNATIVES FOR SOIL

of contamination), as well as alternatives that exceed protective requirements and were not cost competitive (e.g., treatment of soil to attain concentrations protective of all exposure pathways with subsequent disposal in an on-property engineered cell or at an off-site facility); 2) the definition of a set of best management practices (BMPs) applicable to Operable Unit 5 remediation were defined to form a framework within which the alternatives would be formulated; and 3) the development of a set of land use objectives to ensure that the potential alternatives encompassed the complete range of potential postremediation land uses for the site.

The BMPs used to guide the development of the alternatives are as follows:

- All alternatives will use as low as reasonably achievable (ALARA)-based decision making to establish cleanup levels and to evaluate the magnitude of residual risk levels deemed appropriate for the site
- To the extent practicable, on-site disposal areas will be sited to take advantage of the thickest sequence of glacial till to protect the Great Miami Aquifer
- Soil contaminant levels developed for protection of the Great Miami Aquifer will be applicable to all points in the aquifer
- The selection of representative process options for FS purposes will not rule out reconsideration of other evaluated process options and new process options during remedial design
- Groundwater treatment will be provided by existing and planned on-site wastewater treatment facilities; therefore the development of a range of separate groundwater treatment alternatives is not required
- All alternatives, including those that rely on engineering controls, will target a 1000-year duration as the period over which performance objectives will be met.

4.1.2 Land Use Objectives

All of the remedial alternatives developed in Section 4.0 are designed to achieve target land use objectives upon completion of remedial actions. The range of potential future land use objectives employed in this FS was described in Section 2.2. Land use objectives are described as land use scenarios which encompass risk-based exposure scenarios for specified reasonably maximally exposed (RME) individuals, thereby establishing the framework for determining risk-based protective levels. The prevailing land use in the area surrounding the Fernald Environmental Management Project (FEMP), resident farming, was used as the point of departure for establishing potential land use scenarios. Other land use scenarios focus on industrial/recreational land use and/or a trespasser to provide a range of cleanup criteria. Because land use scenarios served as the basis for the development of preliminary remediation levels (PRLs), they also provide the basis for framing the potential remedial alternatives described in Sections 4.2 and 4.3. Section 2.2 consists of a detailed

presentation of land use objectives and the receptors which are the focus of the land use scenarios. The following paragraphs summarize the land use objectives described in Section 2.2, and highlight additional information pertinent to the formulation of potential remedial alternatives.

4.1.2.1 Land Use Objective 1: Full Unrestricted Use

Land Use Objective 1 examines the viability of returning the entire on-property area to full unrestricted use following remediation. Implementation requires the off-site disposal of all remediated soil and sediment. The hypothetical resident farmer is used as the benchmark to establish protective cleanup levels for all environmental media throughout the entire site. Under this objective, no institutional controls are needed and there are no restricted waste management areas on property.

In order to achieve this objective, all of the waste materials associated with the other four operable units must be removed from the site, unless the materials have contaminant concentrations less than the PRL levels that are protective of the resident farmer. Off-site disposal is thus a requirement for the other operable units as well as Operable Unit 5.

4.1.2.2 Land Use Objective 2: Establishment of a Consolidated Waste Management Area, With Unrestricted Use of the Remaining Areas of the Property

This land use objective attempts to control disposal cost by using on-property disposal for the less contaminated media, but continuing to use off-site disposal for the more contaminated media.

Under Objective 2, contaminated soil is managed on property in a consolidated waste management area for which access and institutional restrictions are implemented. The intention is to free as much as possible of the on-property area outside of the waste management boundary for unrestricted use. Under this objective, it is intended that groundwater would be remediated to reduce contaminant concentrations to levels permitting domestic use of the groundwater from any point on or off the FEMP property.

As part of this land use objective, waste materials from other operable units can be placed in the consolidated waste management area provided they meet the waste acceptance criteria for protection of the two receptors that define the area-specific protective requirements for this objective.

4.1.2.3 Land Use Objective 3: Establishment of a Consolidated Waste Management Area With Restricted Use of the Remaining Areas of the Property

This land use objective examines the cost implications of limiting the remaining on-property area to uses requiring less stringent cleanup goals.

Like Land Use Objective 2, Land Use Objective 3 manages contaminated soil on property in a consolidated waste management area, for which access and institutional restrictions are implemented. The intention is also to free as much as possible of the on-property area outside of the waste management boundary for use. In contrast to Objective 2, on-property remediated areas not occupied by the consolidated waste management area are available for industrial uses, developed recreational park uses or undeveloped recreational park uses rather than for unrestricted use by a resident farmer. Additionally, Objective 3 does not anticipate on-property groundwater use for potable purposes under any of the industrial or recreational scenarios. Groundwater use at locations within the property boundary is therefore subject to restrictions even though it is available for use at all points off property.

Remediation of the Great Miami Aquifer under Land Use Objective 3 is governed by the need to protect the Great Miami Aquifer as a sole-source aquifer, and the need to make it suitable for off-property domestic consumption. As a result, maximum concentration levels (MCLs) essentially define the cleanup goals for the Great Miami Aquifer. (A more detailed discussion of the PRL development for the Great Miami Aquifer appears in Appendix C.)

Groundwater remediation under Land Use Objective 3 differs from Objective 2 chiefly with respect to perched groundwater. Under Objective 2 all perched groundwater zones with a potential yield of 1 gallon per minute (gpm) or greater will be remediated. Under Objective 3, of the perched groundwater zones with a potential yield of 1 gpm or greater, only those that also have contaminant concentrations greater than the PRL that is protective of the Great Miami Aquifer and surface water will be remediated. The use of on-property groundwater is thus restricted under this land use objective. Any future use of the groundwater would have to be preceded by a verification of the groundwater quality at the point of use.

Like Land Use Objective 2, the expanded trespasser is used to establish protective levels for the restricted waste management area and the off-property resident farmer is used for the off-property protective levels; unlike Objective 2, Land Use Objective 3 uses industrial and recreational receptors to establish on-property protective levels for the areas outside the waste management area.

4.1.2.4 Land Use Objective 4: Restricted Use of the Entire On-Property Area

This land use objective examines the potential cost advantage of limiting remediation to a minimal level of cleanup, and limiting on-property disposal to the least contaminated materials while emphasizing the use of off-property disposal.

Like Objectives 2 and 3, Land Use Objective 4 manages contaminated soil on property in a consolidated waste management area for which access and institutional restrictions are implemented.

In contrast to Objectives 2 and 3, the intention is to limit access to the property. Additionally, as with Objective 3, Land Use Objective 4 does not anticipate on-property groundwater use for potable purposes. Groundwater use at locations within the property boundary is therefore subject to restrictions, even though it is available for use at all points off property.

While the intent of this land use objective is to implement a remedy which is protective of an expanded trespasser, it should be recognized that large portions of the FEMP currently exhibit actual measured soil contaminant concentrations which could viably be protective of other alternative land uses requiring less strict access restrictions. These alternative land uses, including commercial/industrial or recreational use, could be considered for application to select portions of the FEMP property under this land use objective. Alternative land uses would be based upon an evaluation of the actual concentrations of contaminants present, the nature of administrative controls necessary, and the results of ongoing environmental monitoring that would be conducted as part of this land use objective.

Unlike the other objectives, Land Use Objective 4 uses the expanded trespasser to establish protective levels for the full 1050-acre on-property area. The resident farmer is used to establish protective levels for all off-property areas, as is the case for the other land use objectives.

4.1.3 Waste Acceptance Criteria

The term waste acceptance criteria (WAC) refers to the maximum contaminant concentration a material may exhibit if it is to be acceptably disposed of in a particular manner. The numerical value of a WAC is specific to the material being disposed, the contaminant, the mobility of the contaminant in the material, the method of disposal, and the degree to which the disposal method must protect the human or environmental receptors from additional exposure to the contaminant. For the Operable Unit 5 FS, the materials of greatest concern are soil and sediment. For soil and sediment, Section 3.0 examines two categories of disposal, on property and off site. With respect to on-property disposal as discussed in Section 2.0, the potential methods of disposal include an engineered cell, a consolidation area with a multilayer cap, or a consolidation area with an earthen cover.

As described in Section 2.0, PRLs ultimately determine the volume of soil and sediment which must be remediated to reduce in-place soil and sediment contaminant levels to concentrations resulting in acceptable human health and environmental risks. After determining the soil and sediment volume requiring remediation, that volume is allocated among the disposal options available within a given remedial alternative by comparing the WAC for each disposal option to the contaminant concentrations in the remediated and segregated soil and sediment (while also considering the mobility of the contaminant in the soil and sediment).

The process used for developing WAC relies on fate and transport modeling and is described in detail in Appendix F, Section F.5.0. In summary, WAC development begins by determining the contaminant levels that are acceptable in environmental media at the point of human or environmental receptor exposure (e.g., MCLs at any point in the Great Miami Aquifer), then back calculating the WAC value. The calculation simulates the movement of contaminants between the source and the receptors as they travel through environmental media while considering factors such as leaching potential, solubility, mobility of different contaminants, infiltration rates, etc., to determine the source contaminant concentration resulting in no more than the desired maximum concentration at the point of exposure over a 1000 year duration. The 1000 year duration was adopted as the upper bound of the design performance period based on the 200 to 1000 years design period identified in 40 CFR 192.02 for the disposal for mill tailings. In the case of WAC determined for an engineered disposal cell, the final value of the WAC may be adjusted by incorporating modifications to the engineering controls (e.g., additional impervious layers/liners, greater compaction of clay and soil layers to reduce permeability, etc.,) for the cell design to additionally inhibit the movement of contaminants through the transport path to the receptors.

Section F.5.0. details the development of WAC and estimates of soil and sediment volumes to be allocated among disposal options for on-site disposal components included in potential remedial alternatives for soil. The resulting WAC for each remedial design component are shown by constituent of concern in Table 4-1 and in Appendix F. For the purpose of comparison, the table also shows the maximum detected soil concentration of each constituent of concern as detected during the Operable Unit 5 remedial investigation (RI).

Operable Unit 2's feasibility study and remedy selection process proceeds Operable Unit 5 by approximately 6 months. A comparison was made between the total uranium WAC developed for Operable Unit 2's preferred remedy (on-site disposal in an engineered disposal facility) and the total uranium WAC for this same category of alternative developed through Operable Unit 5. The total uranium WAC of 1080 ppm for Operable Unit 2's preferred remedy is slightly greater than the 1030 ppm WAC developed for the more leachable ($K_l = 15$) soil found within Operable Unit 5 (shown in Table 4-1 and Appendix F). For consistency, the EPA and OEPA require adoption of the 1030 ppm WAC developed through Operable Unit 5 as the maximum WAC to be carried forward for detailed site-wide evaluations of the on-site engineered disposal facility alternative.

WAC for off-site disposal is discussed in Appendix E. Most of the contaminated soil excavated during remediation activities will be well below the WAC for off-site disposal with the exception of soil containing hazardous wastes such as oil, grease and PCBs; such soil would require treatment before shipment. Generally the off-site disposal WAC for specific metals (e.g., uranium) are several times higher than the WAC for on-property disposal.

TABLE 4-1
OPERABLE UNIT 5 FEASIBILITY STUDY
WASTE ACCEPTANCE CRITERIA

Constituent of Concern	Protectiveness Criteria for Great Miami Aquifer	Unit	Disposal Facility	Consolidation Area With a Multilayer Cap	Consolidation Area With an Earthen Cover	Max Detection in Soil 0-1.5 ft Depth[a]	Max Detection in Soil >1.5 ft Depth[b]
Radionuclides:							
Neptunium-237	CR[c]=1×10^{-5}	pCi/g	3.12×10^{9}	1.06×10^{8}	2.99×10^{2}	2.63×10^{0}	3.05×10^{-1}
Strontium-90	CR=1×10^{-5}	pCi/g	5.67×10^{10}	3.04×10^{9}	8.55×10^{4}	2.63×10^{1}	4.76×10^{1}
Technetium-99	CR=1×10^{-5}	pCi/g	2.91×10^{1}	2.91×10^{1}	1.47×10^{1}	6.02×10^{2}	2.05×10^{2}
Total uranium - insoluble (K_l=325)[e]	MCL	mg/kg	2.24×10^{4}	2.27×10^{3}	4.42×10^{1}	8.58×10^{1} [d]	4.56×10^{1} [d]
Total uranium - soluble (K_l=15)[e]	MCL	mg/kg	1.03×10^{3}	1.05×10^{2}	2.04×10^{0}	9.04×10^{4}	6.93×10^{4}
Organics:							
1,2-Dichloroethane	MCL	mg/kg	f	f	5.85×10^{3}	2.00×10^{-3}	1.00×10^{-2}
Carbazole	MCL	mg/kg	7.27×10^{4}	1.22×10^{4}	1.80×10^{0}	N[g]	4.56×10^{1}
Vinyl chloride	MCL	mg/kg	1.51×10^{0}	8.17×10^{-1}	1.85×10^{-2}	N	1.10×10^{-1}
Bis(2-chlorisopropyl)ether	CR=1×10^{-5}	mg/kg	2.44×10^{-2}	2.44×10^{-2}	1.42×10^{-2}	4.80×10^{-2}	N
Alpha-chlordane	MCL	mg/kg	2.89×10^{0}	1.38×10^{0}	7.98×10^{-2}	9.70×10^{-3}	N
Bromodichloromethane	MCL	mg/kg	9.03×10^{-1}	8.90×10^{-1}	5.31×10^{-1}	N	1.30×10^{-2}
4-Nitroaniline	HQ[h]=0.2	mg/kg	4.42×10^{-2}	4.37×10^{-2}	2.80×10^{-2}	3.30×10^{-1}	N
Inorganics:							
Boron	HQ=0.2	mg/kg	1.04×10^{3}	5.11×10^{2}	1.57×10^{1}	1.43×10^{1}	N
Magnesium	HQ=0.2	mg/kg	f	6.08×10^{5}	2.53×10^{3}	6.53×10^{4}	9.32×10^{4}
Mercury	MCL	mg/kg	5.66×10^{4}	9.72×10^{3}	7.01×10^{-1}	6.30×10^{0}	2.30×10^{0}
Chromium VI	HQ=0.2	mg/kg	f	f	6.81×10^{2}	8.01×10^{1} [i]	1.15×10^{2} [i]

a From Final OU5 RI Report, Table 4-14, March 1995.
b From Final OU5 RI Report, Table 4-15, March 1995.
c CR = Cancer risk
d From total uranium data collected outside of the former production area.
e K_l = Leachability coefficient
f Compound will not exceed designated Great Miami Aquifer action level within the 1000-year performance period, regardless of starting concentration in the disposal facility. See Appendix F, Section F.5.I.5.6, for a discussion of best management practices for these compounds.
g N = Not analyzed, or analyzed and not detected.
h HQ = Hazard quotient
i [illegible]ed for total chromium.

4.1.4 Perched Groundwater Remedial Strategy

The remedial strategy for contaminated perched groundwater employs a two-tiered approach to respond to the limited and variable water yield capabilities of the perched groundwater system underlying the FEMP. Under this strategy, a sustainable water yield criterion of 1 gpm has been adopted to establish the extent, location, and protective cleanup levels for those higher yielding perched zones that could hypothetically be used for future domestic water supply. Under Land Use Objectives 1 and 2, which both contemplate the presence of an on-property future residential groundwater user, the perched groundwater zones which yield 1 gpm or greater would be remediated to PRLs that are consistent with the potential future use of these higher yielding zones as a drinking water supply. For the remaining lower yielding perched zones (providing less than 1 gpm yield), remediation would be accomplished to satisfy cross-media-based PRLs which, by definition, are protective of the underlying Great Miami Aquifer and protective of surface water resources that could receive contaminated perched groundwater discharge within the 1000-year performance period adopted for the FEMP RI/FS process. For Land Use Objectives 3 and 4, which do not contemplate the presence of an on-property residential groundwater user, both the higher and lower yielding zones would be remediated only as required to satisfy the cross-media-based PRLs.

As part of the technology screening process presented in Section 3.0, two hydraulic removal options (extraction wells and trenches) and one physical removal option (soil excavation) were retained as potentially viable process options for achieving perched groundwater remediation goals. In order to select from among these viable options, computer modeling simulations were performed to further evaluate the projected performance of the hydraulic options, and to identify the restoration time frames required to restore the contaminated zones to their respective cleanup levels by pump-and-treat technologies. A variety of different extraction well and trench configurations and spacing intervals were examined in the simulations, the results of which are provided in Appendix F.

The computer simulation results indicate that regardless of the extraction approach (trenches or wells) and the cleanup goals desired (cross-media-based PRL or the drinking water-based PRLs for the higher yielding zones), restoration time frames greater than several hundred years would generally be necessary to restore the perched groundwater system through pump-and-treat technologies. These projected remediation time frames, which are controlled by the low permeabilities and the discontinuous nature of the perched groundwater system, would require groundwater treatment capacity to extend well beyond the 30-year design life of all treatment plant options under consideration in the FS. Replacement plants would be required for many years into the future to satisfy long-term perched groundwater pumping and treatment needs. Based on the lengthy time requirements for remediation (several hundred years) coupled with the need for replacement groundwater treatment plants over the long term, soil excavation was selected over hydraulic removal as the representative process option for addressing contamination in the perched groundwater system.

Soil excavation will also provide for a more certain and more verifiable perched groundwater remediation strategy in view of the discontinuous, heterogeneous character of the perched groundwater system.

Under the perched zone excavation strategy, the lower yielding (less than 1 gpm) perched zones that exceed cross-media-based PRLs would be excavated coincident with and as a natural consequence of the subsurface soil excavation process. Lower yielding zones that do not exceed cross-media-based PRLs would remain in place, because the concentration levels that remain within the zones would satisfy protectiveness requirements for the Great Miami Aquifer and all surface water drainages in hydraulic connection with the perched system. The soil volumes associated with this perched groundwater excavation step are identical for all four land use objectives.

Higher yielding (greater than 1 gpm) zones that exceed cross-media-based PRLs will be excavated identically for all four land use objectives. For the remaining portions of the higher yielding zones that do not exceed cross-media-based PRLs, but are contaminated (or could become contaminated in the future) above established limits for domestic drinking water use, the following land use-specific excavation logic has been applied:

- Land Use Objectives 1 and 2: remove all incremental soil volume occurring within the higher yielding zones (411,000 cubic yards of incremental excavation)
- Land Use Objectives 3 and 4: no additional excavation necessary, because by definition no hypothetical on-property domestic receptors are present under these land use objectives.

For Land Use Objectives 1 and 2, the 411,000 cubic yards of additional excavation will remove: all areas of the higher yielding zones currently contaminated above established drinking water limits and those currently unaffected areas that could become contaminated in the future, within the 1000-year performance period adopted for the FS (which is projected to be the remaining area of the higher yielding zones). By virtue of this excavation, all of the known areas of the perched groundwater system that are capable of supporting 1 gpm or greater yield will be physically eliminated, thus removing as a viable exposure pathway the hypothetical domestic use of the perched groundwater system as a drinking water source.

Consistent with this excavation strategy, Section 2.6 presented the soil volumes and excavation footprints that will be required for all soil, including those associated with the removal of the affected perched groundwater zones.

4.1.4.1 Excavation Approach

All of the perched groundwater excavation, monitoring, and control activities would be implemented in accordance with the conceptual plans for soil excavation presented in the Appendix L remedial component descriptions. Along with storm water, perched groundwater that is encountered during excavation would be collected and treated on site in the advanced wastewater treatment (AWWT) facility as part of this plan.

The component descriptions and cost estimates consider and acknowledge the potential need for shoring, dewatering, and other excavation controls that might be necessary to implement the deeper excavations that occur below the water table in the former production area. Actual requirements for these controls will be defined during remedial design, when the detailed sequencing and implementation plans for soil excavation are prepared.

Following removal, all of the excavated perched zones would be backfilled with low-permeability clay-rich soil to ensure that the excavated zones yield less than 1 gpm following remediation. This measure would provide additional assurance that the higher yielding zones would not be available for consumption over the long term. Lower yielding zones that do not require excavation because of the absence of contamination above cross-media-based PRLs will remain in place at their present yield configurations. If originating on site, the low-permeability clay backfill would be expected to meet the PRLs used to define the respective excavation limits for that location. If necessary, imported fill would be used for backfill.

As discussed in Section 4.1.7, perched groundwater that is intercepted during excavation in the vicinity of the fire training area and the sewage treatment plant (both facilities are designated as RCRA-listed hazardous waste management units [HWMUs]) would be pretreated for listed organic constituents before delivery to the AWWT. This action is necessary to avoid contaminating other AWWT treatment residuals with RCRA-listed constituents. Unlike the HWMUs located within the main process area, the fire training area and the sewage treatment plant HWMUs both contain environmental media contamination that cannot also be attributed to other non-HWMU sources, thus triggering EPA's "contained-in" RCRA listed-waste policy for affected groundwater and soil. As stated in EPA's Contained-In Interpretation Memorandum (November 13, 1986), whenever concentration levels of listed constituents exceed health-based levels, the affected environmental media must be managed as listed hazardous waste. To comply with the expectations of this policy memorandum, the FEMP would adopt the detection limits for the listed constituents (displayed earlier in Table 2-10) to represent the action levels to designate when pretreatment of collected perched groundwater from the excavations in these two areas is required.

4.1.4.2 Remedial Action Footprints

Figure 4-2 illustrates the locations of the higher yielding zones that exceed the 1 gpm criterion and thus could hypothetically be used for domestic supply. The zones that are capable of exceeding the 1 gpm criterion have been identified through hydraulic testing activities conducted as part of the RI. These zones occupy approximately 50 acres (roughly 5 percent) of the 1050-acre on-property FEMP area. For Risk Cases 1 and 2, where the on-property resident farmer is considered, all 50 acres will be excavated during the soil remediation. As indicated earlier, this will eliminate the presence of the known higher yielding zones that provide greater than 1 gpm yield. For the remaining risk cases (3 through 8), approximately 80 percent of the higher yielding zones require excavation to satisfy cross-media-based PRLs.

Also as indicated earlier, the less than 1 gpm perched zones will be excavated as a natural consequence of the subsurface soil excavation process and are thus included in the risk-based excavation footprints and soil volumes established for subsurface soil. The delineation of these footprints and the determination of the accompanying soil volumes is discussed in Section 2.0.

4.1.4.3 Verification and Certification Sampling Activities

Remedial action footprints and excavation volumes designated in this FS are developed for cost estimating purposes and to facilitate comparisons among alternatives. As part of remedial design/remedial action (RD/RA) activities, verification sampling will be conducted before and during remedial actions to confirm the locations of excavation footprints, resolve outlier data, and to guide process as it proceeds in the field. A description of the verification sampling program is contained in the component description for soil excavation in Appendix L. The costs for this sampling have been included in the component cost estimates provided in Appendix K.

Physical confirmation of the locations and areal extent of the higher yielding zones that exceed the 1 gpm criterion will also be conducted, as necessary, during remedy implementation. This will be accomplished through additional aquifer yield tests to support the existing tests and areal boundaries determined through the RI investigations. Costs for additional tests have been included in the FS cost estimate to allow for the need to conduct additional confirmatory physical testing.

Certification sampling, which is conducted at the completion of remedial activities, will be necessary to confirm that remedial objectives have been achieved. Through direct measurement of soil concentrations, the certification sampling will confirm that subsurface soil remediation levels have been met. The attainment of perched groundwater remediation levels will be tracked indirectly through the soil analyses and by applying the soil/water partitioning relationships (K_ds) for subsurface soil and perched groundwater. Direct measurement of perched groundwater concentrations outside the excavation areas will also be performed to confirm that the perched groundwater remediation the

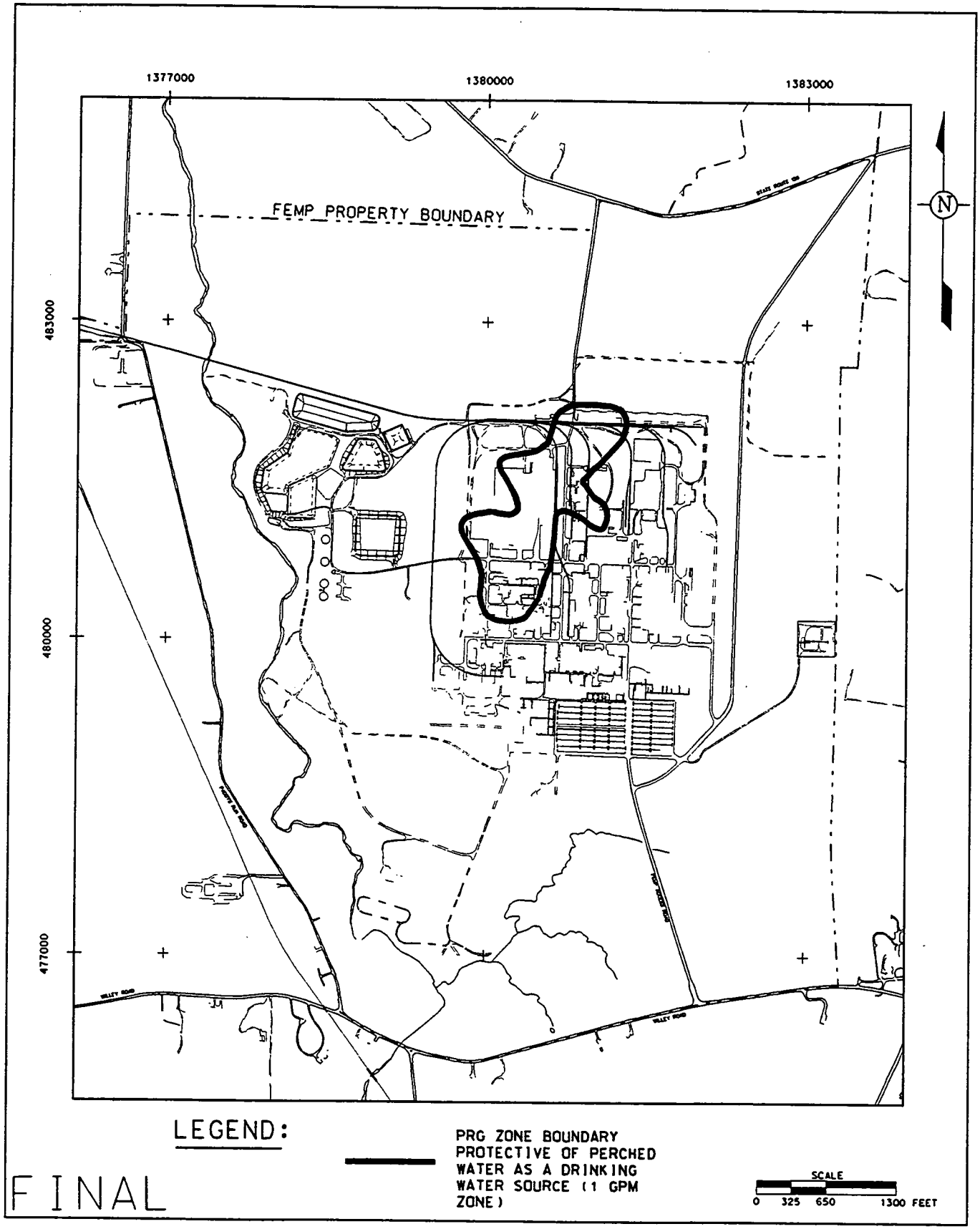


FIGURE 4-2. EXTENT OF PERCHED ZONES EXCEEDING 1 GALLON PER MINUTE CRITERIA

For both the verification and the certification sampling programs, the suite of analytical parameters used to define compliance with remediation levels will include all pertinent constituents of concern (COCs) in addition to total uranium.

4.1.5 Great Miami Aquifer Remedial Strategy

All of the alternatives developed in Section 4.0 will incorporate remedial response measures to address the presence of groundwater contamination in the Great Miami Aquifer. The following three categories of response measures were considered in the identification and formation of a strategy for addressing Great Miami Aquifer contamination:

- Active restoration of on and off-property affected areas
- Containment of all affected areas with off-property groundwater access controls
- Containment of on-property areas and active restoration of off-property areas.

Together with the no-action alternative, these three broad response categories represent the range of GRAs available for controlling or remediating contaminated conditions in the aquifer. Generally, however, the leading remedial strategy for the Great Miami Aquifer, as documented in the Initial Screening of Alternatives for Operable Unit 5 report DOE 1993, EPA, is to implement active restoration of all affected areas of the aquifer. The two containment options, which both employ the use of hydraulic capture to halt the further spread of site-related contaminants, were brought forward for consideration in the FS for comparison purposes and to help frame the overall cost implications of employing the active restoration approach.

Both of the hydraulic containment options -- containment of all affected areas and containment of the on-property area only -- were eliminated as viable technologies during the screening of remedial technologies presented in Section 3.0. The performance evaluations of the containment options, and the technical support for their elimination in favor of the active restoration approach, can be found in Appendix F, Fate and Transport Modeling. Generally, the deciding factors for eliminating the containment options were that: 1) remedial goals would not be achieved within a reasonable time frame (hydraulic containment would be necessary for 75 to 100 years or more under all options) and 2) groundwater treatment capacity (including the need for replacement treatment plants at 35 year intervals) would be required throughout the long-term hydraulic containment period. The modeling simulations demonstrated that active restoration could achieve remedial goals sooner and at equal or lower overall cost when compared to hydraulic containment. All of the alternatives developed in Section 4.0 and carried forward for detailed analysis in Section 5.0 thus incorporate full active restoration as the preferred approach for addressing contaminated groundwater in the aquifer.

An overview of the active restoration approach for remediating the Great Miami Aquifer is provided below.

4.1.5.1 Active Restoration of Affected Areas of the Great Miami Aquifer

Active restoration of the Great Miami Aquifer would be accomplished using a series of modular groundwater extraction well networks and a centralized groundwater treatment facility. Under this strategy, area-specific extraction well networks would be used to remove contaminated groundwater for subsequent treatment at the centralized treatment facility. Each area-specific network would be operated independently and withdrawn from service, as appropriate, once land use-specific remedial goals within an area are achieved. This modular approach, wherein remedial progress and achievement of remedial goals are tracked on an area-by-area, downgradient-to-upgradient basis, has been incorporated identically into all of the alternatives developed in Section 4.0.

The density of well spacings and the intensity of pumping within a specific area would be determined through fate and transport modeling simulations and an assessment of a number of contaminant recovery performance factors, including overall remediation time. The simulations conducted to support the FS-level technical and cost evaluations are contained in Appendix F.

Additional refinements and optimization evaluations, including the consideration of enhancement technologies such as groundwater reinjection and pulse pumping, would be conducted as part of the remedial design process and, as necessary during the ongoing reviews of system operational effectiveness conducted during actual remediation. This is consistent with the performance evaluation strategies outlined in EPA's General Methods for Remedial Operation Performance Evaluations for Pump-and-Treat Remediation. As envisioned in this guidance, once a base case remedy is selected for a site and documented in the Record of Decision (ROD), continuous efforts to promote system performance, assess technological advances, and improve system economics and efficiency should be extended throughout the post-ROD remediation phase. The guidance further envisions the continued improvement of the site characterization database through periodic or opportunistic testing during remediation, to allow refinement of groundwater velocity and flowpath estimates under actual pumping conditions. Such enhancements and refinements are expected as a natural course of events following selection of a base case remedy for the ROD.

The sections below discuss the basis for establishing the Great Miami Aquifer remedial action areas; provide an overview of the anticipated performance considerations and remediation time frames for aquifer restoration; and highlight the verification and certification sampling activities that accompany the restoration activities. The conceptual FS-level engineering design of the Great Miami Aquifer extraction system is described in Appendix L, along with the groundwater treatment component. The

the restoration activities. The conceptual FS-level engineering design of the Great Miami Aquifer extraction system is described in Appendix L, along with the groundwater treatment component. The remedial component descriptions provided in Appendix L serve as the technical basis for the remedial alternative cost estimates provided in Appendix K.

4.1.5.2 Identification of Remedial Action Area Footprints and Groundwater Treatment Levels

The designation of target remedial action areas in the Great Miami Aquifer requires, for remedial planning purposes, consideration of the following factors:

- Identification of contaminant concentration levels that are deemed protective of human health and the environment. Like the situation for soil, EPA can select protective levels for groundwater from a range of regulatory prescribed values. This range includes the 10^{-4} to 10^{-6} carcinogenic risk range levels specified in the NCP, the hazard index value for noncarcinogens as specified in the NCP, and applicable or relevant and appropriate requirement (ARAR)-driven MCLs established under the Safe Drinking Water Act. In response to CERCLA guidance, EPA is generally required to identify cleanup areas and acceptable residual risk levels based on ARAR-based MCLs, unless the cumulative effect of multiple contaminants/multiple exposure pathways indicates that ARAR values are not sufficiently protective. EPA also relies on risk-based values for CERCLA decision making when ARARs are not available for a particular contaminant.

- The need to meet corresponding risk levels for other COCs in addition to uranium. Because uranium is the principal site contaminant present in groundwater, total uranium distributions are used for FS purposes to initially identify remedial action footprints (i.e., "areas of attainment") for the Great Miami Aquifer. The distribution of other contaminants of concern are evaluated in relationship to the uranium footprints initially established. Contaminants that fall outside the uranium footprint (if any) are evaluated through the residual risk assessment iterations conducted as part of the Comprehensive Response Action Risk Evaluation (CRARE) to determine whether the uranium footprint requires expansion to address other COCs. Likewise, other COCs that exist within the uranium footprint are evaluated for their residual risk contributions following the cessation of remedial activities for uranium.

- The need to consider programmatic boundaries created by the presence of the Paddys Run Road Site (PRRS) contaminant plume. For FS purposes, the southernmost boundary of the FEMP Operable Unit 5 plume has been set at the northern boundary of the PRRS plume. This programmatic boundary is used to define the southern limit of the area requiring action as part of the FEMP's Operable Unit 5 response obligation. The northern limits of the PRRS plume has been delineated on the basis of information contained in the draft PRRS RI that was furnished to the Ohio OEPA. All maps depicting remedial areas to be addressed in the Operable Unit 5 FS will acknowledge this administrative boundary. Remediation of the PRRS plume is the subject of a separate CERCLA response action currently under development between the State of Ohio and the PRRS responsible parties. DOE's role and involvement in the cleanup of the PRRS plume (if any) will be defined separately as part of the ongoing identification of PRRS response obligations and in accordance with the PRRS project schedule. The southern extent of groundwater capture created by the FEMP's South Plume Removal Action wells denotes the southern limit of the administrative boundary proposed for the FS.

- The need to consider "current condition" contaminant levels in the Great Miami Aquifer. Monitoring data regarding the distribution of uranium in the Great Miami Aquifer have been collected routinely as part of the RI since 1988. In 1993, a comprehensive "snapshot" well sampling program was instituted to define current conditions in the aquifer for decision-making purposes. The uranium footprints developed in the FS are based on the current condition snapshot results. As part of the RI, comparisons to earlier data were made to substantiate that the 1993 uranium data set is representative for decision making.

Consistent with Operable Unit 5's risk-range approach for establishing remedial action areas, two proposed risk-based remedial action area footprints are identified for the Great Miami Aquifer to assist decision-makers in selecting appropriate groundwater cleanup levels:

- A risk-based footprint corresponding to the 10^{-6} carcinogenic risk level (defined by the 3 ppb unfiltered total uranium contour interval).

- A risk-based footprint corresponding to the proposed 20 ppb Safe Drinking Water Act MCL for uranium (defined by the 20 ppb unfiltered total uranium contour interval).

Both the 3 ppb and the 20 ppb contour intervals include the incremental 1.2 ppb uranium concentrations attributable to natural background, defined in the RI Report (DOE 1995e) as the 95th percentile value of the background data collected for the aquifer. Inclusive of background, the 20 ppb proposed MCL aligns closely with the site-specific 10^{-5} aquifer risk level (27 ppb), and for FS planning purposes the MCL and 10^{-5} footprints are considered to be coincident. Development of a higher-bound 10^{-4} risk based footprint (260 ppb) is not an option for the Great Miami Aquifer, since the proposed 20 ppb MCL represents a to be considered (TBC) upper limit requirement adopted for defining the Great Miami Aquifer cleanup goal.

Figure 4-3 denotes the 3 ppb and 20 ppb perimeters for the Great Miami Aquifer as indicated by the 1993 data set. As illustrated in the figure, the capture zone created by the South Plume Removal Action wells has been designated as the southern (administrative) limit of the Great Miami Aquifer remediation area.

As was discussed earlier in the development of the risk-based cases for each land use objective (see Section 2.7), the 3 ppb uranium 10^{-6} risk-based footprint will be used to define the corresponding Great Miami Aquifer remedial action area for all land use scenarios that contemplate restoring affected areas of the FEMP to conditions allowing for residential farming at a 10^{-6} protective level. For the remaining land use scenarios that contemplate either higher cleanup levels or nonfarming land uses, the 20 ppb uranium (proposed MCL) remedial footprint has been used to define the corresponding action area.

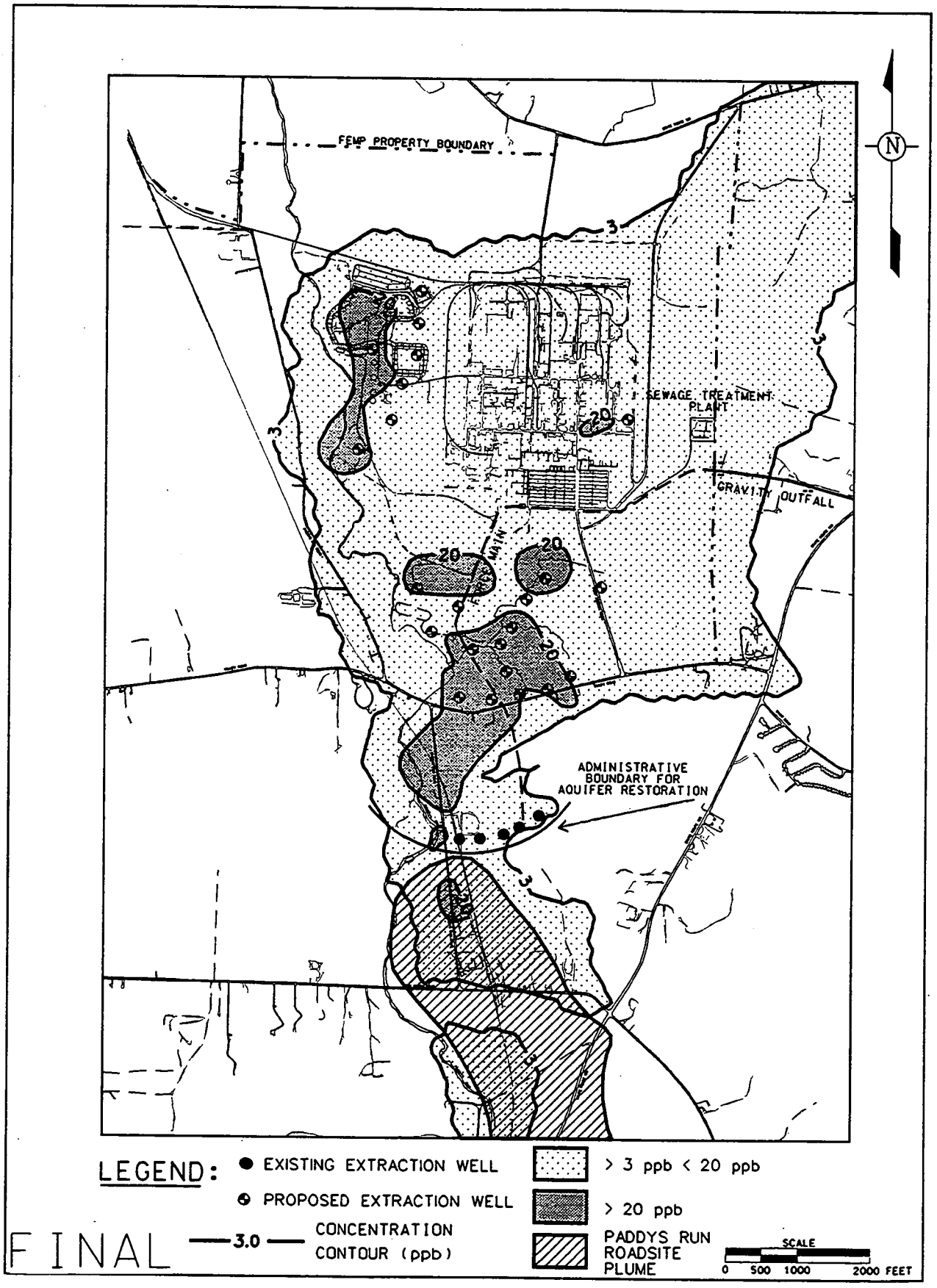


FIGURE 4-3. TARGET AREAS FOR GREAT MIAMI AQUIFER RESTORATION

For the development of the initial base case remedy, similar logic is also applied in the alignment of remedial action footprints with the designation of treatment levels for the contaminated groundwater extracted from the footprints. For the base case scenarios that employ the 20 ppb risk-based footprint, all extracted groundwater that exceeds 20 ppb uranium concentration levels is assumed to be treated before discharge; once contaminant levels in the aquifer fall below 20 ppb of uranium, both extraction and treatment is assumed to be discontinued. For the scenarios that employ the 3 ppb uranium footprint, groundwater will be treated to meet best demonstrated available technology (BDAT) levels for the groundwater treatment facility (currently estimated at approximately 5 ppb of uranium). As with the 20 ppb of uranium proposed MCL case, treatment and extraction will be discontinued once the 3 ppb remedial goal is achieved in the aquifer. For both remedial area footprints, decisions to terminate extraction will be made on an area-by-area basis as each extraction well network reaches respective (as measured in the aquifer) target cleanup concentrations. As indicated in the next section, if at some point in the future target concentrations cannot be achieved in the aquifer because of technology-imposed limitations, a technical impracticability waiver may be required from EPA to discontinue further operations or modify the remedial approach.

As presented in Section 4.1.5.6, the base case remedy of 20 ppb underwent an optimization evaluation to develop additional extraction and treatment scenarios for consideration by EPA.

4.1.5.3 Remedy Performance Analysis

Using the remedial action footprints and treatment goals described above, groundwater modeling was performed to locate and size the groundwater extraction systems necessary for aquifer restoration. Six different active restoration scenarios were initially simulated to evaluate plume capture, uranium removal rate, system efficiency, and the resulting extent and distribution of uranium contamination in the aquifer at various future points in time. These initial simulations were used to develop a baseline system for the 20 ppb plume, from which additional sensitivity evaluations and the remedial requirements for the 3 ppb plume could be identified.

The results of the six initial simulations are presented in Appendix F. From the conceptual design basis provided by these simulations, representative extraction systems were developed for both the 3 ppb and the 20 ppb plumes. The representative system for the 20 ppb case consists of four area-specific extraction well networks (28 wells total) and a total system pumping rate of 6300 gpm. The southernmost network of the system is comprised of the five extraction wells now in place as part of the South Plume Removal Action, which began operation in September 1993 and presently pump at a combined rate of 1500 gpm. The remaining three networks are located within the on-property area. Other than the existing South Plume Removal Action wells, no new off-property extraction wells will be required as part of the representative 20 ppb system.

The modeling simulations for the representative 20 ppb system indicate that uranium cleanup can be accomplished within 30 years, at which time proposed MCL concentrations for uranium will be achieved throughout the 20 ppb footprint. Sensitivity runs (conducted by varying extraction rates, storm sewer outfall ditch surface water loading, adsorption and desorption distribution coefficients (K_ds), and off-site production well pumping rates) indicate that remediation times as high as 70 to 80 years (55 years for the representative upper bound K_d = 12 case) could be required if conditions deviate from those selected as representative for the base case system. For FS planning purposes, the base case simulation results were used to develop groundwater treatment plant requirements, identify operational durations, and prepare FS-level cost estimates.

Once the proposed MCL for uranium is reached at 30 years, it is assumed that groundwater extraction and treatment will no longer be required and the site will enter into long-term postremediation monitoring (with an assumed duration of 50 years for cost estimating purposes). Costs for the long-term monitoring have been included in the cost estimates supplied in Appendix K.

The modeling simulations for the base case 3 ppb system indicate that the 28 well locations identified for the 20 ppb system would also be satisfactory for capturing and restoring the 3 ppb plume, with the exception that two additional deeper wells and one additional shallow well would be necessary in the vicinity of the Operable Unit 2 South Field area. The two additional deeper wells are needed to address uranium contamination in the deeper reaches of the aquifer that occurs at less than 20 ppb but greater than 3 ppb concentration levels. Pumping rates needed to provide the additional vertical and lateral capture to encompass the larger 3 ppb plume increase from 6300 gpm (the 20 ppb system rate) to 7500 gpm. The 7500 gpm rate is the maximum rate that the planned groundwater treatment facility would be expected to accommodate.

The modeling simulations indicate that a remediation time of 75 years would be required to achieve remedial goals for the 3 ppb base case system. Sensitivity runs, conducted identically as those for the 20 ppb case, indicate that remediation times of 100 years or greater may be necessary to achieve the 3 ppb remedial target concentrations throughout the affected area, if conditions deviate from those selected as representative for the base case system. For the upper bound (K_d = 12) conditions, the simulations indicated that recovery rates begin to approach asymptotic conditions at approximately 75 to 80 years. As with the 20 ppb case, the representative base case simulations were used to develop FS-level cost estimates and treatment requirements.

Appendix F includes full discussions of all the modeling simulations highlighted above. Technical support for the selection of the representative input parameters (used to conceptually design the base case systems and prepare the FS-level cost estimates) is also provided in the appendix.

In the event that during actual remediation it is not possible to obtain target remedial goals for uranium (or other COCs occurring within the uranium footprint), the FEMP may need to propose the use of asymptotic recovery limits (as determined through negotiations with EPA and the application of enhancement technologies as necessary) as the ultimate basis for system shutoff. For example, the modeling projections presented in Appendix F show that asymptotic recovery conditions may occur for other, nonuranium COCs (notably radium, manganese, and arsenic) that reside within the 20 ppb uranium footprint. The residual risks posed by these constituents following the 30-year uranium recovery period are discussed in the CRARE presented in Appendix H.

For the 20 ppb footprint, the FEMP may need to ultimately seek a technical impracticability determination if, at some point in the future, the groundwater cannot be restored to below the 20 ppb proposed MCL before recovery conditions become asymptotic, or if other COCs cannot be reduced below their MCLs in a reasonable time frame (to be negotiated with EPA) before conditions become asymptotic for these contaminants. While the FS simulations indicate that the below 20 ppb total uranium concentration threshold is an appropriate proposed restoration goal for the ROD, the simulations also indicate that asymptotic-based limitations may ultimately be a practical reality to what can be achieved. These technical limitations will also need to be recognized in the ROD.

4.1.5.4 Geographic Outliers and Anomalies

The capture zones evaluated through the modeling simulations are effective at capturing FEMP contaminants occurring within the respective 20 ppb and 3 ppb total uranium footprints indicated earlier in Figure 4-3. The capture zones proposed for each of these footprints can be found in Appendix F.

Above-background concentrations have been observed for other, nonuranium constituents in areas outside the respective 20 ppb and 3 ppb capture zones. The RI concluded, however, that these above-background concentrations are attributed to other natural and/or anthropogenic causes. The geographic outliers were in most cases detected in isolated wells further from the site, whereas nearby wells closer to the site indicated background level concentrations. Additionally, most geographic outliers are less than 10 times the corresponding background value. The sporadic and isolated geographic outliers cannot be reasonably attributed to the site, particularly when concentrations of these same constituents adjacent to established point and line sources on property did not reveal characteristic patterns of contamination.

The baseline risk assessment conducted for the RI Report conservatively assumed that all above-background concentrations were site related. Consequently, the baseline risk assessment calculated risk values based on inclusion of geographic outliers. However, the FS uses the conclusions and interpretations set forth in the nature and extent discussion of the RI Report, and does

not assume that all geographic outliers are due to site activities. Best professional judgment based on available data indicates that the nonuranium geographic outliers outside the designated capture zones for the remedial footprints are not attributable to site activities.

These geographic outliers will be subject to future routine monitoring, and will be included as part of the RD/RA verification sampling program (discussed in the next section) conducted to confirm the design-level remedial footprints for the aquifer.

4.1.5.5 Verification and Certification Sampling Activities

The remedial action footprints designated in this FS are developed for cost estimating purposes and to facilitate comparisons among alternatives. Similar to what is necessary for soil and perched groundwater, verification sampling will be conducted as part of RD/RA activities to confirm the locations of the areas requiring action; resolve outlier data; and to guide the remediation process as it proceeds in the field. The costs for verification activities have been included in the component cost estimates provided in Appendix K.

Certification sampling, which is conducted at the completion of remedial activities, will be necessary to confirm that remedial objectives (or asymptotic limitations) have been achieved. The costs associated with certification sampling have been included in the component cost estimates provided in Appendix K. For both the verification and the certification sampling programs, the suite of analytical parameters used to define compliance with PRLs will include all of the COCs in addition to total uranium.

4.1.5.6 Results of Optimization Evaluations

The 20 ppb proposed MCL aquifer restoration system described in the previous subsections centered on the concept of treating all groundwater extracted from the aquifer before discharge to the Great Miami River, regardless of the composite uranium concentration level in the extracted groundwater delivered to the treatment facility. This requirement resulted in a baseline MCL-based system that would require an extraction and treatment capacity of 6300 gpm and which is projected to cost about $304 million (present worth costs). Approximately 9 percent of the costs are associated with the extraction operations and 91 percent are associated with the treatment requirement.

On February 22, 1995 a meeting was held with EPA and OEPA to identify and discuss the expected performance of additional options for treating extracted groundwater recovered from the aquifer. A groundwater restoration optimization study, presented in Appendix F.8, was conducted to examine extraction efficiencies and to evaluate a suite of treatment options for uranium that could also satisfy regulatory requirements and discharge limits. The extraction scenarios examined through the optimization study included:

- Constant extraction (6300 gpm)
- Time-varying extraction (6300 gpm maximum)
- Sequential extraction (4000 gpm maximum)

The treatment scenarios for uranium examined through the optimization study included:

- Treatment of all extracted groundwater
- Treatment of all groundwater greater than 20 ppb uranium (at any wellhead)
- Treatment of all groundwater greater than 5 ppb uranium (at any wellhead)
- Treatment of all groundwater greater than 20 ppb uranium (at any wellhead) up to the existing available groundwater capacity at the AWWT facility (800 gpm)
- Treatment of all groundwater greater than 20 ppb uranium (at any wellhead) up to the future expandable groundwater capacity of the AWWT facility (estimated at 1500 gpm).

The results of the optimization study indicated that the 4000 gpm sequential extraction scenario, coupled with the treatment of all extracted groundwater up to the future expandable capacity of the AWWT facility, can effectively:

- Restore the affected portion of the Great Miami Aquifer to MCLs or equivalent protective requirements within a reasonable time frame (i.e., less than 30 years)
- Comply with all promulgated regulations and permits granted by the EPAs regarding risk-based concentration levels and discharge limits for the Great Miami River
- Comply with all the negotiated mass-based discharge limits and continuously reduce the discharge rate of uranium to the Great Miami River during the course of the site remediation
- Comply with all relevant DOE Orders (e.g., Derived Concentration Guide, DOE Order 5400.5)

The specific performance measures of this approach for uranium are summarized below:

- Restore the Aquifer in 27 years
- Estimated maximum outfall concentration: 16 ppb
- Estimated average outfall concentration: 11 ppb
- Estimated annual peak mass loading rate to river: 423 lbs/yr (including 150 lbs/yr from the collection, treatment, and discharge of surface water and process wastewater)

- Estimated average mass loading rate to river: 307 lbs/yr (including 150 lbs/yr from the collection, treatment, and discharge of surface water and process wastewater)
- Estimated cost (present worth dollars): $ 167 million.

The extraction strategy comprises four extraction systems (a total of 28 extraction wells) pumping a total of approximately 4000 gpm of Great Miami Aquifer groundwater through the year 2020. This case uses an approach with sequenced pumping of different plume areas. As areas of the aquifer are restored to the 20 ppb level, extraction systems are turned off (in the computer simulations) and the pumping rates redistributed to other systems, maintaining a near-constant 4000-gpm total extraction rate. Individual well-pumping rates vary from 160 gpm to 500 gpm. The total extraction rate is 2000 gpm for the first five years of operation, 4000 gpm from Year 5 to Year 20, and then gradually decreases to zero flow at Year 27 once the 20 ppb target concentrations are met throughout the aquifer.

Under the treatment strategy, recovered groundwater with uranium concentrations exceeding 20 ppb up to a maximum of 1500 gpm (the estimated capacity available for groundwater treatment following expansion of the AWWT facility) will be treated to remove uranium before being discharged directly to the Great Miami River. All other recovered groundwater will be combined with the treated portion (which will exit the treatment facility at concentrations of approximately 5 ppb) and discharged to the Great Miami River. The modeling simulations for the optimization study indicate that treatment of the groundwater will need to occur for 20 years to maintain combined concentrations in the outfall line at levels below 20 ppb.

Mass loading rates to the river (from groundwater restoration operations alone) are projected to be approximately 50 lbs/year initially, increasing to a maximum of 273 lbs/year at Year 6, and then reducing continually over the remainder of the remediation period. When combined with the additional mass loading from storm water and process wastewater treatment operations (approximately 150 lbs/yr), the maximum mass loading to the Great Miami River will be less than 600 lb/yr. Additional performance measures of the strategy, including the results of sensitivity runs, can be found in Appendix F.8.

This strategy will be adopted as the representative 20 ppb proposed MCL case and will be coupled with all of the alternatives in the FS that consider restoration of the aquifer to MCLs. All cost estimates (for the alternatives considering restoration to MCLs) employ the adopted strategy. The remaining alternatives that employ the 3 ppb (10^{-6}) case remain unchanged.

4.1.6 Soil and Sediment Remedial Strategy

The remedial strategy for addressing contaminated soil and sediment is comprised of the following major elements:

- Use of total uranium as an indicator constituent to establish the preliminary footprints of excavation for both soil and sediment at various PRLs
- Use of soil PRLs to indicate the areas of sediment in on-property portions of Paddys Run and on-property drainage ditches requiring remedial action
- Use of geostatistical methods (i.e., kriging) to determine the footprint of soil excavation for uranium for each required risk level
- Overlaying the uranium excavation boundaries on the results of the RI to determine any required refinements to the footprints to accommodate other COCs at risk levels equivalent to the respective uranium PRL
- Expanding the volume of soil and sediment requiring remedial action for each risk level to accommodate suspect areas or areas which could not be defined by geostatistical analysis (i.e., contaminated soil below pipelines, soil in containers and piles, and contaminated soil and rubble at the bank of the Great Miami River)
- Estimating the quantity of soil potentially impacted by releases of listed hazardous wastes from HWMUs and petroleum from underground storage tanks
- Including a sampling program in the scope of each remedial alternative, to verify the vertical and horizontal boundaries of soil excavation at a given cleanup level to be conducted as part of RD/RA
- Including a sampling program in the scope of each remedial alternative, to certify, following excavation operations, that cleanup levels had been attained for each constituent.

Available site characterization data collected for surface and subsurface soils and sediment from on-and off-property locations during the RI, Characterization Investigation Study and Litigation Support Study were used to establish the volume of contaminated material at the site. Available concentration data for uranium was subjected to geostatistical analysis using an Intergraph-based software system. This geostatistical analysis estimated the site-wide 3-dimensional distribution of uranium concentration in soil and sediment using a kriging technique. More detail on this technique, as it was applied at the FEMP for Operable Unit 5, is provided in Section 2.0.

While the kriging technique was useful in establishing the projected volumes of affected media within the former production area due to air deposition, leaks, spills, etc., and outside the production area as a result of air deposition, the technique cannot properly account for areas where available data are limited or nonexistent. Examples of where the kriging technique could not be used to estimate

volumes of affected media include projected contaminated soil beneath the waste storage pits, the K-65 silos and berms, soil underlying existing piping outside the production area, the contaminated soil and rubble at the bank of the Great Miami River adjacent to the outfall line, and soil in inventory within the former production area in containers and piles. Additionally, the kriging technique could not be used to estimate the volume of media potentially containing RCRA-listed wastes or the quantity exceeding RCRA characteristic waste concentrations. Further, the kriging technique could not be employed to estimate the volume of soil impacted by releases from underground storage tanks. To determine the volume of impacted media related to each of these issues, estimates were completed on the basis of available information and best engineering judgment.

The distribution of the other Operable Unit 5 COCs in soil and sediment were compared to the vertical and horizontal boundaries of uranium contamination as established by the geostatistical analysis. On the basis of available data, the boundaries of the concentrations exhibiting an ILCR of 10^{-6} for each of these COCs was found to be contained within the footprint of the area exhibiting a greater than 10^{-6} ILCR for uranium in soil and sediment under the full unrestricted future land use (residential farming) scenario. Visual evaluation of the isopleth maps for these COCs provided in the Operable Unit 5 RI Report (DOE 1995e) was conducted to determine if the same trend existed for the other risk cases under evaluation for each of the land use objectives. For Risk Cases 2 through 8, the uranium footprints required expansion to address nonuranium COCs. This can be seen from the color overlays provided in Section 2.13. The soil volumes and footprints of excavation were adjusted as necessary to ensure that the corresponding PRLs for these COCs at equivalent risk levels were within the boundaries of excavation.

A risk management approach for protecting natural resource areas from disturbance was adopted for Land Use Objective 3, because this objective does not contemplate returning the site to a condition allowing for residential farming. Under the risk management approach, the natural resource areas (all wetlands, forested areas, and the riparian corridor along Paddys Run) would not be disturbed, except where necessary to remove ALARA-based uranium hot spots that are detectable with hand-held instruments (approximately 50 ppm total uranium). Once hot-spot criteria are met, the remaining concentrations in the resource areas would be at levels that satisfy cross-media impact considerations.

The soil and sediment excavation footprints and depths determined through the above process were used to determine the soil volumes that require disposition through the range of technology-based alternatives developed later in Section 4.0.

4.1.6.1 Designation of Principal Threat Materials for Operable Unit 5

In the preamble to the NCP, EPA provided a balance between the statutory preference for treatment of all materials to the extent "technically feasible" and the ability to rely on the "use of engineering

and institutional controls" for managing risk (55 Federal Register 8701, March 8, 1990). EPA specifically recognized the difficulties presented by its preference for treatment of all contamination, indicating that it expects to place a priority on the use of treatment to address the principal threats posed by a site, wherever practicable. For wastes that pose a relatively low long-term threat or where treatment is impracticable (commonly termed secondary threat materials), EPA expects to use engineering controls or a combination of engineering and institutional controls where appropriate.

From a site-wide perspective, the FEMP has identified the source materials contained in the waste pits (Operable Unit 1), the source materials contained in the silos (Operable Unit 4), and the inventoried process residuals and legacy wastes in the production area as the principal threat materials present at the site. The remedy decisions for these materials include shipment off site and treatment where necessary to meet off-site commercial disposal facility WAC. Thus, the preferred remedy for these principal threat materials does not include on-property disposal. The remaining materials (Operable Unit 2, Operable Unit 3 buildings and equipment, and the contaminated environmental media in Operable Unit 5) represent the secondary threat materials when considered in a site-wide context. These materials are the high volume, relatively lower long-term threat materials when contrasted against the low volume, high toxicity wastes contained in Operable Units 1, 4, and the process area waste inventories.

To assist in the designation of principal and secondary threat materials specific to Operable Unit 5, the FS is adopting the concept of on-site WAC - for those alternatives contemplating on-site disposal - as the primary criterion for identifying Operable Unit 5's principal threat materials. For a given alternative, those excavated materials that cannot meet the waste acceptance criteria would be deemed principal threat materials. By virtue of exceeding the waste acceptance criteria, these materials would require off-site disposal or, if at some point in the future a treatment technology becomes available to cost-effectively meet the WAC, they would be treated before disposal. This designation would thus provide that the low volume, relatively higher threat materials within Operable Unit 5 be treated or otherwise managed off site, separate from the high volume, relatively lower threat materials within the unit.

Designation of the Operable Unit 5 materials in this manner is consistent with the expectations and intentions of the principal threat material handling requirements envisioned in the NCP, and conforms to the site-wide strategy of sending those materials off site that are found to be inappropriate for on-site disposal given the site-specific constraints that are present at the FEMP.

4.1.6.2 Strategy for Managing Excavated Materials Contaminated with RCRA-Regulated Constituents

As part of its response obligations under CERCLA, the FEMP is required to make reasonable efforts to determine whether CERCLA hazardous substances detected in environmental media qualify as

RCRA-listed or characteristic wastes, consistent with EPA Directive 9347.3-05FS (Determining When Land Disposal Restrictions (LDRs) are Applicable to CERCLA Response Actions, July 1989). As discussed in Section 1.0, the FEMP has entered into formal discussions with OEPA to document an agreed-upon strategy for coupling OEPA hazardous waste regulations for closure of the FEMP's 53 RCRA-regulated HWMUs within the CERCLA response action process underway at the FEMP.

Representatives from OEPA and DOE are contemplating issuance of directors findings and orders (DFOs) to formally document the integrated strategy. As part of the process, the Operable Unit 5 FS is expected to identify the quantities of environmental media that may be affected with RCRA-regulated constituents and to identify a strategy for managing these materials during the CERCLA remediation effort. The subsections below provide this information.

4.1.6.2.1 Estimated Volume of Soil Containing RCRA Regulated Constituents

The attachments to the draft DFO under discussion between OEPA and DOE cite 15 HWMUs that are believed to have potential RCRA contaminated soil in association with the units (Table 4-2). Ten additional geographic areas located away from the HWMUs (also identified in Table 4-2) have also been identified as having a likely potential for soil contamination with characteristic RCRA waste from production-related processes.

The FEMP's strategy for identifying the volumes of contaminated soil that may be affected with RCRA-listed or characteristic waste is based on the following considerations:

- For FS purposes, the 15 HWMUs identified in the attachment to the draft DFOs are considered to have potential environmental media contamination beneath the units. The remaining HWMUs at the site are located in enclosed buildings, on diked concrete pads, or in lined waste pits and are thus assumed not to have significant environmental media associated with the units. This assumption is for volume-estimating purposes only; verification will be conducted following the decision logic displayed in Figures 4-4 and 4-5.

- For soil-volume estimating purposes, it is assumed that 10 percent of the respective footprint area beneath each of the 15 HWMUs has been affected, to a depth coincident with the estimated excavation depth required for uranium within that area. This assumption will be verified during the remedial action as part of the soil verification and certification process. The intended purpose of the assumption is for cost estimating purposes.

- The RCRA constituents in soil located directly beneath the HWMUs are assumed to be listed wastes (if the basis of the listing of the HWMU was for listed waste) or characteristic waste (if the basis of the listing for the HWMU was for characteristic waste). As part of the FEMP's historical RCRA compliance program, process knowledge and HWMU history were used to determine whether characteristic or listed wastes were managed in the units.

- A soil sampling program will be implemented before excavation (for volume verification purposes) and during excavation (for real-time excavation control) to track the actual presence

TABLE 4-2
SOURCE AREAS FOR SOIL CONTAMINANTS REGULATED UNDER THE RESOURCE CONSERVATION AND RECOVERY ACT

HWMU Source Areas	
Unit Number	Description
1	Fire training facility
10	NAR system components
11	Tank farm sump
14	Box furnace
17	Plant 8 east drum storage pad
18	Plant 8 west drum storage pad
28	Trane incinerator
41	Sludge drying beds
46 - 50	UNH tanks
20	Plant 1 storage pad
22	Abandoned sump west of pilot plant
27	Waste Pit 4 (pending reclassification)
42	Waste Pit 5 (pending reclassification)
51	Experimental Treatment Facility (pending reclassification)
Non-HWMU Source Areas	
	Trap range
	Paddys Run bank rubble pile
	KC-2 warehouse train track
	Coal pile run-off area
	Maintenance building
	Substation
	Incinerator
	North of Plant 6 pad
	Waste pile area

or absence of RCRA-regulated constituents, consistent with the strategies outlined in the next subsection. The estimates provided in the FS are for planning purposes and to develop FS-level cost estimates for remedy comparisons.

In Tables 4-3, 4-4, and 4-5, the 15 HWMUs have been divided further into those that historically contained listed RCRA wastes only, those that contained characteristic RCRA wastes only, and those that contained both categories. Summarized on the tables are the specific RCRA constituents historically associated with each unit and the volumes of affected soil anticipated to be present, using the estimating assumptions outlined above. Similar information is provided in Table 4-6 for the 10 general suspect areas (located away from the HWMUs) where characteristic RCRA constituents are also anticipated. The estimated quantities of affected soil in these suspect areas were identified through the RI soil database by denoting those areas where RCRA constituents in soil exceeded their corresponding regulatory toxicity characteristic leaching procedures (TCLP) levels by a factor of 20. For the HWMUs and the suspect areas, a total of approximately 28,000 cubic yards of soil are estimated to be contaminated with RCRA-listed or characteristic constituents, as summarized in Table 4-7.

During the period 1990 to 1991, 10 underground tanks used to store petroleum products were excavated at the FEMP. The excavation of the tanks and removal of the surrounding soil generated 4140 cubic yards of petroleum-contaminated soil. This material now resides in soil piles located in the former production area north of the boiler plant. Because petroleum contamination surrounding some of the tanks had migrated beneath nearby buildings, not all contaminated soil was removed during tank excavation. It is estimated that an additional 2500 cubic yards of petroleum-contaminated soil remain to be excavated during decontamination and decommissioning of the building structures, yielding a total of 6640 cubic yards of petroleum-contaminated soil. This soil will be treated to meet either on-site waste disposal criteria or off-site disposal requirements, as necessary, consistent with the overall management strategy provided in the next subsection.

As requested by OEPA as part of the DFO discussions, the RCRA-based COCs will not be screened out during the FS process; on-site WAC will be developed for each of the RCRA-based COCs (along with the other CERCLA constituents) for all on-site disposal alternatives contemplated in the FS.

4.1.6.2.2 Compliance With RCRA LDR Requirements During Remediation

The alternatives developed later in Section 4.0 acknowledge the need to comply with RCRA LDR requirements for the excavated materials that contain RCRA-regulated constituents. Different strategies are required for the on-site and off-site alternatives, reflecting the differing requirements imposed by the RCRA LDRs. A summary of the respective strategies is provided

TABLE 4-3

HAZARDOUS WASTE MANAGEMENT UNITS CONTAINING LISTED WASTE TO BE CLOSED UNDER THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

HWMU No./ Identification	RCRA Constituent of Concern	Industry/EPA Hazardous Waste No.	Approximate HWMU Dimensions	Estimated Soil Volumes (yd^3)
41/Sludge drying beds	Perchloroethylene	F002	79 x 92 FT	4300
1/Fire training facility	1,1,1-trichloroethane Toluene	F002 F005	105 x 134 ft 85 x 68 ft	2200
				TOTAL 6500

TABLE 4-4

HAZARDOUS WASTE MANAGEMENT UNITS CONTAINING CHARACTERISTIC WASTE TO BE CLOSED UNDER THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

HWMU No./ Identification	RCRA Constituent of Concern	Industry/EPA Hazardous Waste No.	Approximate HWMU Dimensions	Estimated Soil Volumes (yd^3)
10/NAR system components	Corrosivity (nitric acid) Chromium	D002 D007	13,250 ft^2	25
11/tank farm	Corrosivity	D002	165 x 135	285
46/UNH tanks - NFS storage area	Corrosivity (dilute uranyl nitrate) Barium Chromium	D002 D005 D007	61 x 53	85
47/UNH tanks - north of Plant 2	Corrosivity (dilute uranyl nitrate) Barium Chromium	D002 D005 D007	3 Tanks: 8 ft diam x 8 ft high Containment area: 63 x 40 ft	37
48/UNH tanks - southeast of Plant 2	Corrosivity (dilute uranyl nitrate) Barium Chromium	D002 D005 D007	Tank: 25,000 gal Containment area: 55 x 45 ft	64
49/UNH tanks - digestion area	Corrosivity (dilute uranyl nitrate) Barium Chromium	D002 D005 D007	4 Tanks: 3500 gal; 1 Tank: 23,500 gal; Area: 20 x 127 ft 2 Tanks: 3500 gal; 1 Tank: 23,500 gal; Area: 20 x 127 ft	150
50/UNH tanks - raffinate building (2 locations)	Corrosivity (dilute uranyl nitrate) Barium Chromium	D002 D005 D007	3 Tanks: 8 ft diam x 8 ft high Area: 14 x 50 ft 1 Tank: 2200 gal Area 15 x 30 ft	26
27/Waste Pit 4	Barium chloride	D005	184,000 ft^2 and 30 ft deep	Pending reclassification as a SWMU
42/Waste Pit 5	1,1,1-Trichloroethane	–	170 x 320 x 400 x 320 ft and 24 ft deep	Pending reclassification as a SWMU
51/Experimental Treatment Facility	1,1,1-Trichloroethene	–	20 x 48 ft	Pending reclassification as a SWMU
				TOTAL 670

TABLE 4-5
HAZARDOUS WASTE MANAGEMENT UNITS CONTAINING LISTED AND CHARACTERISTIC WASTES TO BE CLOSED UNDER THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

HWMU No./ Identification	RCRA Constituent of Concern	Industry /EPA Hazardous Waste No.	Approximate HWMU Dimensions	Estimated Soil Volumes (yd^3)
14/Box furnace	Perchloroethylene	F002	18 x 14 ft	10
	1,1,1-trichloroethane	F002		
	Trichloroethylene	F002		
	Barium	D005		
	Chromium	D007		
	Lead	D008		
	Silver	D011		
17/Plant 8 east drum storage pad	Xylene	D001	18,300 ft^2	680
	Ethylbenzene	D008		
	Methyl ethyl ketone	D035		
18/Plant 8 west drum storage pad	Xylene	D001	4,500 ft^2	355
	Ignitable lead (ethylbenzene)	D008		
	Methyl ethyl ketone	D035		
22/Abandoned sump west of pilot plant	Barium	D005	2 ft diam x 14 ft deep	46
	Chromium	D007		
	Lead	D008		
	Mercury	D009		
	Endrin	D012		
	Benzene	D018		
	Perchloroethylene	D039		
28/Trane incinerator	1,1,1-trichloroethane	F002	50 x 52 ft	210
	Lead	D008		
20/Plant 1 storage pad	1,1,1-trichloroethane	F002	480,000 ft^2	8890
	Perchloroethylene	F002		
	Methylene chloride	F002		
	Xylene	F003		
	Barium	D005		
	Lead	D008		
				TOTAL 10,190

TABLE 4-6
SUSPECT AREAS CONTAINING RESOURCE CONSERVATION AND RECOVERY ACT CHARACTERISTIC CONSTITUENTS

Location	RCRA Constituent of Concern	Industry/ EPA Hazardous Waste No.	Approximate Dimensions of Source Area (ft) (number of data points)	Estimated Soil Volumes (Cubic Yards)
Trap range	Lead	D008	Area 1 (north): 15 x 15 (4 pts) Area 2 (south): 160 x 169 (4 pts)	Area 1 (north): 25 Area 2 (south): 2,850
Paddys Run stream bank rubble pile area	Area 1:		Area 1 (north): 10 x 10 (1 pt) Area 2 (south): 10 x 10 (4 pts)	Area 1 (north): 10 Area 2 (south): 37
	Chromium	D007		
	Lead	D008		
	Area 2:			
	Nitrobenzene	D036		
	Hexachlorobutadiene	D033		
	Hexachlorobenzene	D032		
	Heptachlor	D031		
	Heptachlor epoxide	D031		
KC-2 warehouse train	Lead	D008	5 x 400 (4 pts)	225
Coal run-off area	Heptachlor	D031	5 x 5 (1 pt)	4
	Heptachlor epoxide	D031		
Scrap metal pile area	Lead	D008	360 x 540 (6 pts)	7200
	Toxaphene	D015		
	Heptachlor	D031		
	Heptachlor epoxide	D031		
	Methoxychlor	D014		
	Endrin	D012		
North side of maintenance building	Vinyl chloride	D043	5 x 200 (6 pts)	370
	Endrin	D012		
	Heptachlor	D031		
	Heptachlor epoxide	D031		
	Lead	D008		
Substation	Lead	D008	5 x 5 (1 pt)	3
Incinerator	Lead	D008	5 x 5 (1 pt)	3

TABLE 4-6
(Continued)

Location	RCRA Constituent of Concern	Industry/ EPA Hazardous Waste No.	Approximate Dimensions of Source Area (ft) (number of data points)	Estimated Soil Volumes (Cubic Yards)
Boring 1327 (north of Plant 6, Past Warehouse)	Lead	D008	5 x 5 (1 pt)	3
Waste Pile Area	Mercury	D009	5 x 5 (1 pt)	95
				TOTAL 10,825

TABLE 4-7

SUMMARY OF SOIL VOLUMES CONTAMINATED WITH WASTE REGULATED UNDER THE RESOURCE CONSERVATION AND RECOVERY ACT

Description	Estimated Total Soil Volume yd^3
HWMUs[a] with listed waste	6500
HWMUs with characteristic waste	670
HWMUs with listed and characteristic waste	10,190
Non-HWMU areas with characteristic waste	10,825
	TOTAL 28,185

[a] Hazardous waste management units

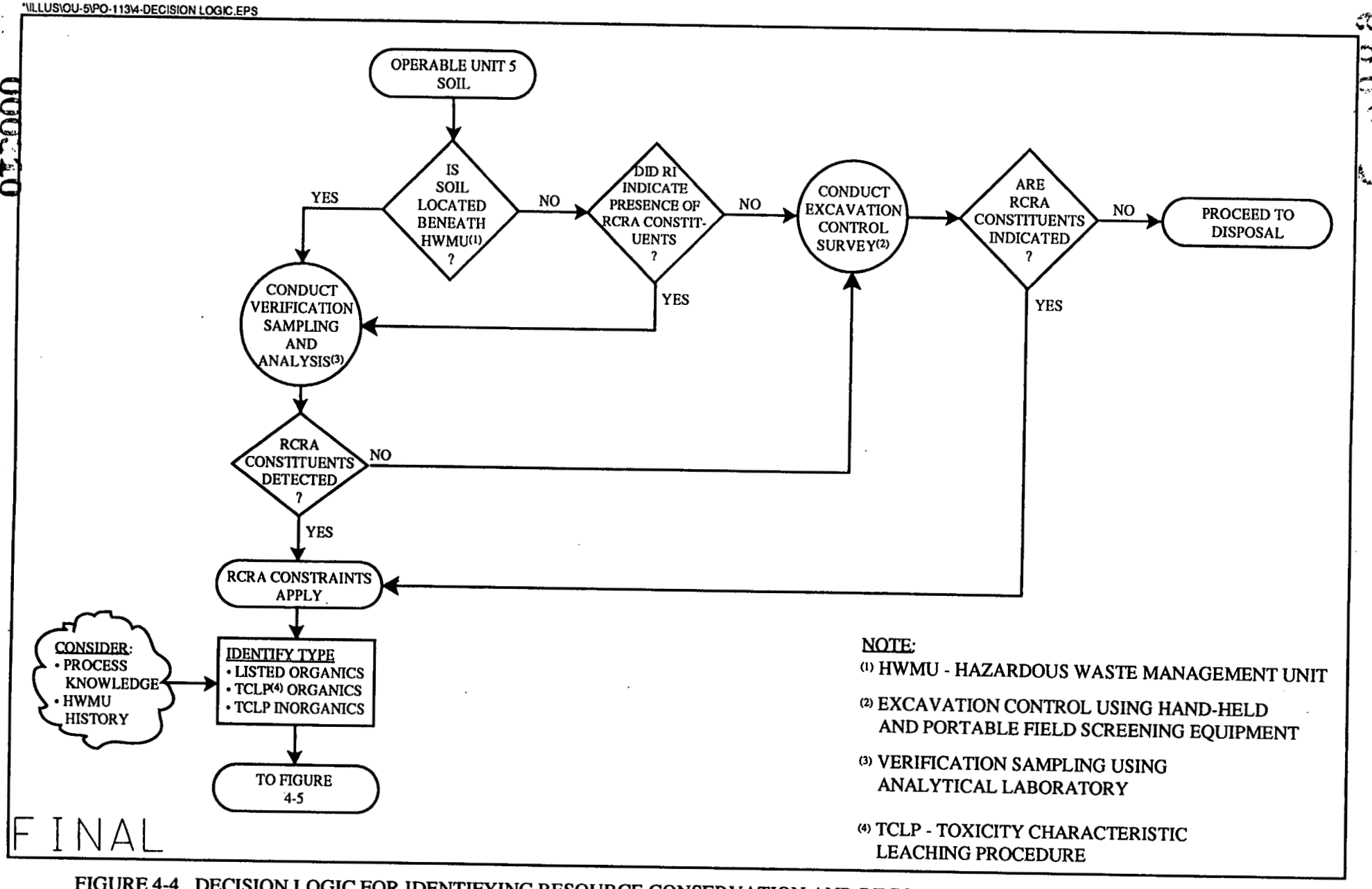
below. Figures 4-4 and 4-5 provide overviews of the RCRA compliance decisions to be made in the field to identify and track the RCRA-regulated constituents, and to implement the key elements of the on-site and off-site strategies.

On-site LDR Compliance Strategy

For the alternatives that contemplate disposal of RCRA-contaminated soil on property, the FEMP would use the RCRA Subtitle C corrective action management unit (CAMU) provisions for defining compliance measures for the LDR requirements. Under this strategy, the excavated soil is considered "remediation wastes" meeting the definition set forth at 40 CFR 260.10. In order to be placed within the respective on-property disposal facility under consideration for each on-site alternative, the excavated soil must meet specific WAC that are deemed protective of human health and the environment. By virtue of their definition as remediation wastes, the excavated soil would not need to meet the specific LDR treatment standards provided they meet the protectiveness requirement for disposal. Materials that do not meet the specific WAC for the RCRA-regulated constituents would thus need to be treated before placement in the facility, or alternatively, sent off site for disposal. This strategy would apply to both listed and characteristic RCRA-regulated constituents present in the Operable Unit 5 environmental media. For the ***nonradioactive*** inorganic constituents, cement stabilization would be used as the representative treatment technology for meeting the respective WAC. For the organic constituents, low temperature thermal treatment would be used as the representative treatment technology. In the event that the treated soil does not attain the WAC, the soil would require off-site disposal.

The CAMU-based approach to satisfying LDR requirements for RCRA-contaminated soil is analogous to the compliance strategy embodied in the "area of contamination" (AOC) concept defined in OSWER Directive 9347.1-02 (Policy for Superfund Compliance with the RCRA Land Disposal Restrictions, April 17, 1989), with the exception that the CAMU provisions allow for locating the management facility in an on-property area adjacent to (rather than immediately within) the area of contamination. In developing the CAMU refinements to the original AOC concept, EPA recognized that locating the facility in an adjacent area (termed a "facilitation area" in the RCRA CAMU provisions) would generally enhance remedy implementation by providing additional working space for the excavation and handling of materials. Other than this location-based modification, the CAMU and AOC concepts envision identical approaches for determining the applicability of LDR requirements for CERCLA actions. Both concepts rely on the concept of "placement" to define when the LDR treatment requirements are applicable for remediation wastes. For the disposal actions that do not constitute placement (and thus do not trigger LDR treatment standards), both the CAMU and the AOC concepts require that the remediation wastes be managed so as to be protective of human health and the environment.

*\ILLUS\OU-5\PO-113\4-DECISION LOGIC.EPS



FINAL

FIGURE 4-4. DECISION LOGIC FOR IDENTIFYING RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)-REGULATED SOIL

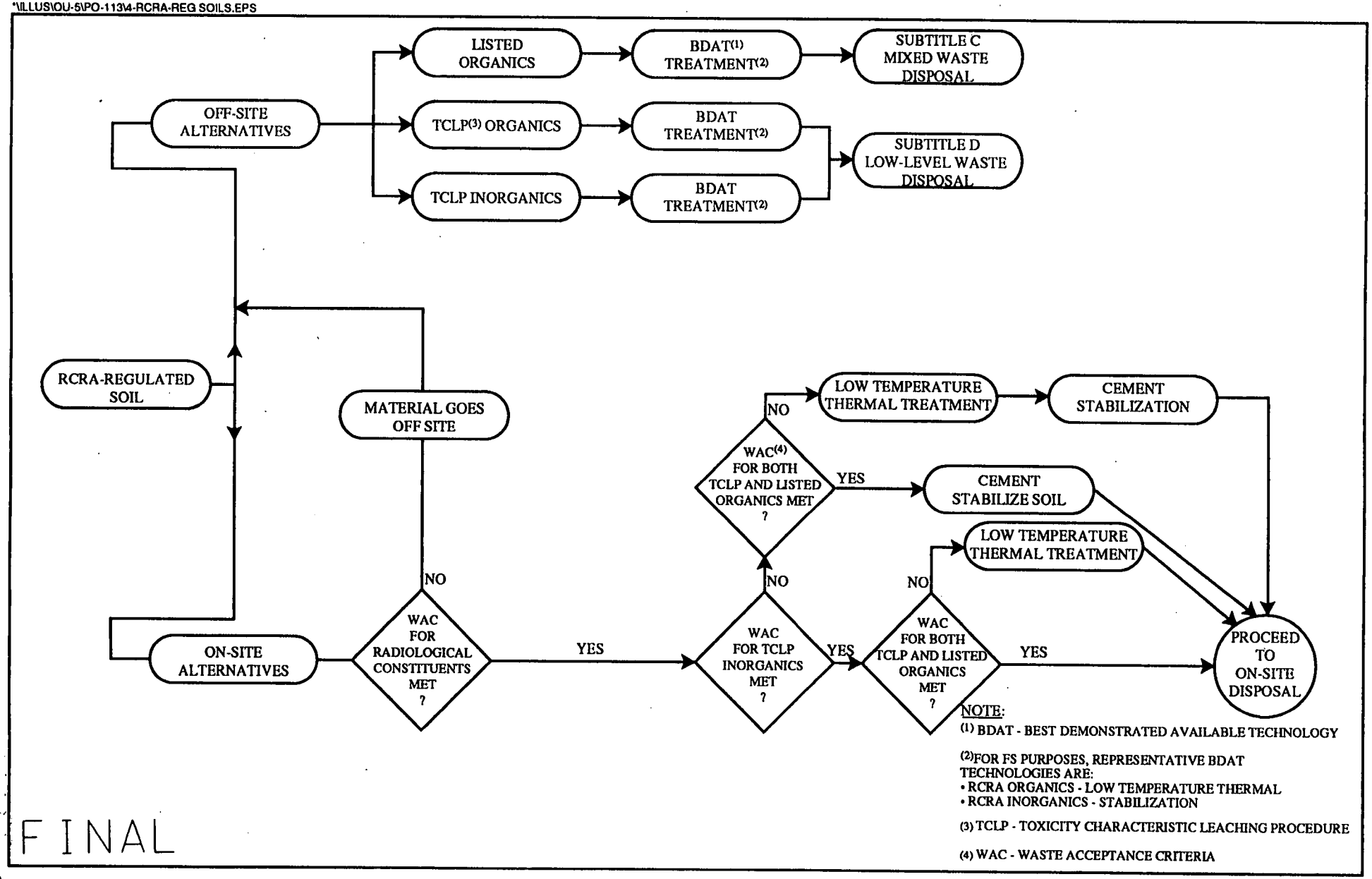


FIGURE 4-5. DISPOSAL AND TREATMENT REQUIREMENTS FOR RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)-REGULATED SOILS

000041

6002

In summary, the on-property disposal actions contemplated in the Operable Unit 5 alternatives would not constitute placement under the CAMU concept, and thus would not require treatment of the environmental media to the LDR treatment standards. The alternatives would, however, be expected to meet the protectiveness threshold envisioned by the CAMU provisions for wastes that do not require treatment. The RCRA-contaminated soil tracking process (shown earlier in Figure 4-4) and the site-specific WAC developed for the RCRA-based COCs would be used as the site-specific means for determining which materials can be disposed of safely on site and in the protective manner envisioned by EPA.

Appendix F provides the calculated WAC for the RCRA-based COCs as determined through fate and transport modeling. Several of the RCRA constituents, including a number of the RCRA-regulated organic solvents, do not have a calculated WAC value because the mass-balance modeling simulations show that these constituents do not have the capability to exceed designated Great Miami Aquifer action levels within the 1000-year simulation period, regardless of the starting concentrations for these constituents in the respective disposal facility alternative under consideration. It is recognized, however, that for the RCRA organic solvents, the mass balance model that is used to establish WAC cannot address the potential deleterious effects that full-strength solvents can have on the earthen materials comprising disposal facility liners or the underlying native clays present beneath the facility. As a best management practice for these compounds, the FEMP acknowledges that it cannot place any RCRA-based COCs into the disposal facility at concentrations that are incompatible with the clay liners (for those disposal alternatives relying on clay liners) or the underlying native clays beneath the liners. As a means to track these concentrations, the FEMP will rely on field screening methods (e.g., photoionization detectors or field gas chromatographs) during the excavation control surveys to identify the soil that is contaminated with RCRA organics above threshold values. The RCRA organic compounds that are present at concentrations that are detectable with field screening equipment would be segregated for treatment as necessary or sent off site for disposal, depending on the alternative under consideration. In the interest of conservatism, this would include all soil conceivably contaminated at "full strength" concentrations (i.e., saturated with organic solvents) and those existing at the part per million concentrations detectable with the field screening equipment. The details of the excavation control surveys and field screening methods for the RCRA organic compounds would be identified during remedial design and the preparation of the implementation plans for the Operable Unit 5 response actions.

As part of the public comment process for the Operable Unit 2 Proposed Plan, the OEPA expressed a concern that no characteristic RCRA wastes should be placed in the engineered disposal facility selected as the preferred remedy for Operable Unit 2. To address this expressed concern, the on-site disposal alternatives for Operable Unit 5 would need to adopt the four RCRA characteristic tests (ignitability, reactivity, corrosivity, and toxicity) as additional components of the WAC for the

RCRA-based COCs. Of primary concern to the OEPA is the possibility that contaminated Operable Unit 5 soil and Operable Unit 3 demolition debris could meet the on-site WAC established for the RCRA COCs, yet fail the toxicity characteristic leaching procedure (TCLP) test. Under these circumstances, the soil that does not pass the RCRA characteristic tests would require treatment (to remove the RCRA characteristic) before placement in an on-property facility. For the organic RCRA COCs, this would involve low temperature thermal treatment; for the inorganic COCs, this would involve cement stabilization. To accommodate this position, the soil that does not pass the characteristic tests (following retesting after the treatment step) would then require disposal offsite.

Off-Site LDR Compliance Strategy

The CAMU provisions are applicable only to on-site waste disposition activities. All off-site alternatives must therefore meet the LDR treatment standards for the RCRA-regulated constituents. The off-site strategy, highlighted earlier in Figure 4-5, requires that a designation be made deeming the RCRA constituents present in the media as either listed or characteristic waste. As illustrated on Figure 4-5, all media contaminated with listed constituents will need to be treated to meet LDR treatment standards, and then disposed off site as Subtitle C mixed waste. Conversely, all media contaminated with characteristic waste will need to be treated to meet LDR treatment standards, but can then be disposed of as low-level (Subtitle D nonhazardous) waste. The designation of the media into listed and characteristic categories would be accomplished during remedy implementation by considering process knowledge and HWMU history. For FS planning purposes and cost estimating, it is assumed that the soil directly underlying the HWMUs that contained listed wastes or a mixture of listed and characteristic wastes throughout their history (shown earlier in Tables 4-3 and 4-5) would be handled as listed wastes and sent to a Subtitle C mixed-waste facility following treatment. For the HWMUs that handled characteristic wastes only, it is assumed that the soil beneath the units would be managed as characteristic waste and sent to a Subtitle D low-level facility following treatment. The Subtitle D posttreatment pathway would also apply to the general areas on the site (e.g., soil not directly beneath the HWMUs where RCRA constituents have been detected in the soil).

Low-temperature thermal treatment and cement stabilization are selected as the representative BDAT treatment technologies for treatment of the organic and inorganic wastes, respectively, for the off-site alternatives.

It should be noted that all soil that meets the respective PRLs for the RCRA-based COCs are not considered to be affected and can remain in place (without further action) under both the on-site and off-site disposal strategies.

RCRA Compliance Strategy for Perched Groundwater

Perched groundwater that contains RCRA-regulated substances would require management according to the RCRA constraints imposed by the origin(s) of the constituents in the groundwater, as outlined below.

Perched groundwater that is intercepted during excavation in the vicinity of the fire training area and the sewage treatment plant (both facilities are designated RCRA-listed organic waste HWMUs) would be pretreated for listed organic constituents before delivery to the AWWT facility. This action is necessary to avoid contaminating other AWWT treatment residuals with RCRA-listed constituents. Unlike the HWMUs located within the main process area, the fire training area and the sewage treatment plant HWMUs both contain environmental media contamination that cannot also be attributed to other non-HWMU sources, thus triggering EPA's "contained-in" RCRA listed-waste policy for affected groundwater and soil. As stated in EPA's Contained-In Interpretation Memorandum, whenever concentration levels for listed constituents exceed health-based levels, the affected environmental media must be managed as listed hazardous waste. To comply with the expectations of this policy memorandum, the FEMP would adopt the detection limits for the listed constituents (displayed earlier in Table 2-10) as the action levels to designate when pretreatment of perched groundwater collected from the excavations in these two areas is required.

All other perched groundwater that is removed during excavation in the remaining areas of the site will be sent directly to the AWWT facility for treatment. RCRA constituents present in this groundwater would be considered characteristic hazardous wastes as a result of the many and varied sources of the constituents in the perched groundwater, including spills and leaks during active production operations. These constituents can be removed via treatment at the AWWT directly without attaching the "listed waste" label to the AWWT treatment residuals, and thus the pretreatment step is not required. As a natural course of action during all operations, the AWWT treatment residuals will need to be evaluated for TCLP values and managed accordingly.

4.1.7 Strategy for Groundwater, Storm Water and Wastewater Treatment

All remedial alternatives have adopted a consistent strategy for addressing collected storm water, wastewater, and recovered groundwater. Wastewater includes existing base flows at the FEMP (e.g., storm water, boiler makeup water, etc.,) and process wastewater from the implementation of remedial actions for Operable Unit 5 and the other operable units. More detail on the strategy is presented in the discussions of the remedial alternatives and in the component descriptions provided in Appendix L. The remedial strategy for addressing the treatment of collected storm water, wastewater flows and recovered groundwater is comprised of the following major elements:

- Interim treatment of a portion of the extracted Great Miami Aquifer groundwater recovered from the operational South Plume Recovery wells using available capacity from existing ion exchange treatment systems, including:

  - South Plume interim treatment system
  - Interim advanced wastewater treatment (IAWWT) units
  - AWWT facility (startup in 1995)

- Collection of site remediation and operations wastewater with treatment of these flows in the AWWT facility

- Collection of contaminated storm water runoff using the existing collection systems including the storm sewers and ditches and the storm water retention basin. Supplement the existing systems, as necessary, during remedial actions to collect contaminated storm water. Treat collected storm water in the AWWT facility. Discontinue storm water collection and treatment following completion of soil/sediment remediation activities.

- Treatment of perched water collected from the existing recovery wells for an interim time period at the Plant 8 system, with transfer of the flows to the AWWT facility when it becomes operational. Collection of perched water in the excavation pits created during soil related remedial actions and transfer of the water to the AWWT facility. Pretreatment (as required) of perched groundwater containing listed RCRA organic contaminants collected during excavation at the fire training facility and the sewage treatment plant.

- Treatment of recovered Great Miami Aquifer groundwater in the groundwater treatment facility, constructed as an addition to the AWWT facility. The facility would employ ion exchange and carbon filtration, if required, treatment techniques and be constructed in modules to enable increases or decreases in required capacities. Treatment would be applied to all groundwater, recovered from a well network system, which exhibits concentrations in the aquifer exceeding PRLs.

- Discharge of all recovered groundwater, wastewater, and collected storm water through the existing pipeline to the Great Miami River (or possible reinjection to the Great Miami Aquifer, if selected as an enhancement technology during remedy design or implementation).

The active life of the AWWT facility and the groundwater treatment facility is estimated to be on the order of 30 to 35 years; in order to meet the estimated treatment duration for the 20 ppb uranium footprint (projected to be 27 years, as documented in Appendix F), only one equivalent plant lifetime of capacity will be required. To meet the estimated treatment duration for the 3 ppb uranium footprint (projected to be 75 years, as documented in Appendix F), at least two equivalent plant lifetimes of treatment capacity will be required. These treatment capacity needs and estimated capacity lifetime equivalents have been factored into the FS-level cost estimates provided in Appendix K.

On the basis of available site information and modeling projections, the total mass of uranium discharged to the Great Miami River is anticipated to be the following:

- Up to 1000 pounds of uranium per year until the AWWT facility comes on line in 1995, at which time the loading is anticipated to be reduced temporarily to approximately 150 pounds per year, pending startup of full-scale groundwater remediation activities.

- Less than 600 pounds of uranium per year following startup of the adopted groundwater remediation strategy.

4.1.8 Flora, Fauna, and Cultural Resource Considerations

The Operable Unit 5 baseline ecological risk assessment identified that measured concentrations of COCs in surface soil, sediment and surface water at the FEMP could present unacceptable risks to ecological receptors. To reduce or eliminate the potential for future impacts to ecological receptors from these constituents, benchmark criteria were established to define media-specific threshold values which might produce these unacceptable risks if left in the media. These benchmark values were taken into consideration in the establishment of PRLs, as previously discussed in Section 2.0.

During the conduct of remedial activities to address soil, sediment and groundwater at the site, construction activities may disturb natural wetlands, floodplains or existing cultural resources. Additionally, remedial activities could potentially affect threatened and endangered species if identified on the site.

A wetlands delineation was completed for the FEMP property and was previously discussed in Section 2.0. If a remedial alternative is selected which requires significant off-property excavations, a wetlands delineation would be conducted to determine the presence of wetlands within the footprint of excavation. If the proposed remedial activity would require excavation activities in a wetland, an appropriate mitigation plan would be developed and implemented consistent with requirements of Section 404(b)(1) of the Clean Water Act following consultation with EPA, OEPA and the Corps of Engineers.

Select remedial activities may require excavations or other construction activities within the floodplain of Paddys Run. If such activities are required, the affected portion of the 100- and 500-year floodplains would be regraded to near original contours.

Threatened and endangered species surveys are currently being conducted on FEMP property. If threatened and endangered species are determined to be present and affected on FEMP property due to proposed remedial activities, mitigative measures would be implemented in consultation with appropriate federal and state agencies. Examples of mitigation include: restoration of riparian habitat and placement of loose-bark tree species for the Indiana bat, and relocation of potentially affected mountain bindweed and slender fingergrass species to a known local habitat.

Surveys of threatened and endangered species in potentially affected off-property areas have not been conducted. The presence of threatened and endangered species would be determined by performing a threatened and endangered species survey following selection of the remedy for Operable Unit 5, at a time when the boundaries of excavation are finalized through the selection of a desired residual risk goal in the ROD. If threatened and endangered species are determined to be present, appropriate mitigative measures would be implemented as part of the remedy following consultation with appropriate federal and state agencies.

The plans for any mitigative measures required for wetlands or threatened or endangered species will be clearly defined in the RD work plan and detailed within the remedial design.

A Phase 1 and 2 Cultural Resource Survey would be performed consistent with the Historic Preservation Act Section 106 to determine the presence of historic and prehistoric (archeological) sites eligible for the National Register of Historic Places which would be potentially impacted by remedial activities. A Phase 3 survey and data recovery may also be performed, as necessary, pending the results of Phase 1 and 2. If the selected remedy is projected to have an adverse impact on any identified resources, consultation with the Advisory Council on Historic Preservation and the State Historic Preservation Office would be completed to establish the necessary mitigative measures.

4.2 OVERVIEW OF PRELIMINARY ALTERNATIVES BY LAND USE OBJECTIVE

Based on the process options that were retained following evaluation in Section 3.0, the BMPs described in Section 4.1.1, and the land use objectives summarized in Section 4.1.2, a range of alternatives were developed. Table 4-8 offers a summary presentation of land use objectives and remedial alternatives. Table 4-9 is a matrix to aid in understanding the common elements among the various alternatives.

As discussed in Section 1.0, the NCP requires that the postremediation condition for CERCLA sites satisfy all ARARs ensure that incremental cancer risks resulting from the presence of site contaminants fall within a prescribed one in ten thousand (10^{-4}) to one in one million (10^{-6}) risk range or a HI equal to one. Thus, the footprints of proposed cleanup areas for a given land use can vary, depending on what site-specific residual risk values regulatory decision makers deem to be protective for the site constraints that are present. This situation would occur regardless of the land use objective sought.

As an aid to the decision maker for evaluating site-specific constraints, risk-based soil remediation footprints (and accompanying soil volumes) were established in Section 2.0 for each land use objective, over a broad residual risk range. For each land use objective, Section 2.0 examined

TABLE 4-8
SUMMARY OF OPERABLE UNIT 5 REMEDIAL ALTERNATIVES

	Land Use Objective		Remedial Alternative Description	Comments
1	Full unrestricted use of groundwater and land on and off the FEMP property.	1	Excavation of soil and sediment (including perched groundwater zones) with off-site disposal; extraction of Great Miami Aquifer water with treatment before discharge.	Establishes the cost-related boundary for achieving the unconstrained land use potential. Media volume shipped off site - 2.4 to 9.4 million cubic yards
2	Establishment of a consolidated waste management area with unrestricted use of the remaining areas of the property.	2A	Excavation of soil and sediment (including perched groundwater zones) with segregation and, depending on contaminant concentrations compared to the waste acceptance criteria (WAC) for the disposal facility, placement of soil and sediment with contaminant concentrations less than the WAC into an **on-property disposal facility** or shipment of soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Attempts to control disposal cost by using on-property disposal for less contaminated media, but using an off-site disposal for the more heavily contaminated media. Media volume placed in disposal cell - 2.4 to 9.3 million cubic yards Media volume shipped off site - 25,000 to 50,000 cubic yards Achieves unconstrained land use potential for the property not used for disposal.
		2B	Excavation of soil and sediment (including perched groundwater zones) with segregation and, depending on contaminant concentrations compared with the WAC for the consolidation area with a multilayer cap, placement of soil and sediment into the **on-property consolidation area with a multilayer cap** or shipment of soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Allows a comparison of disposal costs by using a multilayered cap over a consolidation area in the place of a disposal cell (Alt. 2A). Media volume placed in consolidation area - 2.4 to 8.8 million cubic yards Media volume shipped off site - 25,000 to 515,000 cubic yards Continues to achieve unconstrained land use potential for the property not used for disposal.

TABLE 4-8
(Continued)

Land Use Objective		Remedial Alternative Description	Comments
	2C	Excavation of soil and sediment (including perched groundwater zones) with segregation and, depending on contaminant concentration compared to the WAC for an on-property consolidation area with an earthen cover, placement of soil and sediment into an **on-property consolidation area with an earthen cover** or shipment of the soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Allows a comparison of disposal costs by using a consolidation area with an earthen cover in place of a disposal facility (Alt 2A) or a consolidation area with cap (Alt 2B). Media volume placed in consolidation area - 0 to 1.2 million cubic yards Media volume shipped off site - 1.2 to 9.4 million cubic yards Continues to achieve unconstrained land use potential for the property not used for disposal.
3 Establishment of a consolidated waste management area with restricted (surface use only) use of the remaining area of the property.	3A	Excavation of soil and sediment (including perched groundwater zones) with segregation and, depending on contaminant concentrations compared with the WAC for the disposal cell, placement of soil and sediment with contaminant concentrations less than the WAC into an **on-property disposal facility,** or shipment of soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Similar to Alt. 2A but examines the effect of less stringent preliminary remediation levels (PRLs) resulting in less media excavated. Media volume placed in disposal facility - 1.8 to 2.3 million cubic yards Media volume shipped off site - 25,000 cubic yards Restricts use of the remaining property (not used by the disposal cell) to industrial development and/or recreational uses such as undeveloped or developed parks.
	3B	Excavation of soil and sediment (including perched groundwater zones) with segregation and, depending on contaminant concentrations compared to the WAC for the consolidation area with a multilayer cap, placement of the soil and sediment with contaminant concentrations less than the WAC into an **on-property consolidation area with a multilayer cap**, or shipment of soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Similar to Alt. 2B but examines the effect of less stringent PRLs resulting in less media excavated. Media volume placed in consolidation area - 1.8 to 2.3 million cubic yards Media volume shipped off site - 25,000 cubic yards Restricts use of the remaining property (not used by the consolidation area with a multilayer cap) to an industrial development, undeveloped park, or developed park.

TABLE 4-8
(Continued)

Land Use Objective		Remedial Alternative Description	Comments
	3C	Excavation of soil and sediment (including perched groundwater zones) with segregation and, depending on contaminant concentrations compared to the WAC for the consolidation area with an earthen cover, placement of the soil and sediment with contaminant concentrations less than the WAC into an **on-property consolidation area with an earthen cover**, or shipment of soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Similar to Alt. 2C but examines the effect of less stringent PRLs resulting in less media excavated. Media volume placed in consolidation area - 0.7 to 1.2 million cubic yards Media volume shipped off site - 1.1 to 1.2 million cubic yards Restricts use of the remaining property (not used by the consolidation area with an earthen cover) to an industrial development, undeveloped park, or developed park.
4 Restricted use of the entire on-property area.	4A	Selective excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentrations compared with the disposal cell WAC, direct placement of the soil and sediment with contaminant concentrations less than the WAC into an **on-property disposal facility,** or shipment of the soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Examines the effect of minimum PRLs resulting in minimal excavation. Media volume placed in disposal cell - 1.8 million cubic yards Media volume shipped off site - 25,000 cubic yards Examines the effect of restricted use of the entire FEMP property.
	4B	Selective excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentrations, direct placement of the soil and sediment with contaminants concentrations less than the WAC into an **on-property consolidation area with a multilayer cap**, or shipment of the soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Similar to Alt. 4A in minimal excavation approach. Media volume placed in consolidation area - 1.8 million cubic yards Media volume shipped off site - 25,000 cubic yards Examines the effect of restricted use of the entire FEMP property.

TABLE 4-8
(Continued)

Land Use Objective	Remedial Alternative Description	Comments
	4C Selective excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentrations, direct placement of the soil and sediment with contaminant concentrations less than the WAC into an **on property consolidation area with an earthen cover** or shipment of the soil and sediment with concentrations exceeding the WAC to an **off-site disposal facility**; extraction of Great Miami Aquifer water with treatment before discharge.	Similar to Alt. 4A in minimal excavation approach. Media volume placed in consolidation area - 0.7 million cubic yards Media volume shipped off site - 1.1 million cubic yards Examines the effect of restricted use of the entire FEMP property.

TABLE 4-9
MATRIX OF OPERABLE UNIT 5 REMEDIAL ALTERNATIVES

	Land Use Objectives [a]	1	2			3			4		
Remedial Elements	Remedial Alternative	1	2A	2B	2C	3A	3B	3C	4A	4B	4C
Soil											
Soil excavation (including perched groundwater zones)		X	X	X	X	X	X	X	X	X	X
Segregation based on contaminant levels			X	X	X	X	X	X	X	X	X
On-property disposal cell			X			X			X		
On-property consolidation area with earthen cover					X			X			X
On-property consolidation area with cap				X			X			X	
Ship to off-site disposal facility		X	X	X	X	X	X	X	X	X	X
Off-property soil excavation		X	X	X	X	X	X	X	X	X	X
Groundwater											
Extract/treat/discharge all contaminated Great Miami Aquifer water		X	X	X	X	X	X	X	X	X	X

[a] Land Use Objectives:
1: Full unrestricted use.
2: Establishment of a consolidated waste management area with unrestricted use of the remaining area of the property.
3: Establishment of a consolidated waste management area with restricted use of the remaining area of the property.
4: Restricted use of the entire on-property area.

multiple risk scenario cases to reflect several mixes of land uses, receptors and risk levels. From this information, the decision maker can evaluate the site-specific cost implications of achieving protective levels over the risk range, in addition to examining the cost and technical constraints offered by the land use objectives and the various alternatives themselves. While the application of land use objectives serves to focus the alternative development and screening process, it is important to note that the process does not by itself result in a recommended specific land use for the site. Rather, the process provides the framework for assessing the incremental costs and administrative constraints required to move from one land use objective to another. From this framework, project stakeholders who are participating in the ultimate land use decision for the FEMP (including the Fernald Citizens Task Force) can formulate a recommended specific use or series of uses for the FEMP property. Under the broad land use objectives used in this FS, the resultant specific land uses for which the FEMP property would be available for consideration by the stakeholders include: residential farming; industrial or commercial development; recreational development; undeveloped open space; and restricted (no allowable access) use.

This section summarizes the potential remedial alternatives developed for the Operable Unit 5 FS. Although the summary level descriptions are repetitive for all the "A" alternatives as well as the "B" and "C" alternatives, the reader should note that the differences between the alternatives labeled with similar letters become apparent only after the application of the risk levels and the WAC described in Section 4.1.3 and volumes of contaminated soil are calculated and categorized for remediation purposes. The differences among the alternatives becomes apparent in Section 4.3 particularly with respect to the data tables that accompany the descriptions of the alternatives.

4.2.1 Land Use Objective 1: Full Unrestricted Use

By definition only one alternative is applicable to this land use objective:

- Alternative 1 - Full excavation of soil (including perched groundwater zones) with off-site disposal; extraction of Great Miami Aquifer water with treatment before discharge

This alternative is described in Section 4.3.1.

4.2.2 Land Use Objective 2: Establishment of a Consolidated Waste Management Area, with Unrestricted Use of the Remaining Area of the Property

The alternatives developed to meet this land use objective are as follows:

- Alternative 2A - Excavate soil and sediment and consolidate in an on-property engineered disposal facility. For soil and sediment with contaminant concentrations which exceed the WAC for the disposal facility, ship the material to an off-site disposal facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

- Alternative 2B - Excavate soil and sediment and consolidate in an on-property consolidation area with a multilayered cap. For soil and sediment with contaminant concentrations which exceed the WAC for the consolidation area with cap, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

- Alternative 2C - Excavate soil and sediment and consolidate in an on-property consolidation area with an earthen cover. For soil and sediment with contaminant concentrations which exceed the WAC for the consolidation area with earthen cover, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

These alternatives are described in Section 4.3.2.

4.2.3 Land Use Objective 3: Establishment of a Consolidated Waste Management Area with Restricted Use of the Remaining Area of the Property

The alternatives developed to meet this land use objective are as follows:

- Alternative 3A - Excavate soil and sediment and consolidate in an on-property engineered disposal facility. For soil and sediment with contaminant concentrations which exceed the WAC for the disposal facility, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

- Alternative 3B - Excavate soil and sediment and consolidate in an on-property consolidation area with a multilayered cap. For soil and sediment with contaminant concentrations which exceed the WAC for the consolidation area with cap, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

- Alternative 3C - Excavate soil and sediment and consolidate in an on-property consolidation area with an earthen cover. For soil and sediment with contaminant concentrations which exceed the WAC for the consolidation area with earthen cover, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

These alternatives are described in Section 4.3.3.

4.2.4 Land Use Objective 4: Restricted Use of the Entire On-Property Area

The alternatives developed to meet this land use objective are as follows:

- Alternative 4A - Excavate soil and sediment and consolidate in an on-property engineered disposal facility. For soil and sediment with contaminant concentrations which exceed the WAC for the disposal facility, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

- Alternative 4B - Excavate soil and sediment and consolidate in an on-property consolidation area with a multilayered cap. For soil and sediment with contaminant concentrations which

exceed the WAC for the consolidation area with cap, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

- Alternative 4C - Excavate soil and sediment and consolidate in an on-property consolidation area with an earthen cover. For soil and sediment with contaminant concentrations which exceed the WAC for the consolidation area with earthen cover, ship the material for disposal at an off-site facility. Pump groundwater from the Great Miami Aquifer and treat before discharge.

These alternatives are described in Section 4.3.4.

4.2.5 No Action

Only one alternative meets this administrative requirement:

- No-action alternative.

This alternative is described in Section 4.3.1.

4.3 DESCRIPTION OF ALTERNATIVES

4.3.1 No-Action Alternative - No Further Action Over any Removal or Remedial Action that Has Already Occurred

The no-action alternative, required by CERCLA regulations (40 CFR 300.430(e)(6)), is intended to provide a comparative baseline against which other alternatives can be evaluated. This may be described as a "walk away" alternative, since existing, ongoing maintenance, monitoring, and remedial actions would be discontinued and the site would be left "as is" without the implementation of any additional containment, removal, treatment, or mitigating actions. This alternative would not provide for ongoing monitoring of soil, perched groundwater, or groundwater from the Great Miami Aquifer within the scope of Operable Unit 5 and does not provide for any active or passive institutional controls to reduce the potential for exposure (e.g., physical barriers, deed restrictions, etc.). All existing remedial activities, monitoring programs, and institutional controls including security measures and physical barriers would be discontinued. By definition, this is a zero-future-cost alternative. It is also a zero-protection alternative in that it provides no protection to any receptor in the form of engineering or institutional controls.

No technologies/process options would be considered since no actions would be taken. No soil or sediment would be excavated. Therefore, no imported material would be required for backfill. No future extraction from the Great Miami Aquifer would occur.

Under this alternative, the time required to attain remedial objectives would be extremely long, i.e., in excess of 1000 years. Any improvements in contaminant levels would occur over extensive periods as the contaminants remaining on the site were gradually dispersed into the environment or

decayed at rates depending on their respective half-lives. This no-action alternative would be unacceptable because acceptance would imply that the property could be released for unrestricted use.

4.3.2 Alternative 1 - Excavation of Soil (Including Perched Groundwater Zones) with Off-Site Disposal; Extraction of Contaminated Groundwater with Treatment Before Discharge

Alternative 1 provides decision makers with a perspective on the cost, volumes and technical considerations involved in achieving an unrestricted land use for the entire site. Under this alternative, soil and sediment that exceed PRLs would be excavated with conventional construction equipment, staged (as necessary), loaded onto rail cars and hauled to an off-site licensed disposal facility.

Contaminated groundwater would be recovered from the Great Miami Aquifer through the use of extraction wells and conveyed to a new central water treatment facility before discharge to the Great Miami River. Perched groundwater zones (i.e., soil and groundwater) that exceed PRLs based upon projected cross-media impacts to the Great Miami Aquifer and/or surface water would be excavated along with all remaining other perched groundwater zones exhibiting sustained yields greater than 1 gpm.

Impacts to natural resources (e.g., wetlands, floodplains, and terrestrial and aquatic habitat) and cultural resources are anticipated from the implementation of Alternative 1. Appropriate mitigative measures would be employed to reduce anticipated impacts. Mitigation remedies for wetland impacts would be determined using the 404(b)(1) guidelines from the Clean Water Act.

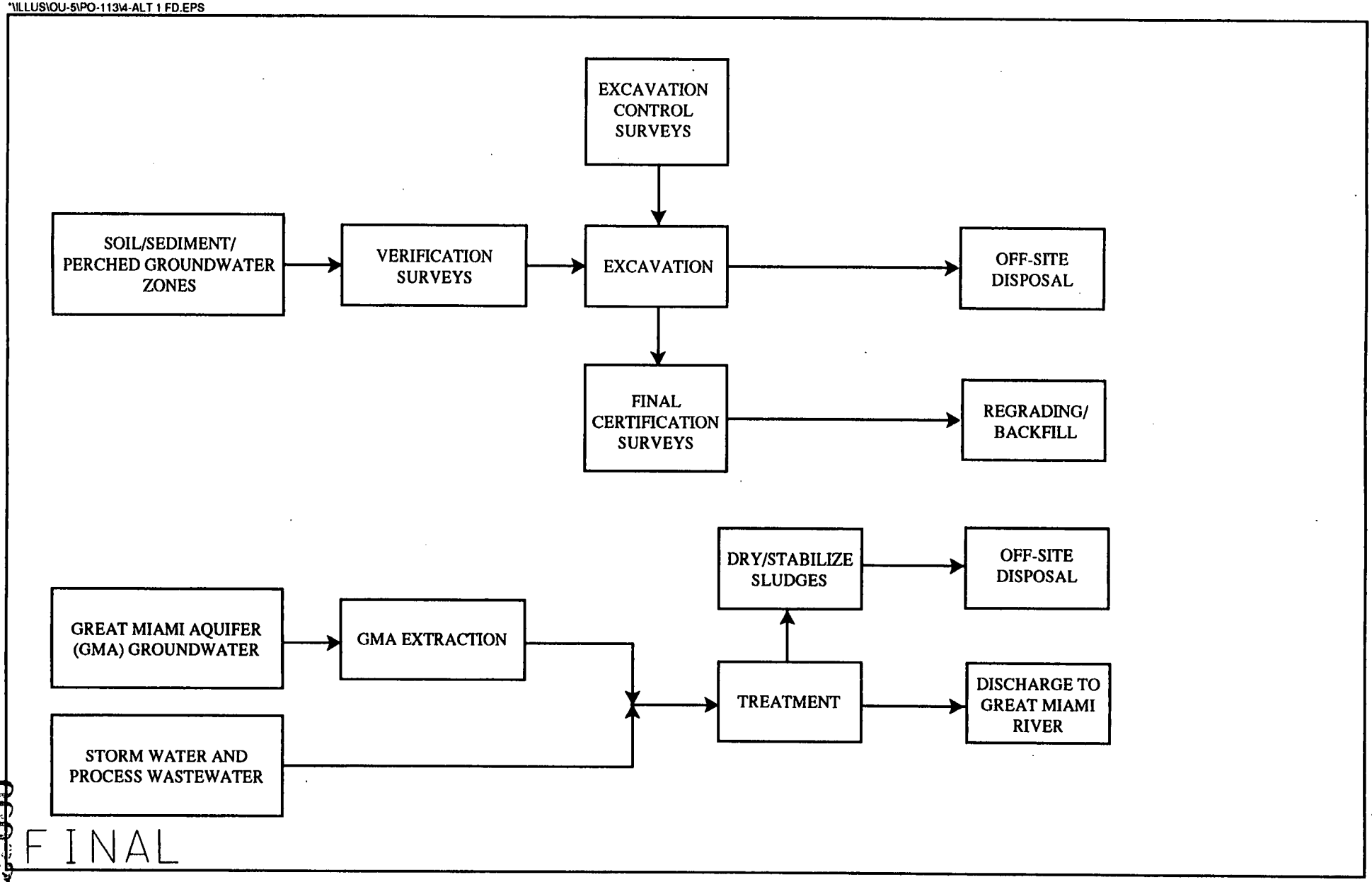
Figure 4-6 presents a conceptual flow diagram of the major elements of Alternative 1. Table 4-9 is a matrix table showing the elements for each alternative. Section 5.0 provides a more detailed description of the alternatives passing the screening process conducted in Section 4.4. The following presents a summary level description of the alternative.

Soil

Using the process options identified and screened in Section 3.0 and the remedial strategies discussed in Section 4.1.5, Alternative 1 applies the following remedial activities to contaminated soil exceeding PRLs:

- Conducting a sampling program focused on verifying the lateral and vertical extent of soil contamination exceeding PRLs, including confirming estimates of media impacted by releases from HWMUs. Soil verification sampling would focus on both the mass and mobility of the contaminants

*\ILLUS\OU-5\PO-113\4-ALT 1 FD.EPS



FINAL

FIGURE 4-6. ALTERNATIVE 1 CONCEPTUAL FLOW DIAGRAM

000207

2069

- Excavating soil exceeding PRLs including the trap range, soil beneath the below-grade pipelines and utilities, and any materials left in place by remediation of other operable units
- Excavating and sorting of the contaminated rubble and soil located adjacent to the outfall line at the Great Miami River
- Treating soil containing hazardous waste to comply with LDRs for off-site disposal
- Backfilling deep excavations with native or imported clay materials
- Regrading and revegetating excavated areas on property
- Backfilling, regrading, and revegetation/restoration of affected off-property areas
- Collecting certification samples to demonstrate attainment of PRLs
- Shipping excavated materials via covered gondola rail cars to an off-site licensed disposal facility. The representative facility adopted for this FS is Envirocare in Clive, Utah.

Sediment

Alternative 1 would adopt the following remedial activities for sediment:

- Sampling of sediment in Paddys Run, the SSOD, the pilot plant drainage ditch, and the Great Miami River to verify the need for excavation/dredging operations
- Dredging or excavation operations to remove sediment exceeding PRLs
- Collection of certification samples to demonstrate attainment of PRLs
- Backfilling and regrading (as required) in excavated areas
- Shipment of excavated/dredged materials with soil by rail cars to an off-site disposal facility.

Perched Groundwater

Alternative 1 adopts the following activities for remediating contaminated perched groundwater:

- Excavation of contaminated perched groundwater zones (i.e., soil and groundwater) exceeding PRLs based upon cross-media impacts to the Great Miami Aquifer and the potential for domestic well usage and all uncontaminated perched groundwater zones physically capable of a sustained yield of 1 gpm
- Use of pumping wells or collection trenches if required to facilitate dewatering of perched zones in support of excavation activities
- Pretreatment of perched water (collected from the excavations) to remove listed hazardous waste before transferring the groundwater to the AWWT facility

- Treatment of perched water (collected from the excavations) at the AWWT facility before discharge to the Great Miami River
- Backfilling deep excavations with low permeability native or imported soil
- Off-site disposal of excavated materials, along with contaminated soil
- Dewatering, stabilization (if required), and off-site disposal of treatment residues, spent resins, or other remediation residuals.

Great Miami Aquifer

The following summarizes the remedial activities adopted under Alternative 1 for remediation of the Great Miami Aquifer:

- Extraction of contaminated groundwater exceeding PRLs with recovery wells
- Treatment of recovered groundwater exceeding PRLs (as measured in the aquifer) in a central groundwater treatment facility (constructed as an expansion to the existing AWWT facility)
- Beneficial reuse of treated groundwater, (e.g., for dilution of sodium hydroxide, backwashing of resins, etc.), when practical
- Discharge of treated groundwater to the Great Miami River
- Dewatering, stabilization (if required), and off-site disposal of treatment residues, spent resins, and other remediation residuals.

Surface Water/Wastewater

The following summarizes the remedial activities adopted under Alternative 1 to address surface water and wastewater generated during remedial activities:

- Continued collection of surface water into storm water retention basins until certified completion of excavation activities
- Treatment of collected storm water and process wastewaters generated by Operable Units 1 through 5 remedial activities at the AWWT facility with discharge to the Great Miami River
- Dewatering, stabilization (if required), and off-property disposal of treatment residuals, spent resins, and other remediation residuals
- Decommissioning and dismantling of the AWWT facility, the groundwater treatment facility and other Operable Unit 5 support facilities with off-site disposal of generated rubble.

Institutional/Monitoring Requirements

The following summarizes the institutional controls and monitoring activities required to support Alternative 1:

- Performance monitoring during groundwater recovery operations
- Discharge monitoring of effluents to the Great Miami River
- Environmental monitoring during the implementation of the alternative to ensure the protection of human health and compliance with ARARs
- Provide an alternate water supply, through use of Hamilton County public water supply, to consumers using groundwater with contaminant concentrations above PRLs
- Provide access restriction to FEMP and off-property excavation areas during remedial operations
- Continue environmental monitoring following completion of remedial actions to the extent necessary to ensure long-term performance of the remedy.

Technical Data Summary - Alternative 1

Adopting the defined remedial strategy, specific technical data were developed to the extent necessary to support the alternative screening process. This technical data were developed for the risk cases previously defined in Section 2.0 for the pertinent land use objectives (i.e., Cases 1 and 2 for Land Use Objective 1). Table 4-10 provides a summary of the technical data including remediation levels, excavation volumes, disposal requirements, and costs for Alternative 1.

4.3.3 Alternatives 2A, 3A, and 4A - Excavation of Soil (Including Perched Groundwater Zones) with Segregation and, Depending on Contaminant Concentrations, Direct Placement in an On-Property Disposal Cell or Shipment to an Off-Site Disposal Facility; Extraction of Great Miami Aquifer with Treatment Before Discharge

Alternatives 2A, 3A, and 4A are referred to as the "A" alternatives in this section because the same summary level description of primary elements/activities applies to all three alternatives. Differences among these alternatives result from the application of the land use objectives and the associated risk scenarios.

The "A" alternatives vary because of the receptors protected by the various land use objectives. That is, the most sensitive on-property receptor to be protected in Alternative 2A is the resident farmer; in

Alternative 3A the receptor to be protected is an industrial worker or a recreational user of a developed or undeveloped park; and in Alternative 4A the receptor to be protected is the expanded trespasser.

TABLE 4-10
SUMMARY OF ALTERNATIVE 1

	Risk Range	
	Case 1	Case 2
Soil/Perched Groundwater/Sediment		
On-property receptor	Resident Farmer	Resident Farmer
On-property risk level	1×10^{-6}	1×10^{-5}
On-property uranium cleanup level (ppm)	5	15
Off-property receptor	Resident Farmer	Resident Farmer
Off-property risk level	1×10^{-6}	1×10^{-5}
Off-property uranium cleanup level (ppm)	5	15
Volume requiring excavation (yd^3)[a]		
- On-property	4,450,000	2,340,000
- Off-property	5,200,000	400,000
- Total	9,650,000	2,740,000
Off-site disposal		
- Volume (yd^3)	9,350,000	2,400,000
- Rail cars	165,000	42,200
On-site disposal (yd^3)[b]	0	0
Soil remediation time frame (years)	22	22
Great Miami Aquifer Groundwater		
Receptor	Resident Farmer	Resident Farmer
Risk level	1×10^{-6}	MCL / 1×10^{-5}
Uranium cleanup level (ppb)	3	20
Number of extraction wells	31	28
Maximum pumping rate (gpm)	7500	4000
Time frame to restore aquifer (years)	75	27
Present Worth Cost ($)	4,330,000,000	1,240,000,000
Total Project Cost ($)	13,870,000,000	3,020,000,000

[a] In situ volume estimate.
[b] Volume does not consider excavation of soil below cleanup level to gain access to deeper contamination.

The "A" alternatives provide decision makers with a comparison of the costs, volumes and technical considerations involved in disposing of less-contaminated media in an on-property disposal cell as compared with off-site disposal as in Alternative 1. The more heavily contaminated media is shipped to off-site disposal.

Under the "A" alternatives all soil and sediment that exceeds PRLs based on the various receptors would be excavated with conventional construction equipment, staged (as necessary), separated according to contaminant concentrations and loaded into covered trucks or roll-off containers to be transported to the on-property disposal facility or loaded onto rail cars to be hauled to an off-site disposal facility. Contaminated groundwater would be recovered from the Great Miami Aquifer through the use of extraction wells and conveyed to a new central water treatment facility before discharge to the Great Miami River. Perched groundwater zones (i.e., soil and groundwater) that exceed PRLs based upon projected cross-media impacts to the Great Miami Aquifer and/or surface water would be excavated. In Alternative 2A (but not in 3A or 4A), all uncontaminated perched groundwater zones exhibiting sustained yields greater than 1 gpm would also be excavated. This difference is as a result of the projected receptor scenarios developed under Land Use Objectives 3 and 4 which do not contemplate on-property groundwater consumption.

Impacts to natural resources (e.g., wetlands, floodplains, and terrestrial and aquatic habitat) and cultural resources are anticipated from the implementation of the "A" alternatives. Appropriate mitigative measures would be employed to reduce anticipated impacts. Mitigation measures for wetland impacts would be determined using the 404(b)(1) guidelines from the Clean Water Act.

WACs used in determining appropriate actions to be taken in developing the "A" alternatives were previously presented in Section 4.1.3. For the "A" alternatives, WACs for placement in the disposal cell are listed in Table 4-1.

Figure 4-7 presents a conceptual flow diagram of the major elements of the "A" alternatives. Table 4-9 is a matrix table showing the elements for each alternative; Section 5.0 provides a more detailed description of the alternatives passing the screening process conducted in Section 4.4. The following presents a summary level description of the "A" alternatives.

Soil

Using the process options identified and screened in Section 3.0 and the remedial strategies discussed in Section 4.1.5, the "A" alternatives apply the following remedial activities to contaminated soil exceeding PRLs:

*\ILLUS\OU-5\PO-113\4-ALTS 2A-4A FD.EPS

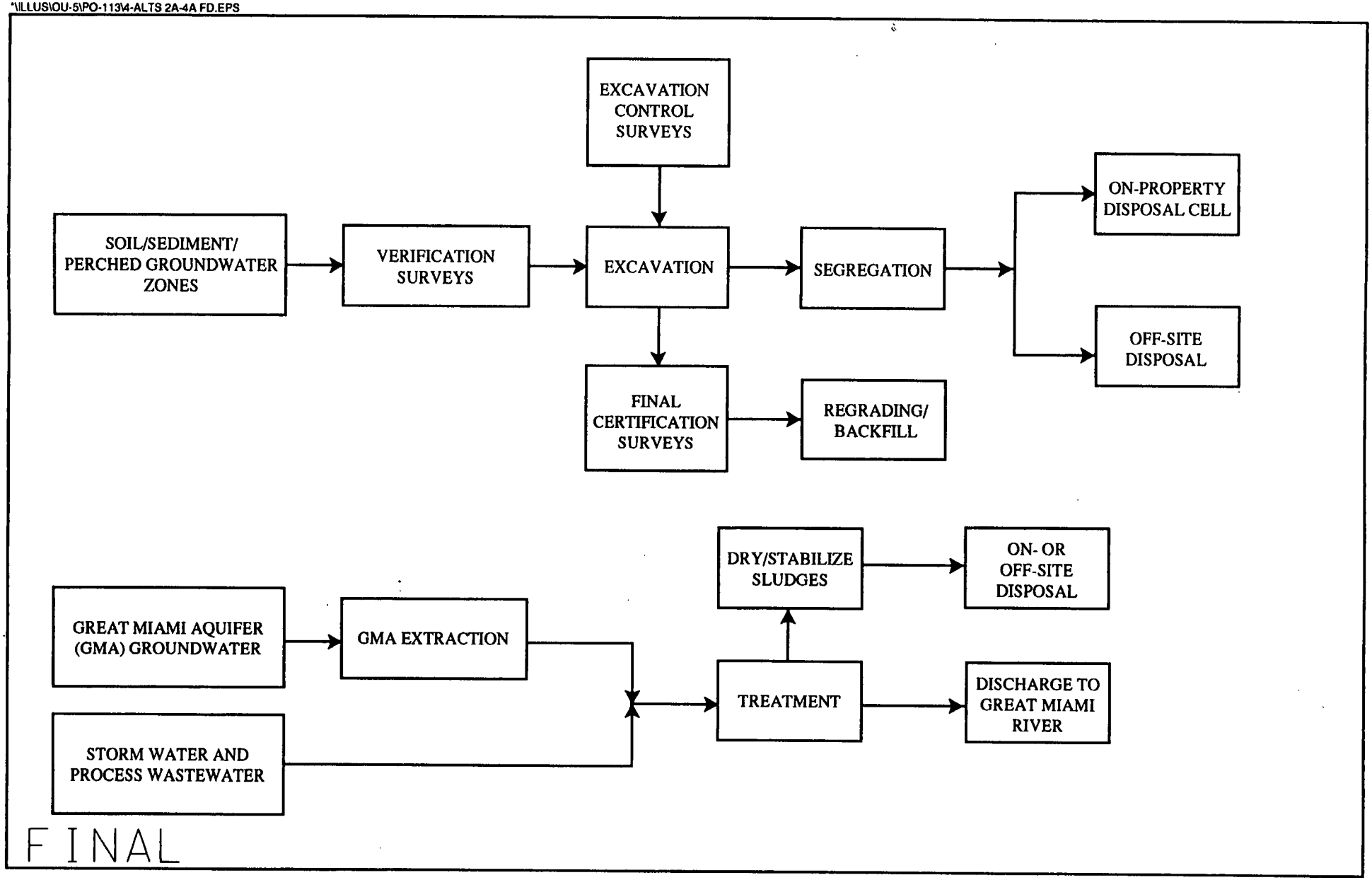


FIGURE 4-7. ALTERNATIVES 2A, 3A, AND 4A CONCEPTUAL FLOW DIAGRAM

000333

2009

- Conducting a sampling program focused on verifying the lateral and vertical extent of soil contamination exceeding PRLs, including confirming estimates of media impacted by releases from HWMUs; soil verification sampling would focus on both the mass and mobility of the contaminants by determining concentration levels and leachability coefficients (K_i) as appropriate.

- Excavating soil exceeding PRLs including the trap range, soil beneath the below-grade pipelines and utilities, and any materials left in place by remediation of other operable units

- Excavating and sorting the contaminated rubble and soil located adjacent to the outfall line at the Great Miami River

- Pretreating soil with concentrations of RCRA-regulated constituents above the WAC established for these constituents.

- Backfilling deep excavations with native or imported clay materials

- Regrading and revegetating excavated areas on property

- Backfilling, regrading, revegetating/restoring affected off-property areas

- Collecting certification samples to demonstrate attainment of PRLs

- Placing excavated soil meeting WAC into an engineered disposal facility located on property

- Shipping excavated materials not meeting the above WAC to an off-site licensed disposal facility.

Sediment

The "A" alternatives would adopt the following remedial activities for sediment:

- Sampling of sediment in Paddys Run, the SSOD, the pilot plant drainage ditch and the Great Miami River to verify the need for excavation/dredging operations

- Dredging or excavation operations to remove sediment exceeding PRLs

- Collecting certification samples to demonstrate attainment of PRLs

- Backfilling and regrading (as required) in excavated areas

- Placing excavated/dredged materials meeting WAC into the disposal facility located on property

- Shipping excavated/dredged materials not meeting the above WAC to an off-site disposal facility, along with soil.

Perched Groundwater

The "A" alternatives adopt the following activities for remediating contaminated perched groundwater:

- Excavation of contaminated perched groundwater zones (i.e., soil and groundwater) exceeding PRLs (based upon cross-media impacts to the Great Miami Aquifer and the potential for domestic well usage). In Alternative 2A (but not in 3A or 4A) all uncontaminated perched groundwater zones physically capable of a sustained yield of 1 gpm would also be excavated

- Use of pumping wells or collection trenches, if required, to facilitate dewatering of perched zones in support of excavation activities

- Pretreatment of perched water (collected from the excavations) to remove listed hazardous waste before transferring the groundwater to the AWWT facility

- Treatment of perched water (collected from the excavations) at the AWWT facility before discharge to the Great Miami River

- Backfilling deep excavations with low-permeability native or imported soil

- On-property disposal in the disposal facility of excavated materials meeting the WAC for the disposal facility

- Off-site disposal of excavated materials, exceeding the above WAC, along with contaminated soil

- Dewatering, stabilization (if required) and off-site disposal of treatment residues, spent resins, or other remediation residuals; if WAC can be met, on-property disposal facilities may be used.

Great Miami Aquifer

The following summarizes the remedial activities adopted under the "A" alternatives for the Great Miami Aquifer:

- Extraction of contaminated groundwater exceeding PRLs with recovery wells

- Treatment of recovered groundwater exceeding PRLs (as measured in the aquifer) in a central groundwater treatment facility (constructed as an expansion to the existing AWWT facility)

- Beneficial reuse of treated groundwater (e.g., dilution of sodium hydroxide, backwashing of resins, etc.), when practical

- Discharge of treated groundwater to the Great Miami River

- Dewatering, stabilization (if required) and off-site disposal of treatment residues, spent resins, or other remediation residuals; if WAC can be met, on-property disposal facilities may be used.

Surface Water/Wastewater

The following summarizes the remedial activities adopted under the "A" alternatives to address surface water and wastewater generated during remedial activities:

- Continued collection of surface water into storm water retention basins until completion of excavation activities is certified
- Treatment of collected storm water and process wastewaters generated by Operable Units 1 through 5 remedial activities at the AWWT facility with discharge to the Great Miami River
- Dewatering, stabilization (if required) and off-property disposal of treatment residuals, spent resins, or other remediation residuals; if WAC can be met, on-property disposal facilities may be used.
- Decommissioning and dismantling of the AWWT facility, the groundwater treatment facility and other Operable Unit 5 support facilities with off-site disposal of generated rubble.

Institutional/Monitoring Requirements

The following summarizes the institutional controls and monitoring activities required to support the "A" alternatives:

- Performance monitoring during groundwater recovery operations
- Discharge monitoring of effluents to the Great Miami River
- Environmental monitoring during the implementation of the alternatives to ensure the protection of human health and compliance with ARARs
- Providing an alternate water supply, through use of Hamilton County public water supply, to consumers using groundwater with contaminant concentrations above PRLs
- Provide access restrictions to FEMP and off-property excavation areas during remedial operations
- Provide access restrictions to the portion of the property occupied by the disposal facility; continued federal ownership of this portion of the property would be required
- Access restrictions of the remaining areas would vary according to the land use objective; in Objective 2, use of the area outside the consolidation area would be unrestricted
- Continued environmental monitoring following commencement of remedial actions to extent necessary to ensure long-term performance of the remedy
- Assess the continued performance of the completed remedial actions by having EPA conduct, in consultation with the State of Ohio and DOE, CERCLA reviews at five-year intervals following completion of remedial actions.

Engineered Disposal Facility

The feature of the "A" alternatives that distinguishes them from the others is the disposal facility that would be used to dispose of excavated soil and sediment meeting the WAC developed for that unit. The disposal facility would be designed in accordance with the regulatory requirements of both RCRA and the Uranium Mill Tailings Radiation Control Act (UMTRA) and would be designed for a 1000-year life. (The 1000-year duration was adopted as the upper bound of the design performance period based on the 200- to 1000-year design period identified in 40 CFR 192.02 for the disposal of mill tailings.) The soil and sediment would be disposed of in bulk, rather than in containers. Modeling results indicate that stabilization or other treatment of the soil and sediment will not be necessary to enhance the degree of protection provided by the on-property disposal facility. Treatability studies for brickmaking, phosphate amendment, and physical separation will be conducted to evaluate the enhancement of long-term effectiveness and for addressing the NCP preference for treatment to reduce toxicity, mobility, or volume. Additional treatment technologies may be evaluated before implementation as new technologies evolve. Conceptually, the disposal facility would require a multilayer capping system including a vegetative soil layer, a composite gravel and geotextile filter layer, a biotic barrier, a composite gravel and geotextile drainage layer, a composite sheet of high-density polyethylene over bentonite geocomposite, a compacted clay soil layer with a maximum permeability coefficient of 1×10^{-7} cm/sec to impede infiltration and attenuate radon emissions, and a compacted contouring soil layer. The disposal facility would also contain a multilayer liner system which would include a leachate detection zone, a leachate collection system, a synthetic membrane, a leak detection zone, a leak collection system, and a low-permeability clay layer with a maximum permeability of 1×10^{-7} cm/sec. A protective layer to minimize burrowing or root penetration would be included. Long-term maintenance of the disposal facility would be provided.

4.3.3.1 Alternative 2A

This alternative was developed to provide decision makers with a comparison of the cost, volumes and technical considerations involved by using a disposal facility to dispose of soil and sediment on property. It differs from the other "A" alternatives in that the disposal facility is used to a greater extent (i.e., it is used to dispose of more soil) although it conforms to more stringent WACs and therefore provides greater protection for on-property activities. This results from the fact that Land Use Objectives 3 and 4 provide for protection of industrial workers, recreational users and trespassers rather than a resident farmer, and thus require the excavation of less soil and sediment.

Because all areas of the site, outside of the consolidation area, are suitable for unrestricted use, the on-site resident farmer receptor establishes the basis of this alternative for determining the necessary degree of protection. The farmer is assumed to experience daily exposure to contaminants in soil, groundwater and feed products via inhalation, ingestion and dermal contact.

Alternative 2A is comprised of removing contaminated soil and sediment, including off-property contaminated soil and containing a portion of these media in the on-property disposal facility and transporting the remainder, the more highly contaminated media, to an off-site disposal facility.

Alternative 2A uses criteria that would allow unrestricted use of all areas of the FEMP other than the areas containing the disposal facility. Therefore, all areas not occupied by the disposal facility could be released at the discretion of the federal government (after all remedial criteria are met) and not maintained under federal ownership. Table 4-11 provides a summary of Alternative 2A.

4.3.3.2 Alternative 3A

Alternative 3A was developed to provide the decision makers with a comparison of the costs, volumes and technical considerations when limiting on-property land use to more restrictive uses (i.e., requiring less stringent PRLs). It differs from Alternative 2A in that 3A allows only more restrictive uses connected with industrial and recreational activities.

In Alternative 3A, industrial workers and/or recreational uses serve as the basis for the risk scenarios that determine the degree of protection necessary. Such individuals are assumed to be exposed to media remaining after remediation for a limited number of hours per day and days per year.

In Alternative 3A, contaminated soil and sediment, including off-property contaminated soil, is excavated and contained in an on-property disposal facility or, for the soil that fails to meet the WAC for the disposal facility, transported to an off-site disposal facility.

Alternative 3A uses criteria that would allow the areas of the FEMP other than the area containing the disposal cell to be released for restricted use. Restrictions would prohibit the use of perched groundwater, and would limit land use to include industrial and/or recreational activities. Areas of the site other than the disposal cell could be released from federal ownership. Table 4-12 provides a summary of Alternative 3A.

4.3.3.3 Alternative 4A

Alternative 4A was developed to provide decision makers with a comparison of the potential advantage (when compared with Alternatives 2A or 3A) of limiting remediation of soil to the minimum level of cleanup. It differs from Alternatives 2A and 3A in that only uses by an expanded trespasser are protected.

As in all the "A" alternatives, contaminated soil and sediment, including off-property contaminated soil, would be removed and placed in the on-property disposal facility or, for the remaining soil that failed to meet the WAC for the disposal facility, transported to off-site disposal.

TABLE 4-11
SUMMARY OF ALTERNATIVE 2A

Soil/Perched Groundwater/Sediment	Risk Range	
	Case 1	Case 2
On-property receptor	Resident Farmer	Resident Farmer
On-property risk level	1×10^{-6}	1×10^{-5}
On-property uranium cleanup level (ppm)	5	15
Off-property receptor	Resident Farmer	Resident Farmer
Off-property risk level	1×10^{-6}	1×10^{-5}
Off-property uranium cleanup level (ppm)	5	15
Volume requiring excavation (yd^3)[a]		
- On-property	4,450,000	2,340,000
- Off-property	5,200,000	400,000
- Total	9,650,000	2,740,000
Off-site disposal		
- Volume (yd^3)	50,000	25,000
- Rail cars[b]	880	440
On-site disposal (yd^3)[c]	9,300,000	2,375,000
Soil remediation time frame (years)	22	22
Great Miami Aquifer Groundwater		
Receptor	Resident Farmer	Resident Farmer
Risk level	1×10^{-6}	MCL / 1×10^{-5}
Uranium cleanup level (ppb)	3	20
Number of extraction wells	31	28
Maximum pumping rate (gpm)	7500	4000
Time frame to restore aquifer (years)	75	27
Present Worth Cost ($)	2,290,000,000	720,000,000
Total Project Cost ($)	12,030,000,000	2,580,000,000

[a] In situ volume estimate.
[b] For off-site disposal of volumes of less than 50,000 yd^3, shipment may be made by truck rather than rail.
[c] Volume does not consider excavation of soil below cleanup level to gain access to deeper contamination.

TABLE 4-12
SUMMARY OF ALTERNATIVE 3A

	Risk Range				
Soil/Perched Groundwater/Sediment	Case 3	Case 4	Case 5	Case 6	Case 7
On-property receptor	Industrial User	Developed Park User	Undeveloped Park User	Undeveloped Park User	Undeveloped Park User
On-property risk level	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6} w/ ALARA goal for uranium
On-property uranium cleanup level (ppm)	15	40[a]	80[a]	80[a]	50[a]
Off-property receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Off-property risk level	1×10^{-5}	1×10^{-5}	1×10^{-5}	HI=1	HI=1
Off-property uranium cleanup level (ppm)	15	15	15	50	50
Volume requiring excavation (yd^3)[b]					
- On-property	1,990,000	1,800,000	1,790,000	1,789,000	1,799,000
- Off-property	400,000	400,000	400,000	1,000	1,000
- Total	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Off-site disposal					
- Volume (yd^3)	25,000	25,000	25,000	25,000	25,000
- Rail cars[c]	440	440	440	440	440
On-site disposal (yd^3)[d]	2,340,000	1,750,000	1,750,000	1,750,000	1,750,000
Soil remediation time frame (years)	22	22	22	22	22
Great Miami Aquifer Groundwater					
Receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Risk level	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}
Uranium cleanup level (ppb)	20	20	20	20	20
Number of extraction wells	28	28	28	28	28
Maximum pumping rate (gpm)	4000	4000	4000	4000	4000
Time frame to restore aquifer (years)	27	27	27	27	27
Present Worth Cost ($)	690,000,000	630,000,000	610,000,000	580,000,000	580,000,000
Total Project Cost ($)	2,510,000,000	2,220,000,000	2,180,000,000	2,110,000,000	2,110,000,000

[a] Cleanup level of 20 ppm for uranium is required in the production area to protect the aquifer.
[b] In-situ volume estimate.
[c] For off-site disposal of volumes of less than 50,000 yd^3, shipment may be made by truck rather than rail.
[d] Volume does not include quantity of soil below on-property cleanup level excavated to gain access to deeper contamination or to meet off-property risk goal.

Alternative 4A uses criteria that, in addition to protecting the expanded trespasser, might result in alternate uses of select areas on property being considered on the basis of measured soil concentrations and the results of ongoing environmental monitoring. Under this alternative, continued federal ownership of the entire property would be maintained. Table 4-13 provides a summary of Alternative 4A.

Technical Data Summary - "A" Alternatives

Adopting the defined remedial strategy, specific technical data were developed to the extent necessary to support the alternative screening process. These technical data were developed for the risk cases previously defined in Section 2.0 for the pertinent land use objectives (i.e., Cases 1 and 2 for Objective 2; Cases 3, 4, 5, 6, and 7 for Objective 3; and Cases 8 and 9 for Objective 4).

4.3.4 Alternatives 2B, 3B, and 4B - Excavation of Soil (Including Perched Groundwater Zones) with Segregation and, Depending on Contaminant Concentrations, Direct Placement in an On-Property Consolidation Area with Cap or Shipment to Off-Site Disposal Facility; Extraction of Contaminated Groundwater with Treatment Before Discharge

Alternatives 2B, 3B, and 4B are referred to as the "B" alternatives in this section because the same summary level description of primary elements/activities applies to all three alternatives. Differences among these alternatives result from the application of the land use objectives and the associated risk scenarios to the "B" alternatives.

The "B" alternatives vary because of the receptors protected by the various land use objectives. That is, the most sensitive on-property receptor to be protected in Alternative 2B is the resident farmer; in Alternative 3B the receptor to be protected is an industrial worker or a recreational user of a developed or undeveloped park; and in Alternative 4B the receptor to be protected is the expanded trespasser.

The "B" alternatives provide decision makers with a comparison of the costs, volumes and technical considerations involved in disposing of less contaminated media in an on-property consolidation area with a cap as compared with disposal in an on-property disposal cell as in the "A" alternatives. As in the "A" alternatives the more heavily contaminated media is shipped to off-site disposal.

Under the "B" alternatives all soil and sediment that exceeds PRLs based on the various receptors would be excavated with conventional construction equipment, staged (as necessary), separated according to contaminant concentrations and loaded into covered trucks or roll-off containers to be transported to the on-property consolidation area or loaded onto rail cars to be hauled to an off-site disposal facility.

TABLE 4-13
SUMMARY OF ALTERNATIVE 4A

	Risk Range	
Soil/Perched Groundwater/Sediment	Case 8	Case 9
On-property receptor	Trespasser	Trespasser
On-property risk level	1×10^{-6}	1×10^{-6}
On-property uranium cleanup level[a] (ppm)	100	100
Off-property receptor	Resident Farmer	Resident Farmer
Off-property risk level	1×10^{-5}	HI=1
Off-property uranium cleanup level (ppm)	15	50
Volume requiring excavation (yd^3)[b]		
- On-property	1,790,000	1,789,000
- Off-property	400,000	1,000
- Total	2,190,000	1,790,000
Off-site disposal		
- Volume (yd^3)[b]	25,000	25,000
- Rail cars[c]	440	440
On-site disposal[d] (yd^3)	1,750,000	1,750,000
Soil remediation time frame (years)	22	22
Great Miami Aquifer Groundwater		
Receptor	Resident Farmer	Resident Farmer
Risk level	MCL / 1×10^{-5}	MCL / 1×10^{-5}
Uranium cleanup level (ppb)	20	20
Number of extraction wells	28	28
Maximum pumping rate (gpm)	4000	4000
Time frame to restore aquifer (years)	27	27
Present Worth Cost ($)	610,000,000	580,000,000
Total Project Cost ($)	2,180,000,000	2,110,000,000

[a] Cleanup level of 20 ppm for uranium is required in the production area to protect the aquifer.
[b] In-situ volume estimate.
[c] For off-site disposal of volumes of less than 50,000 yd^3, shipment may be made by truck rather than rail.
[d] Volume does not include quantity of soil below on-property cleanup level excavated to gain access to deeper contamination or to meet off-property risk goal.

Contaminated groundwater would be recovered from the Great Miami Aquifer through the use of extraction wells and conveyed to a new central water treatment facility before discharge to the Great Miami River. Perched groundwater zones (i.e., soil and groundwater) that exceed PRLs based upon projected cross-media impacts to the Great Miami Aquifer and/or surface water would be excavated. In Alternative 2B (but not in 3B or 4B) all uncontaminated perched groundwater zones exhibiting sustained yields greater than 1 gpm would also be excavated. This difference is a result of the projected receptor scenarios developed under Land Use Objectives 3 and 4 that do not contemplate on-property groundwater consumption.

Impacts to natural resources (e.g., wetlands, floodplains, and terrestrial and aquatic habitat) and cultural resources are anticipated from the implementation of the "B" alternatives. Appropriate mitigative measures would be employed to reduce anticipated impacts. Mitigation measures for wetland impacts would be determined using the 404(b)(1) guidelines from the Clean Water Act. WAC used in determining appropriate actions to be taken in developing the "B" alternatives were previously presented in Section 4.1.3. For the "B" alternatives, WAC for placement in the consolidation area with cap are listed in Table 4-1.

Figure 4-8 presents a conceptual flow diagram of the major elements of the "B" alternatives. Table 4-9 is a matrix table showing the elements for each alternative. Section 5.0 provides a more detailed description of the alternatives passing the screening process conducted in Section 4.4. The following presents a summary level description of the "B" alternatives.

Soil

Using the process options identified and screened in Section 3.0 and the remedial strategies discussed in Section 4.1.5, the "B" alternatives apply the following remedial activities to contaminated soil exceeding PRLs:

- Conducting a sampling program focused on verifying the lateral and vertical extent of soil contamination exceeding PRLs, including confirming estimates of media impacted by releases from HWMUs; soil verification sampling would focus on both the mass and mobility of the contaminants by determining concentration levels and leachability coefficients K_l as appropriate.

- Excavating soil exceeding PRLs including the trap range, soil beneath the below-grade pipelines and utilities, and any materials left in place by remediation of other operable units

- Excavating and sorting the contaminated rubble and soil located adjacent to the outfall line at the Great Miami River

- Pretreating soil with concentrations of RCRA-regulated constituents above the WAC established for these constituents.

*\ILLUS\OU-5\PO-113\ALTS 2B-4B FD.EPS

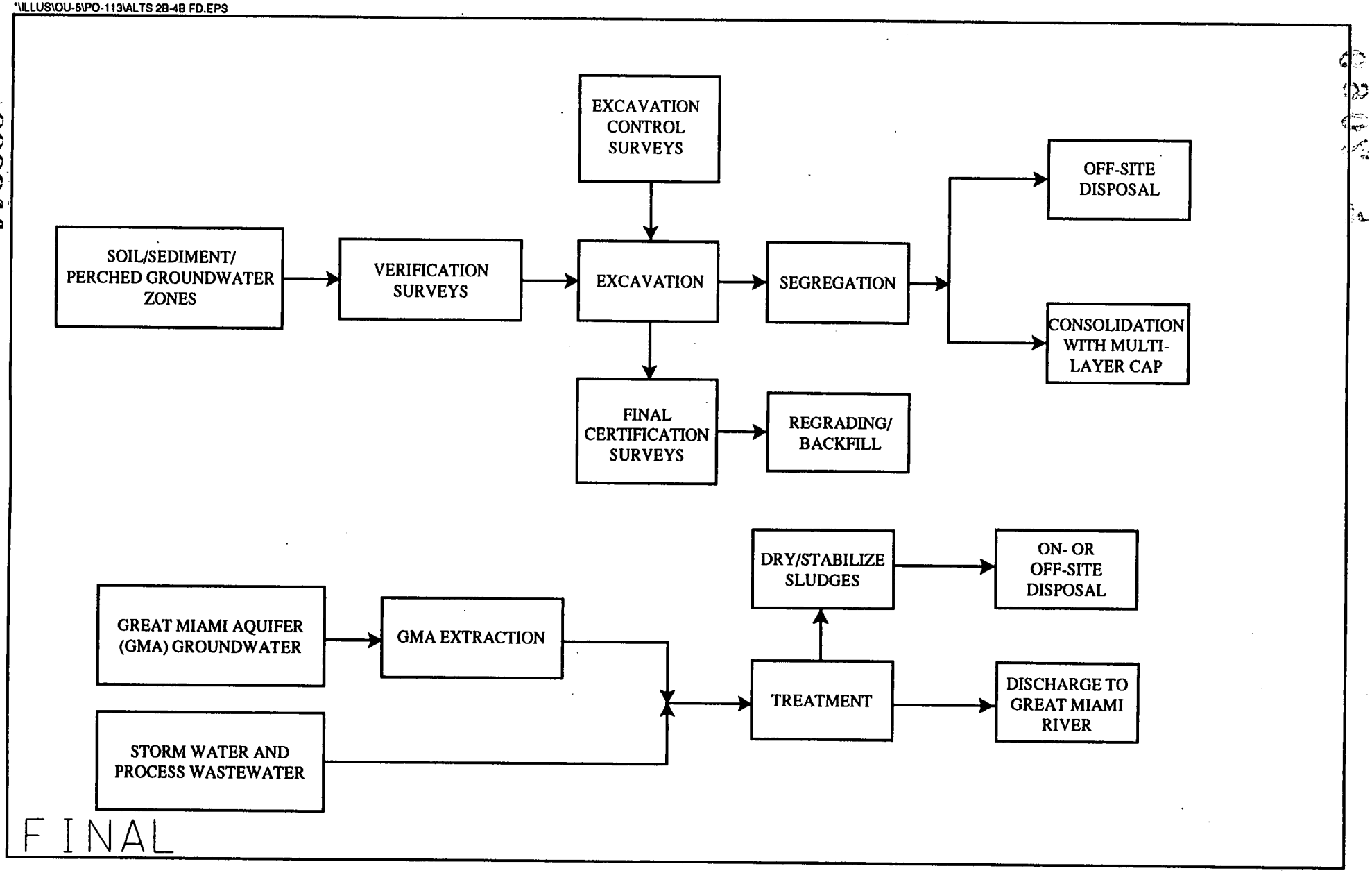


FIGURE 4-8. ALTERNATIVES 2B, 3B, AND 4B CONCEPTUAL FLOW DIAGRAM

000344

- Backfilling deep excavations with native or imported clay materials
- Regrading and revegetating excavated areas on property
- Backfilling, regrading, revegetating/restoring affected off-property areas
- Collecting certification samples to demonstrate attainment of PRLs
- Placing excavated soil meeting WAC into the consolidated area with cap located on property
- Shipping excavated materials not meeting the above WAC to an off-site licensed disposal facility.

Sediment

The "B" alternatives would adopt the following remedial activities for sediment:

- Sampling of sediments in Paddys Run, the SSOD, the pilot plant drainage ditch and the Great Miami River to verify the need for excavation/dredging operations
- Dredging or excavating to remove sediment exceeding PRLs
- Collecting certification samples to demonstrate attainment of PRLs
- Backfilling and regrading (as required) in excavated areas
- Placing excavated/dredged materials meeting WAC into the consolidation area with cap located on property
- Shipping excavated/dredged materials not meeting the above WAC to an off-site disposal facility, along with soil.

Perched Groundwater

The "B" alternatives adopt the following remedial activities for remediating contaminated perched groundwater:

- Excavating contaminated perched groundwater zones (i.e., soil and groundwater) exceeding PRLs based upon cross-media impacts to the Great Miami Aquifer and the potential for domestic well usage; in Alternative 2B (but not in 3B or 4B) all uncontaminated perched groundwater zones physically capable of a sustained yield of 1 gpm would also be excavated
- Using pumping wells or collection trenches, if required, to facilitate dewatering of perched zones in support of excavation activities
- Pretreating perched water (collected from the excavations) to remove listed hazardous waste before transferring the groundwater to the AWWT facility
- Treating perched water (collected from the excavations) at the AWWT facility before discharge to the Great Miami River
- Backfilling deep excavations with low permeability native or imported soil

- On-property disposal in the consolidation area with cap of excavated materials meeting the WAC for the consolidation area

- Off-site disposal of excavated materials, exceeding the above WAC, along with contaminated soil

- Dewatering, stabilization (if required) and off-site disposal of treatment residues, spent resins, or other remediation residuals. If WAC can be met, on-property disposal facilities may be used.

Great Miami Aquifer

The following summarizes the remedial activities adopted under the "B" alternatives for remediation of the Great Miami Aquifer:

- Extraction of contaminated groundwater exceeding PRLs with recovery wells

- Treatment of recovered groundwater exceeding PRLs (as measured in the aquifer) in a central groundwater treatment facility (constructed as an expansion to the existing AWWT facility)

- Beneficial reuse of treated groundwater (e.g., dilution of sodium hydroxide, backwashing of resins, etc.), when practical

- Discharge of treated groundwater to the Great Miami River

- Dewatering, stabilization (if required) and off-site disposal of treatment residues, spent resins, or other remediation residuals. If WAC can be met, on-property disposal facilities may be used.

Surface Water/Wastewater

The following summarizes the remedial activities adopted under the "B" alternatives to address surface water and wastewater generated during remedial activities:

- Continued collection of surface water into storm water retention basins until completion of excavation activities is certified

- Treatment of collected storm water and process wastewaters generated by Operable Units 1 through 5 remedial activities at the AWWT facility with discharge to the Great Miami River

- Dewatering, stabilization (if required) and off-property disposal of treatment residuals, spent resins, or other remediation residuals. If WAC can be met, on-property disposal facilities may be used.

- Decommissioning and dismantling of the AWWT facility, the groundwater treatment facility and other Operable Unit 5 support facilities with off-site disposal of generated rubble.

Institutional/Monitoring Requirements

The following summarizes the institutional controls and monitoring activities required to support the "B" alternatives:

- Performance monitoring during groundwater recovery operations
- Discharge monitoring of effluents to the Great Miami River
- Environmental monitoring during the implementation of the alternatives to ensure the protection of human health and compliance with ARARs
- Providing an alternate water supply, through use of Hamilton County public water supply, to consumers using groundwater with contaminant concentrations above PRLs
- Providing access restrictions to FEMP and off-property excavation areas during remedial operations
- Providing access restrictions to the portion of the property occupied by the consolidation area; continued federal ownership of this portion of the property would be required
- Access restrictions of the remaining areas would vary according to the land use objectives; in Objective 2 use of the area outside the consolidation area would be unrestricted
- Continued environmental monitoring following commencement of remedial actions to the extent necessary to ensure long-term performance of the remedy
- Assess the continued performance of the completed remedial actions by having EPA conduct, in consultation with the State of Ohio and DOE, CERCLA reviews at five-year intervals following completion of remedial actions.

Consolidation Area with a Multilayer Cap

The feature of the "B" alternatives that distinguishes them from the other alternatives is the consolidation area with a multilayer cap that would be used to dispose of excavated soil and sediment meeting the WAC developed for that unit. The cap would be designed in accordance with the regulatory requirements of both RCRA and UMTRA. The design performance period would be 1000 years. Modeling results indicate that stabilization or other treatment of the soil and sediment will not be necessary to enhance the degree of protection provided by the consolidation area with a multilayer cap. Treatability studies for brickmaking, phosphate amendment, and physical separation will be conducted to evaluate the enhancement of long-term effectiveness and for addressing the NCP preference for treatment to reduce toxicity, mobility, or volume. Additional treatment technologies may be evaluated before implementation as new technologies evolve. Placement in one-foot lifts, compaction of the material, and installation of the multilayer cap over the consolidation area would be the sequence of remedial activities. Conceptually, the consolidation area/multilayer cap system would include a geomembrane layer of 40-mil minimum thickness, a low permeability clay layer with a

maximum permeability of 1 x 10^{-7} cm/sec, a high-permeability drainage layer, a geotextile layer, and a vegetative soil layer for reseeding. Long-term maintenance of the consolidation area/multilayer cap would be provided.

4.3.4.1 Alternative 2B

This alternative was developed to provide decision makers with a comparison of the cost, volumes and technical considerations involved in using a consolidation area with a cap to dispose of soil and sediment on property instead of an engineered disposal facility as in the "A" alternatives. It differs from the other "B" alternatives in that the consolidation area is used to a greater extent (i.e., it is used to dispose of more soil) although it conforms to more stringent WAC and therefore provides greater protection for on-property activities. This results from the fact that Land Use Objectives 3 and 4 provide for protection of industrial workers, recreational uses and trespassers, rather than a resident farmer, and thus require the excavation of less soil and sediment.

Because all areas of the site outside of the consolidation area are suitable for unrestricted use, the on-site resident farmer receptor establishes the basis of this alternative for determining the necessary degree of protection. The farmer is assumed to experience daily exposure to contaminants in soil, groundwater and feed products via inhalation, ingestion and dermal contact.

Alternative 2B is comprised of removing contaminated soil and sediment, including off-property contaminated soil, and containing a portion of these media in the on-property consolidation area with a multilayer cap and transporting the remainder, the more highly contaminated media, to an off-site disposal facility.

Alternative 2B uses criteria that would allow unrestricted use of all areas of the FEMP other than the areas containing the consolidation area. Therefore, all areas not occupied by the consolidation area could be released at the discretion of the federal government (after all remedial criteria are met) and not maintained under federal ownership. Table 4-14 provides a summary of Alternative 2B.

4.3.4.2 Alternative 3B

Alternative 3B was developed to provide the decision makers with a comparison of the costs, volumes and technical considerations when limiting on-property land use to more restrictive uses (i.e., requiring less stringent PRLs.) It differs from Alternative 3A in that contaminated soil would be disposed of in a consolidation area with a multilayer cap rather than in an engineered disposal facility. It differs from Alternative 2B in that 3B only allows more restrictive uses connected with industrial and recreational activities.

TABLE 4-14
SUMMARY OF ALTERNATIVE 2B

	Risk Range	
Soil/Perched Groundwater/Sediment	Case 1	Case 2
On-property receptor	Resident Farmer	Resident Farmer
On-property risk level	1×10^{-6}	1×10^{-5}
On-property uranium cleanup level (ppm)	5	15
Off-property receptor	Resident Farmer	Resident Farmer
Off-property risk level	1×10^{-6}	1×10^{-5}
Off-property uranium cleanup level (ppm)	5	15
Volume requiring excavation (yd^3)[a]		
- On-property	4,450,000	2,340,000
- Off-property	5,200,000	400,000
- Total	9,650,000	2,740,000
Off-site disposal		
- Volume (cubic yards)	515,000	25,000
- Rail cars[b]	9,060	440
On-site disposal (yd^3)[c]	8,830,000	2,370,000
Soil remediation time frame (years)	22	22
Great Miami Aquifer Groundwater		
Receptor	Resident Farmer	Resident Farmer
Risk level	1×10^{-6}	MCL / 1×10^{-5}
Uranium cleanup level (ppb)	3	20
Number of extraction wells	31	28
Maximum pumping rate (gpm)	7500	4000
Time frame to restore aquifer (years)	75	27
Present Worth Cost ($)	2,320,000,000	720,000,000
Total Project Cost ($)	9,170,000,000	2,590,000,000

[a] In situ volume estimate.
[b] For off-site disposal of volumes of less than 50,000 yd^3, shipment may be made by truck rather than rail.
[c] Volume does not consider excavation of soil below cleanup level to gain access to deeper contamination.

In Alternative 3B, industrial workers and/or recreational uses serve as the basis for the risk scenarios which determine the degree of protection necessary. Such individuals are assumed to be exposed to media remaining after remediation for a limited number of hours per day and days per year.

In Alternative 3B, contaminated soil and sediment, including off-property contaminated soil, is excavated and contained in an on-property consolidation area with a multilayer cap or, for the soil that fails to meet the WAC for the consolidation area, transported to an off-site disposal facility.

Alternative 3B uses criteria that would allow the areas of the FEMP other than the area containing the consolidation area to be released for restricted use. Restrictions would prohibit the use of perched groundwater and would limit land use to industrial and/or recreational activities. Areas of the site other than the consolidation area could be released from federal ownership. Table 4-15 provides a summary of Alternative 3B.

4.3.4.3 Alternative 4B

Alternative 4B was developed to provide decision makers with a comparison of the potential advantage (when compared with Alternatives 2B or 3B) of limiting remediation of soil to the minimum level of cleanup. It differs from Alternative 4A in that soil is disposed of in an on-property consolidation area with a multilayer cap rather than in an engineered disposal facility. It differs from Alternatives 2B and 3B in that only uses by an expanded trespasser are protected in Alternative 4B.

As in all the "B" alternatives, contaminated soil and sediment, including off-property contaminated soil, would be removed and placed in the on-property consolidation area or, for the remaining soil that failed to meet the WAC for the consolidation area, transported to an off-site disposal facility.

Alternative 4B uses criteria that in addition to protecting the expanded trespasser might result in alternate uses of select areas on property being considered on the basis of measured soil concentrations and the results of ongoing environmental monitoring. Under this alternative, continued federal ownership of the entire property would be maintained. Table 4-16 provides a summary of Alternative 4B.

Technical Data Summary - "B" Alternatives

Adopting the defined remedial strategy, specific technical data were developed to the extent necessary to support the alternative screening process. These technical data were developed for the risk cases previously defined in Section 2.0 for the pertinent land use objectives (i.e., Cases 1 and 2 for Objective 2; Cases 3, 4, 5, 6, and 7 for Objective 3; and Cases 8 and 9 for Objective 4).

TABLE 4-15
SUMMARY OF ALTERNATIVE 3B

	Risk Range				
Soil/Perched Groundwater/Sediment	Case 3	Case 4	Case 5	Case 6	Case 7
On-property receptor	Industrial User	Developed Park User	Undeveloped Park User	Undeveloped Park User	Undeveloped Park User
On-property risk level	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6} w/ ALARA goal for uranium
On-property uranium cleanup level (ppm)	15	40[a]	80[a]	80[a]	50[a]
Off-property receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Off-property risk level	1×10^{-5}	1×10^{-5}	1×10^{-5}	HI=1	HI=1
Off-property uranium cleanup level (ppm)	15	15	15	50	50
Volume requiring excavation (yd^3)[b]					
- On-property	1,990,000	1,800,000	1,790,000	1,789,000	1,799,000
- Off-property	400,000	400,000	400,000	1,000	1,000
- Total	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Off-site disposal					
- Volume (yd^3)	25,000	25,000	25,000	25,000	25,000
- Rail cars[c]	440	440	440	440	440
On-site disposal (yd^3)[d]	2,340,000	1,750,000	1,750,000	1,750,000	3,750,000
Soil remediation time frame (years)	22	22	22	22	22
Great Miami Aquifer Groundwater					
Receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Risk level	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}
Uranium cleanup level (ppb)	20	20	20	20	20
Number of extraction wells	28	28	28	28	28
Maximum pumping rate (gpm)	4000	4000	4000	4000	4000
Time frame to restore aquifer (years)	27	27	27	27	27
Present Worth Cost ($)	690,000,000	630,000,000	610,000,000	580,000,000	700,000,000
Total Project Cost ($)	2,510,000,000	2,220,000,000	2,170,000,000	2,100,000,000	2,100,000,000

[a] Cleanup level of 20 ppm for uranium is required in the production area to protect the aquifer.
[b] In-situ volume estimate.
[c] For off-site disposal of volumes of less than 50,000 yd^3, shipment may be made by truck rather than rail.
[d] Volume does not include quantity of soil below on-property cleanup level excavated to gain access to deeper contamination or to meet off-property risk goal.

TABLE 4-16
SUMMARY OF ALTERNATIVE 4B

	Risk Range	
Soil/Perched Groundwater/Sediment	Case 8	Case 9
On-property receptor	Trespasser	Trespasser
On-property risk level	1×10^{-6}	1×10^{-6}
On-property uranium cleanup level[a] (ppm)	100	100
Off-property receptor	Resident Farmer	Resident Farmer
Off-property risk level	1×10^{-5}	HI=1
Off-property uranium cleanup level (ppm)	15	50
Volume requiring excavation (yd^3)[b]		
- On-property	1,790,000	1,789,000
- Off-property	400,000	1,000
- Total	2,190,000	1,790,000
Off-site disposal		
- Volume (yd^3)	25,000	25,000
- Rail cars[c]	440	440
On-site disposal (yd^3)[d]	1,750,000	1,750,000
Soil remediation time frame (years)	22	22
Great Miami Aquifer Groundwater		
Receptor	Resident Farmer	Resident Farmer
Risk level	MCL / 1×10^{-5}	MCL / 1×10^{-5}
Uranium cleanup level (ppb)	20	20
Number of extraction wells	28	28
Maximum pumping rate (gpm)	4000	4000
Time frame to restore aquifer (years)	27	27
Present Worth Cost ($)	610,000,000	580,000,000
Total Project Cost ($)	2,170,000,000	2,110,000,000

[a] Cleanup level of 20 ppm for uranium is required in the production area to protect the aquifer.
[b] In-situ volume estimate.
[c] For off-site disposal of volumes less than 50,000 yd^3, shipment may be made by truck rather than rail.
[d] Volume does not include quantity of soil below on-property cleanup level excavated to gain access to deeper contamination or to meet off-property risk goal.

4.3.5 Alternatives 2C, 3C, and 4C - Excavation of Soil (Including Perched Groundwater Zones) with Segregation, and Depending on Contaminant Concentrations, Direct Placement in an On-Property Consolidation Area with an Earthen Cover or Shipment to an Off-Site Disposal Facility; Extraction of Great Miami Aquifer with Treatment Before Discharge

Alternatives 2C, 3C, and 4C are referred to as the "C" alternatives in this section because the same summary level description of primary elements/activities applies to all three alternatives. Differences among these alternatives result from the application of the land use objectives and the associated risk scenarios to the "C" alternatives.

The "C" alternatives vary because of the receptors protected by the various land use objectives. That is, the most sensitive on-property receptor to be protected in Alternative 2C is the resident farmer; in Alternative 3C the receptor is an industrial worker or a recreational user of a developed or undeveloped park; and in 4C the receptor to be protected is the expanded trespasser.

The "C" alternatives were developed to provide decision makers with a comparison of the costs, volumes and technical considerations involved in disposing of contaminated soil in a consolidation area with an earthen cover. As in the "A" alternatives, soil that does not meet WAC for disposal on site is shipped to off-site disposal. In the "C" alternatives the amount of soil shipped off site is considerable because of the stringent WAC for disposal in a consolidation area with an earthen cover, whereas in the "A" and "B" alternatives the amount of soil shipped to off-site disposal is relatively small.

Under this alternative, soil and sediment that exceed PRLs would be excavated with conventional construction equipment, separated according to contaminant concentration, staged (as necessary) and either placed in a consolidation area with an earthen cover or loaded onto rail cars and hauled to an off-site licensed disposal facility.

Contaminated groundwater would be recovered from the Great Miami Aquifer through the use of extraction wells and conveyed to a new central water treatment facility before discharge to the Great Miami River. Perched groundwater zones (i.e., soil and groundwater) that exceed PRLs based upon projected cross-media impacts to the Great Miami Aquifer and/or surface water would be excavated along with all uncontaminated perched groundwater zones exhibiting sustained yields greater than 1 gpm for Alternative 2C. For Alternatives 3C and 4C, uncontaminated perched groundwater zones would be left in place. This difference is a result of the projected receptor scenarios developed under Land Use Objectives 3 and 4 which do not contemplate on-property groundwater consumption.

Impacts to natural resources (e.g., wetlands, floodplains, and terrestrial and aquatic habitat) and cultural resources are anticipated from the implementation of the "C" alternatives. Appropriate mitigation measures would be employed to reduce anticipated impacts. Mitigation measures for wetland impacts would be determined using the 404(b)(1) guidelines from the Clean Water Act.

WAC used in determining appropriate actions to be taken in developing the "C" alternatives were previously presented in Section 4.1.3. For the "C" alternatives, WAC for placement in the consolidation area with an earthen cap are listed in Table 4-1.

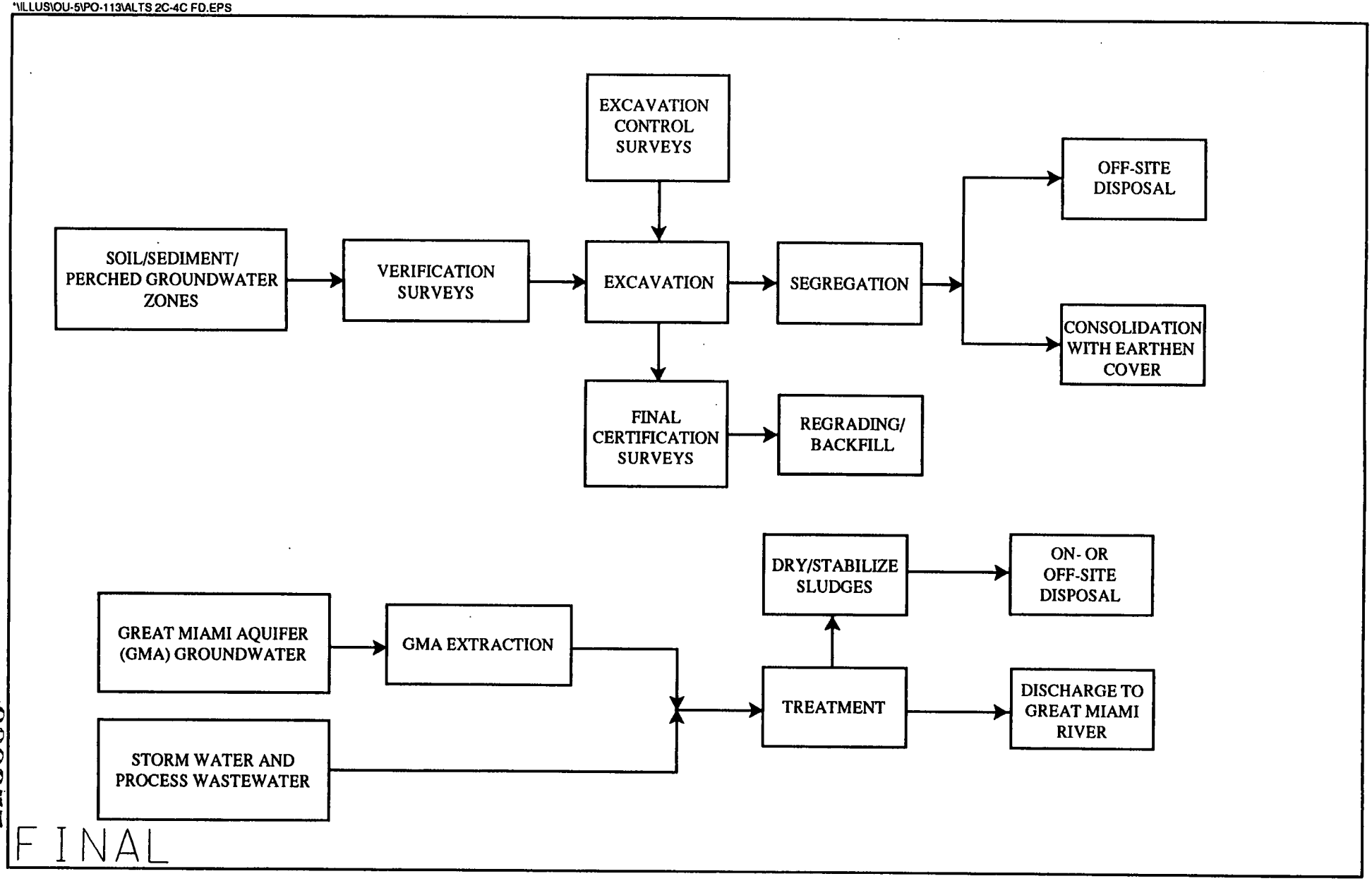
Figure 4-9 presents a conceptual flow diagram of the major elements of the "C" alternatives. Table 4-9 is a matrix table showing the elements for each alternative. Section 5.0 provides a more detailed description of the alternatives passing the screening process conducted in Section 4.0. The following presents a summary level description of the "C" alternatives.

Soil

Using the process options identified and screened in Section 3.0 and the remedial strategies discussed in Section 4.1.5, the "C" alternatives apply the following remedial activities to contaminated soil exceeding PRLs:

- Conducting a sampling program focused on verifying the lateral and vertical extent of soil contamination exceeding PRLs, including confirming estimates of media impacted by releases from HWMUs; soil verification sampling would focus on both the mass and mobility of the contaminants
- Excavating soil exceeding the PRLs including the trap range, beneath the below-grade pipelines, and any additional materials left in place by remediation of other operable units
- Excavating and sorting the contaminated rubble and soil located adjacent to the outfall line at the Great Miami River
- Pretreating soil with concentrations of RCRA-regulated constituents above the WAC established for these constituents.
- Backfilling deep excavation native or imported clay materials
- Regrading and revegetating of excavated areas on property
- Backfilling, regrading, and revegetation/restoration of affected off-property areas
- Collecting certification samples to demonstrate attainment of PRLs
- Placing soil meeting the WAC into the consolidation area with an earthen cover located on property
- Shipping of excavated materials which do exceed the WAC via covered gondola rail cars to an off-site licensed disposal facility.

*\ILLUS\OU-5\PO-113\ALTS 2C-4C FD.EPS



FINAL

FIGURE 4-9. ALTERNATIVES 2C, 3C, AND 4C CONCEPTUAL FLOW DIAGRAM

Sediment

The "C" alternatives would adopt the following remedial activities for sediment:

- Sampling of sediments in Paddys Run, the SSOD, the pilot plant drainage ditch and the Great Miami River to verify the need for excavation/dredging operations
- Dredging or excavating operations to remove sediment exceeding PRLs
- Collecting certification samples to demonstrate attainment of PRLs
- Backfilling and regrading (as required) in excavated areas
- Placing soil which does not exceed the WAC in the consolidation area with an earthen cover located on property
- Shipping of excavated materials which do exceed the WAC by rail cars to an off-site disposal facility, along with soil.

Perched Groundwater

The "C" alternatives adopt the following remedial activities for remediating contaminated perched groundwater:

- Excavating contaminated perched groundwater zones (i.e., soil and groundwater) exceeding PRLs based upon cross-media impacts to the Great Miami Aquifer and the potential for domestic well usage; in Alternative 2C (but not in 3C or 4C) all uncontaminated perched groundwater zones physically capable of a sustained yield of 1 gpm would also be excavated
- Using pumping wells or collection trenches, if required, to facilitate dewatering of perched zones in support of excavation activities
- Pretreating perched water (collected from the excavation) to remove listed hazardous wastes before transferring the groundwater to the AWWT facility
- Treating perched water (collected from the excavations) at the AWWT facility before discharge to the Great Miami River
- Backfilling deep excavations with low permeability native or imported soil
- On-property placement of soil which do not exceed the WAC in the consolidation area with an earthen cover
- Off-site disposal of excavated materials exceeding the above WAC, along with the contaminated soil
- Dewatering, stabilization (if required) and off-site disposal of treatment residues, spent resins, and other remediation residuals. If WAC can be met, on-property disposal facilities may be used.

Great Miami Aquifer

The following summarizes the remedial activities adopted under the "C" alternatives for remediation of the Great Miami Aquifer:

- Extraction of contaminated groundwater exceeding PRLS with recovery wells
- Treatment of recovered groundwater exceeding PRLs (as measured in the aquifer) in a central groundwater treatment facility (constructed as an expansion to the existing AWWT facility)
- Beneficial reuse of treated groundwater, (e.g., dilution of sodium hydroxide, backwashing of resins, etc.), when practical
- Discharge of treated groundwater to the Great Miami River
- Dewatering, stabilization (if required) and off-site disposal of treatment residuals, spent resins, and other remediation residuals.

Surface Water/Wastewater

The following summarizes the remedial activities adopted under the "C" alternatives to address surface water and wastewater generated during remedial activities:

- Continued collection of surface water into storm water retention basins until completion of excavation activities is certified
- Treatment of collected storm water and process wastewaters generated by Operable Units 1 through 5 remedial activities at the AWWT facility with discharge to the Great Miami River
- Dewatering, stabilization (if required) and off-site disposal of treatment residuals, spent resins, and other remediation residuals. If WAC can be met, on-property disposal facilities may be used.
- Decommissioning and dismantling of the AWWT facility, the groundwater treatment facility and other Operable Unit 5 support facilities with off-site disposal of generated rubble.

Institutional/Monitoring Requirements

The following summarizes the institutional controls and monitoring activities required to support the "C" alternatives:

- Performance monitoring during groundwater recovery operations
- Discharge monitoring of effluents to the Great Miami River
- Environmental monitoring during the implementation of the alternative to ensure the protection of human health and compliance with ARARs
- Providing an alternate water supply, through the use of Hamilton County public water supply, to consumers using groundwater with contaminant concentrations above PRLs

- Providing access restrictions to FEMP and off-property excavation areas during remedial operations
- Providing access restrictions to the portion of the property occupied by the consolidation area; continued federal ownership of this portion of the property would be required
- Access restrictions of the remaining areas would vary according to the land use objectives; in Objective 2 use of the area outside the consolidation area would be unrestricted
- Continued environmental monitoring following commencement of remedial actions to extent necessary to ensure long-term performance of the remedy
- Assess the continued performance of the completed remedial actions by having EPA conduct, in consultation with the State of Ohio and DOE, CERCLA reviews at five-year intervals following completion of remedial actions.

Consolidation Area with Earthen Cover

The feature of the "C" alternatives that distinguishes them from the other alternatives is the consolidation area with an earthen cover that would be used to dispose of excavated soil and sediment meeting the WAC developed for that unit. Modeling results indicate that stabilization or other treatment of the soil and sediment will not be necessary to enhance the degree of protection provided by the consolidation area with an earthen cover. Treatability studies for brickmaking, phosphate amendment, and physical separation will be conducted to evaluate the enhancement of long-term effectiveness and for addressing the NCP preference for treatment to reduce toxicity, mobility, or volume. Additional treatment technologies may be evaluated before implementation as new technologies evolve. Conceptually, the consolidation area would be constructed in one-foot layers and compacted. As an area is filled to final grade, that area would be covered with 12 inches of soil and vegetated using topsoil and grasses indigenous to the area. Long-term maintenance of the consolidation area would be provided. The design performance period would be 1000 years.

4.3.5.1 Alternative 2C

This alternative was developed to provide decision makers with a comparison of the cost, volumes and technical considerations involved in using a consolidation area with an earthen cover to dispose of soil and sediment on property instead of in an engineered disposal facility as in the "A" alternatives. It differs from the other "C" alternatives in that the consolidation area is used to a greater extent (i.e., it is used to dispose of more soil) although it conforms to more stringent WAC and therefore provides greater protection for on-property activities. This results from the fact that Land Use Objectives 3 and 4 provide for protection of industrial workers, recreational users and trespassers, rather than a resident farmer, and thus require the excavation of less soil and sediment.

Because all areas of the site, outside of the consolidation area, are suitable for unrestricted use, the on-site resident farmer receptor establishes the basis of this alternative for determining the necessary

degree of protection. The farmer is assumed to experience daily exposure to contaminants in soil, groundwater and feed products via inhalation, ingestion and dermal contact.

Alternative 2C is comprised of removing contaminated soil and sediment, including off-property contaminated soil, and containing a portion of these media in the on-property consolidation area with an earthen cover and transporting the remainder, the more highly contaminated media, to an off-site disposal facility.

Alternative 2C uses criteria that would allow unrestricted use of all areas of the FEMP other than the area containing the consolidation area. Therefore, all areas not occupied by the consolidation area could be released at the discretion of the federal government (after all remedial criteria are met) and not maintained under federal ownership. Table 4-17 provides a summary of Alternative 2C.

4.3.5.2 Alternative 3C

Alternative 3C was developed to provide the decision makers with a comparison of the costs, volumes and technical considerations when limiting on-property land use to more restrictive uses (i.e., requiring less stringent PRLs.) It differs from Alternative 3A in that contaminated soil would be disposed of in a consolidation area with an earthen cover rather than in an engineered disposal facility. It differs from Alternative 2C in that 3C allows only more restrictive uses connected with industrial and recreational activities.

In Alternative 3C, industrial workers and/or recreational uses serve as the basis for the risk scenarios which determine the degree of protection necessary. Such individuals are assumed to be exposed to media remaining after remediation for a limited number of hours per day and days per year.

In Alternative 3C, contaminated soil and sediment, including off-property contaminated soil, is excavated and contained in an on-property consolidation area with an earthen cover or, for the soil that fails to meet the WAC for the consolidation area, transported to an off-site disposal facility.

Alternative 3C uses criteria that would allow the areas of the FEMP other than the area containing the consolidation area to be released for restricted use. Restrictions would prohibit the use of perched groundwater and would limit land use to include industrial and/or recreational activities. Areas of the site other than the consolidation area could be released from federal ownership. Table 4-18 provides a summary of Alternative 3C.

4.3.5.3 Alternative 4C

Alternative 4C was developed to provide decision makers with a comparison of the potential advantage (when compared with Alternatives 2C or 3C) of limiting remediation of soil to the

TABLE 4-17
SUMMARY OF ALTERNATIVE 2C

Soil/Perched Groundwater/Sediment	Risk Range	
	Case 1	Case 2
On-Property Receptor	Resident Farmer	Resident Farmer
On-Property Risk Level	1×10^{-6}	1×10^{-5}
On-Property Uranium Cleanup Level (ppm)	5	15
Off-Property Receptor	Resident Farmer	Resident Farmer
Off-Property Risk Level	1×10^{-6}	1×10^{-5}
Off-Property Uranium Cleanup Level (ppm)	5	15
Volume requiring excavation (yd^3)[a]		
- On-Property	4,450,000	2,340,000
- Off-Property	5,200,000	400,000
- Total	9,650,000	2,740,000
Off-Site Disposal		
- Volume (yd^3)	9,350,000	1,160,000
- Rail Cars	165,000	20,400
On-Site Disposal[b] (yd^3)	0	1,240,000
Soil Remediation Time Frame (years)	22	22
Great Miami Aquifer Groundwater		
Receptor	Resident Farmer	Resident Farmer
Risk Level	1×10^{-6}	MCL / 1×10^{-5}
Uranium Cleanup Level (ppb)	3	20
Number of Extraction Wells	31	28
Maximum Pumping Rate (gpm)	7500	4000
Time Frame to Restore Aquifer (years)	75	27
Present Worth Cost ($)	4,330,000,000	1,910,000,000
Total Project Cost ($)	13,870,000,000	2,780,000,000

[a] Volume does not consider excavation of soil below cleanup level to gain access to deeper contamination.

[b] In-situ volume estimate.

TABLE 4-18
SUMMARY OF ALTERNATIVE 3C

Soil/Perched Groundwater/Sediment	Risk Range				
	Case 3	Case 4	Case 5	Case 6	Case 7
On-Property Receptor	Industrial User	Developed Park User	Undeveloped Park User	Undeveloped Park User	Undeveloped Park User
On-Property Risk Level	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6} w/ ALARA goal for uranium
On-Property Uranium Cleanup Level (ppm)	15	40[a]	80[a]	80[a]	50[a]
Off-Property Receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Off-Property Risk Level	1×10^{-5}	1×10^{-5}	1×10^{-5}	HI=1	HI=1
Off-Property Uranium Cleanup Level (ppm)	15	15	15	50	50
Volume requiring excavation (yd^3)[b]					
- On-Property	1,990,000	1,800,000	1,790,000	1,789,000	1,799,000
- Off-Property	400,000	400,000	400,000	1,000	1,000
- Total	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Off-Site Disposal					
- Volume (yd^3)	1,150,000	1,130,000	1,120,000	1,120,000	1,120,000
- Rail Cars	20,200	19,900	19,700	19,700	19,700
On-Site Disposal (yd^3)[c]	1,220,000	652,000	652,000	652,000	652,000
Soil Remediation Time Frame (years)	22	22	22	22	22
Great Miami Aquifer Groundwater					
Receptor	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer	Resident Farmer
Risk Level	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}	MCL / 1×10^{-5}
Uranium Cleanup Level (ppb)	20	20	20	20	20
Number of Extraction Wells	28	28	28	28	28
Maximum Pumping Rate (gpm)	4000	4000	4000	4000	4000
Time Frame to Restore Aquifer (years)	27	27	27	27	27
Present Worth Cost ($)	880,000,000	820,000,000	800,000,000	770,000,000	770,000,000
Total Project Cost ($)	2,690,000,000	2,290,000,000	2,240,000,000	2,170,000,000	2,170,000,000

[a] Cleanup level of 20 ppm for uranium is required in the production area to protect the aquifer.
[b] In-situ volume estimate.
[c] Volume does not include quantity of soil below on-property cleanup level excavated to gain access to deeper contamination or to meet off-property risk goal.

minimum level of cleanup. It differs from Alternative 4A in that soil is disposed of in an on-property consolidation area with an earthen cover rather than in an engineered disposal facility. It differs from Alternatives 2C and 3C in that only uses by an expanded trespasser are protected in Alternative 4C.

As in all the "C" alternatives, contaminated soil and sediment, including off-property contaminated soil, would be removed and placed in the on-property consolidation area or, for the remaining soil that failed to meet the WAC for the consolidation area, transported for off-site disposal.

Alternative 4C uses criteria that in addition to protecting the expanded trespasser might result in alternate uses of select areas on property being considered on the basis of measured soil concentrations and the results of ongoing environmental monitoring. Under this alternative, continued federal ownership of the entire property would be maintained. Table 4-19 provides a summary of Alternative 4C.

Technical Data Summary - "C" Alternatives

Adopting the defined remedial strategy, specific technical data were developed to the extent necessary to support the alternative screening process. The technical data were developed for the risk cases previously defined in Section 2.0 for the pertinent land use objectives (i.e., Cases 1 and 2 for Objective 2C; Cases 3, 4, 5, 6 and 7 for Objective 3C; and Cases 8 and 9 for Objective 4C.)

4.4 SCREENING OF ALTERNATIVES

4.4.1 Introduction and Purpose

The alternatives developed in Section 4.1 and described in Section 4.3 were evaluated against three broad criteria: effectiveness, implementability, and cost. The criteria for evaluating alternatives are provided in EPA guidance (EPA 1988a) and in the NCP (40 CFR 300). Of these criteria, effectiveness was given the highest consideration. Because the purpose of this screening is to reduce the number of alternatives undergoing a more extensive and qualitative analysis, alternatives were evaluated more generally in this phase than in subsequent detailed analysis. As required by the NCP, the no-action alternative was retained as a baseline against which other alternatives were compared.

Consistent with the NCP, nine specific criteria, within the three broad criteria of effectiveness, implementability and cost, are emphasized to perform the detailed analysis of alternatives. Seven of these criteria are taken into consideration during the initial screening of alternatives. The intent of this screening is to retain those alternatives with the most favorable composite analysis of all factors. The screening criteria are described below.

TABLE 4-19
SUMMARY OF ALTERNATIVE 4C

Soil/Perched Groundwater/Sediment	Risk Range	
	Case 8	Case 9
On-Property Receptor	Trespasser	Trespasser
On-Property Risk Level	1×10^{-6}	1×10^{-6}
On-Property Uranium Cleanup Level[a] (ppm)	100	100
Off-Property Receptor	Resident Farmer	Resident Farmer
Off-Property Risk Level	1×10^{-5}	HI=1
Off-Property Uranium Cleanup Level (ppm)	15	50
Volume requiring excavation (yd^3)[b]		
- On-Property	1,790,000	1,789,000
- Off-Property	400,000	1,000
- Total	2,190,000	1,790,000
Off-Site Disposal		
- Volume (yd^3)	1,120,000	1,120,000
- Rail Cars	19,700	19,700
On-Site Disposal (yd^3)[c]	652,000	652,000
Soil Remediation Time Frame (years)	22	22
Great Miami Aquifer Groundwater		
Receptor	Resident Farmer	Resident Farmer
Risk Level	MCL / 1×10^{-5}	MCL / 1×10^{-5}
Uranium Cleanup Level (ppb)	20	20
Number of Extraction Wells	28	28
Maximum Pumping Rate (gpm)	4000	4000
Time Frame to Restore Aquifer (years)	27	27
Present Worth Cost ($)	800,000,000	780,000,000
Total Project Cost ($)	2,240,000,000	2,170,000,000

[a] Cleanup level of 20 ppm for uranium is required in the production area to protect the aquifer.
[b] In-situ volume estimate.
[c] Volume does not include quantity of soil below on-property cleanup level excavated to gain access to deeper contamination or to meet off-property risk goal.

4.4.1.1 Effectiveness

A key aspect of the screening evaluation is the effectiveness in protecting human health and the environment. In addition to determining the effectiveness of the alternatives in meeting the remedial action objectives and providing protection of human health and the environment, each alternative is evaluated for its effectiveness in achieving reductions in toxicity, mobility, or volume through treatment. Reduction of toxicity, mobility, or volume refers to changes in one or more characteristics of the hazardous substances or contaminated media by the use of treatment that decreases the inherent threats or risks associated with the hazardous material. The short- and long-term effectiveness are also evaluated. Short-term effectiveness refers to the active remediation (construction and implementation) period. Long-term effectiveness refers to the period after the remediation is complete.

Compliance with ARARs is also evaluated under this criterion. ARARs provide the necessary criteria that must be satisfied in order for a remedial alternative to be eligible for selection. In turn, the selected remedial action must comply with all ARARs, unless the use of a waiver is justified.

4.4.1.2 Implementability

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

Technical feasibility refers to the ability to construct, operate, and meet technology-specific regulations for process options until a remedial action is complete. It also includes operation, maintenance, and monitoring of technical components of an alternative, if required, in the future after the remedial action is complete.

Administrative feasibility refers to the ability to obtain approvals from other offices and agencies; the availability of treatment, storage, or disposal services and capacity; and the requirements for and availability of specific equipment and technical specialists.

4.4.1.3 Cost

Cost estimates were prepared for each alternative to allow a relative comparison between similar alternatives. The cost estimates were based on a variety of cost-estimating data, such as cost curves, generic unit costs, vendor information, conventional cost-estimating guides, commercial remedial costs, and previous similar estimates as modified by site-specific information. Cost categories include capital and annual operation and maintenance (O&M) costs.

The capital cost includes direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install a remedial action.

Indirect costs include expenditures for engineering, financial, and other services that are not part of actual installation activities but are required to complete the installation of a remedial alternative.

Annual O&M costs are postconstruction costs necessary to ensure the continued effectiveness of a remedial action. Examples of O&M costs include maintenance and monitoring costs.

Net present worth costs combine capital and annual O&M costs that occur over different time frames. The present worth analysis is used to evaluate expenditures that may occur over different time periods by discounting future costs to a common base year. This allows the costs of various remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and dispersed as needed, would be sufficient to cover all future costs associated with the remedial action.

Total project costs were also computed for each alternative. Total project costs are presented to provide the decision makers with a more realistic portrayal of the actual costs which would be incurred by the federal government to complete remedial actions. The total project cost represents the total escalated cost the government would incur over the life of the project assuming that new funding is acquired on a yearly basis (as it is currently acquired at the FEMP) with an assumed yearly inflation rate of 3.7 percent for supplied services, equipment and materials.

4.4.2 No-Action Alternative

A description of this alternative, no further action over any removal or remedial action that has already occurred, is provided in Section 4.3.1.

Screening Criterion - Effectiveness

The no-action alternative is not protective of human health and the environment because it will result in leaving contaminated media in place with no containment, removal, treatment, or other mitigating measures other than protective barriers that are currently in place. The no-action alternative provides the baseline against which other alternatives are compared.

The no-action alternative would not attain all chemical-specific ARARs. There are not any location-or action-specific ARARs associated with the no-action alternative (see Appendix B).

This alternative would not be effective over the long-term because soil and sediment contaminants would continue to migrate to groundwater and off-property areas. Contaminated groundwater would continue to migrate. Residual risks would be the same as presented in the baseline risk assessment.

The no-action alternative provides no treatment to reduce toxicity, mobility, or volume.

There would be no short-term impacts to the public, workers, or the environment during construction or implementation because no remedial action would be conducted.

Screening Criterion - Implementability

No technologies or process options would be implemented under the no-action alternative.

No permits, licenses, or approvals associated with taking a remedial action would be needed because no actions would be taken at the site.

This criterion is not applicable to the no-action alternative.

Screening Criterion - Cost

There are no net present worth, capital, or annual O&M costs associated with the no-action alternative.

Summary

The no-action alternative is retained for detailed analysis as required by the NCP.

4.4.3 Alternative 1

A description of this alternative, excavation of soil (including perched groundwater zones) with off-site disposal; extraction of Great Miami Aquifer with treatment before discharge, is provided in Section 4.3.2.

Screening Criterion - Effectiveness

This alternative protects human health and the environment by permanently removing all soil and sediment that exceed PRLs based on protection of on- and off-property resident farmers and protection of groundwater. Protection is also achieved by remediating all contaminated groundwater so that, when the remediation is complete, the groundwater would be suitable as a source of drinking water. At the completion of remedial actions, all on-property and off-property areas would be available for unrestricted use.

This alternative would attain all chemical-, location-, and action-specific ARARs (see Appendix B).

Modeling projections indicate that asymptotic conditions may occur for radium, manganese and arsenic within the Great Miami Aquifer at concentrations which exceed the cleanup criteria (i.e., MCLs, HI = 0.2) for these constituents. Despite the projected pumping duration of more than 27 to 75 years for this alternative, the projected geochemical properties of these contaminants within the groundwater system (as represented by their distribution coefficients) may preclude their ability to be adequately flushed to attain PRLs. It should be recognized that there is significant uncertainty associated with accurately modeling the desorption process for these constituents. The FEMP would progressively monitor the effectiveness of groundwater restoration activities to verify the modeling assumptions. In the event the performance data

indicate that asymptotic conditions have been attained for these parameters and that the benefits with continued recovery activities become disproportionate with the associated costs, a TI waiver would be sought.

At the completion of this remedial alternative, soil contaminant concentrations would be reduced to levels below the PRLs, and the site would be available for full unrestricted use. After completion of groundwater restoration, the groundwater contaminant concentrations would be reduced to levels below the PRLs, and site groundwater would be suitable as a source of drinking water. No long-term action would be required after remediation was complete to maintain the effectiveness of this alternative.

In general, Alternative 1 provides no treatment of soil or sediment to reduce toxicity, mobility, or volume. Soil contaminated with hazardous waste as a result of releases from HWMUs would be treated only if necessary to attain LDR treatment standards. Groundwater removed from the perched groundwater zones and the Great Miami Aquifer would be treated using unit processes installed at the AWWT facility and the groundwater treatment facility before being discharged to the Great Miami River.

The predominant short-term impacts associated with this alternative are connected with the transport of material (soil/sediment and groundwater treatment residuals) to the off-site disposal facility, the mechanical hazards to workers during remediation, and the disturbance of soil and the attendant airborne dust emissions. Appropriate mitigative measures would be applied during remedial actions to protect workers and the public. Engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls) would be applied during the implementation phase to minimize short-term risks to the public. Protective equipment and dust suppression techniques would be used to minimize short-term risks to workers. The greatest potential short-term threat to the public and workers would be related to possible fatalities and injuries connected with off-site transport of remediation materials. This threat is directly related to Department of Transportation (DOT) statistics applied to the significant number of rail cars required to ship the material off-site. Short-term risks assessments will be conducted during the detailed analysis of alternatives to quantify the magnitude of these risks. Appendix G discusses short-term risk in more detail.

Minimal impacts to wetlands or floodplain areas are anticipated. Approximately 17 to 36 acres of on-property wetlands will be impacted during implementation of this alternative. A wetland delineation would be conducted to determine whether off-property wetlands, if any, would be adversely affected. Mitigation for wetland impacts would be determined using Clean Water Act Section 404(b)(1) guidelines. There would be short-term impacts to the 100-year and 500-year floodplains of Paddys Run due to excavation activities within and adjacent to the stream. Remediation activities would not alter the flow patterns or uses of the floodplain. Disturbed areas of the floodplain would be regraded to near-original contours after excavation.

It is estimated that it will take 22 years to complete remediation of soil and sediment. Much of this extensive time period is the result of the time required for remediation of other FEMP operable units. A significant inventory of contaminated soil is located adjacent to or underlying the production facilities. Gaining access to this soil must be coordinated with the Operable Unit 3 demolition activities. The current schedule envisions up to 16 years to demolish all FEMP production-related facilities. This must be initiated and partially completed before extensive activity can begin on Operable Unit 5 remediation. Groundwater extraction from the Great Miami Aquifer without treatment is anticipated to continue for 27 to 75 years until PRLs are achieved. This large range is the result of two scenarios being considered, one with a PRL of 20 ppb of uranium which would be completed in about 27 years and the other with a PRL of 3 ppb which would be completed in about 75 years. Wastewater/groundwater treatment is anticipated to be required for up to 27 years for the MCL (20 ppb uranium) case and up to 75 years for the 3 ppb case.

Screening Criterion - Implementability

The proposed soil removal and disposal technologies are widely used. The proposed groundwater extraction and treatment technologies are widely used and reliable if properly maintained. No difficulties would be anticipated in excavation of soil and sediment, installation and maintenance of groundwater extraction systems, or maintenance of the AWWT or groundwater treatment facility processes. The application of ion exchange to such large anticipated fluid volumes would represent an extension of the current industry application of the technology. Adopting a modular system approach would preclude scale-up issues. The maintenance requirements can be accomplished with readily available resources. Groundwater monitoring would be required to observe the progress and effectiveness of groundwater restoration. Monitoring of the treated AWWT and groundwater treatment facility effluents to the Great Miami River would also be required to insure compliance with discharge limits.

The ability to appropriately verify the footprint of excavation at the 10^{-6} soil PRL off-property would be difficult, but implementable. Setting cleanup boundaries would be hindered by the inherent uncertainty in the analytical technique in differentiating above PRL areas from areas exhibiting background.

No permits or licenses for on-site activities would be required to implement this alternative. The FEMP currently holds an Ohio National Pollutant Discharge Elimination System (NPDES) permit allowing the discharge of treated water to the Great Miami River. The NPDES permit would need to be substantially modified to include the additional groundwater flows and contaminants, and the discharge of treated groundwater would be governed by NPDES permit conditions. The maximum groundwater discharge rate (7500 gpm for a PRL of 3 ppb) is less than 10 percent of the historical minimum daily flow rate (76,000 gpm) and 0.5 percent of the historical average flow rate (1,483,000 gpm) of the Great Miami River measured at Hamilton, Ohio, which is the nearest U.S. Geological Survey (USGS) gauging station (Shindel et al. 1987).

The transport of low-level radioactive waste from the FEMP to an off-site facility involves several requirements under EPA and DOT regulations and DOE orders. In addition, compliance with the requirements of each state through which the waste would be transported must be achieved. This would involve obtaining permits and/or notification of the pertinent state agency regarding transport schedules and hauling routes. FEMP waste has been shipped by truck to disposal sites in the western United States, and it is assumed that rail transport would also be acceptable.

For cases involving significant off-property excavation to attain PRLs, significant administrative barriers would be incurred in acquiring access to private properties to perform the required cleanup. Vehicle right-of-way access authorities would be exercised, if required. This method could be extremely time consuming and delay project completion.

No special equipment or specialists are required to implement this alternative. Resources required for maintenance and monitoring should be readily available. Few facilities in the United States are permitted to accept low-level radioactive or mixed waste. Discussions with the disposal facility and state of Utah officials have indicated that the representative facility could potentially be expanded to provide the needed capacity for this alternative. The representative commercial facility has an available permitted capacity of 1.5 million cubic yards with the potential to add an additional
15 million cubic yards of disposal capacity. Environmental issues, compliance issues, and permitting delays could affect the availability of future disposal capacity. The long duration of the remediation effort and the large volume of soil required to be disposed of off site under this alternative (2.40 to 9.35 million cubic yards depending on the target risk level) cause a heavy dependance on the continued availability of off-site disposal capacity. To the extent that the availability of the capacity diminishes, the implementability of the alternative becomes less certain.

Screening Criteria - Cost

The total net present worth cost of this alternative is estimated to range from 1240 to 4340 million dollars, depending on the risk level (i.e., level of protectiveness selected as the remediation goal). Detailed cost estimates appear in Appendix K.

Summary

Alternative 1 would be effective in reducing the toxicity, mobility, and volume of groundwater contaminants. This alternative provides no treatment of soil or sediment to reduce toxicity, mobility, or volume, except for treatment necessary to meet LDR treatment standards. Remedial action objectives would be achieved. This alternative provides for the protection of human health and the environment at the FEMP site because all contaminants would be removed from the site and eliminates the need to rely on long-term institutional controls. Alternative 1 is retained for detailed analysis.

4.4.4 Alternatives 2A, 3A, and 4A

Descriptions of these "A" alternatives, excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentrations, direct placement in an on-property disposal facility or shipment to an off-site disposal facility; extraction of Great Miami Aquifer groundwater with treatment before discharge, are provided in Section 4.3.3.

Screening Criterion - Effectiveness

These alternatives would be protective of human health and the environment by removing soil and sediment with contaminant levels that exceed PRLs. The PRLs vary depending on the most sensitive receptor to be protected based on the particular land use objective. For Alternative 2A, the most sensitive on-property receptor is the resident farmer. For Alternative 3A, this receptor is an industrial worker or a recreational user of a developed or undeveloped park. For Alternative 4A, this receptor is the expanded trespasser. For all of the "A" alternatives, the most sensitive off-property receptor to be protected is the off-property resident farmer. The soil and sediment would be contained in an on-property engineered disposal facility or shipped off site for disposal, depending on the contaminant concentrations. Media that exceeded the WAC for the on-property disposal facility, with the exception of the soil containing hazardous waste which will be pretreated to meet the WAC, would be disposed of off site. Protection is also achieved by remediating contaminated groundwater so that, when remediation is complete, the groundwater would achieve PRLs.

Under Alternative 2A, all contaminated and uncontaminated perched groundwater zones of sufficient yield to be used as a source of drinking water would be removed. For Alternatives 3A and 4A, only contaminated perched groundwater zones with a potential for cross-media impacts which exceed groundwater PRLs would be removed.

At the completion of soil and sediment remedial actions under Alternative 2A, portions of the FEMP property, except for the disposal facility, could be available for unrestricted land use. At the completion of soil and sediment remedial actions under Alternative 3A, portions of the FEMP property, except for the disposal facility, could be available for restricted land use, such as industrial or recreational uses. At the completion of soil and sediment remedial actions under Alternative 4A, portions of the FEMP property, except for the disposal facility, could be used for alternate land uses, at the discretion of the federal government, on the basis of measured soil concentrations and the results of ongoing environmental monitoring. For all of the "A" alternatives, off-property areas would be available for unrestricted land use at the completion of remedial actions for soil and sediment.

The "A" alternatives would attain all chemical-, location-, and action-specific ARARs, except for certain State of Ohio solid waste facility siting requirements (see Appendix B). A waiver of these siting requirements would be needed based on a demonstration of equivalent performance. This would be demonstrated through: the use of stringent design criteria for the capping and lining systems; situating the

cell at a location on the FEMP property which exhibits some of the most favorable geologic conditions present at the site; and delineation of concentration-based WAC for the disposal facility, all of which ensure the long-term performance of the disposal system. A more thorough discussion concerning the basis for requesting the waiver is presented in Appendix B and Section 5.0.

Modeling projections indicate that asymptotic conditions may occur for radium, manganese and arsenic within the Great Miami Aquifer at concentrations which exceed the cleanup criteria (i.e., MCLs, HI = 0.2) for these constituents. Despite the projected pumping duration of more than 27 to 75 years for these alternatives, the projected geochemical properties of these contaminants within the groundwater system (as represented by their distribution coefficients) may preclude their ability to be adequately flushed to attain PRLs. It should be recognized that there is significant uncertainty associated with accurately modeling the desorption process for these constituents. The FEMP would progressively monitor the effectiveness of groundwater restoration activities to verify the modeling assumptions. In the event the performance data indicate that asymptotic conditions have been attained for these parameters and that the benefits with continued recovery activities become disproportionate with the associated costs, a TI waiver would be sought.

For all of the "A" alternatives, the contaminated soil and sediment not attaining the WAC would be disposed of in an off-site facility. Less contaminated soil and sediment would be disposed of in an aboveground engineered facility with multilayer capping and lining systems. The conceptual design of the capping system would include a vegetative soil layer, a composite gravel and geotextile filter layer, a biotic barrier, a composite gravel and geotextile drainage layer, a composite sheet of high density polyethylene (HDPE) over bentonite geocomposite, a compacted, low-permeability clay soil layer to impede infiltration and attenuate radon emissions, and a compacted contouring soil layer of varying thickness. To ensure protection of the aquifer the lining system would include a leachate detection zone, a leachate collection system, a synthetic membrane, a leak detection zone, a leak collection system, and a low-permeability clay layer. A protective layer to minimize burrowing or root penetration would also be included. These design features reduce the potential for infiltration and contaminant migration. These features also enhance the detection and collection of infiltration into and contaminant migration from the disposal unit. The disposal facility would be designed for a 1000-year life with provisions for intruder protection. The performance of the disposal system will be measured by leachate, leak, and groundwater monitoring systems. Regular inspections, repairs, and maintenance of the disposal facility would continue, as needed, to insure the long-term effectiveness and permanence of these alternatives. The rigorous design requirements and the establishment of appropriate concentration-based WAC would also ensure the long-term effectiveness of these alternatives.

The groundwater contaminant concentrations would be reduced to levels below the PRLs (except as previously discussed) after the completion of groundwater restoration. The adoption of conservatively

based PRLs which accommodate cross-media impact considerations would provide added certainty to the long-term protection of the Great Miami Aquifer.

In general, the "A" alternatives provide no treatment of soil or sediment to reduce toxicity, mobility, or volume. Soil contaminated with hazardous waste as a result of releases from HWMUs that is to be disposed of off site would be treated only if necessary to attain LDR treatment standards. Soil contaminated with hazardous waste envisioned for on-property disposal would be treated to the extent necessary to attain the WAC. DOE, however, has made a commitment to investigate treatment options for all soil destined for the on-property disposal facility over the life of the remedial action. Groundwater extracted and removed from the perched groundwater zones and the Great Miami Aquifer would be treated, as required, using unit processes installed at the AWWT and/or groundwater treatment facility before being discharged to the Great Miami River.

The predominant short-term impacts associated with these alternatives are connected with the transport of material (soil/sediment and groundwater treatment residuals) to the off-site disposal facility, mechanical hazards to workers during remediation, and the disturbance of soil and the attendant airborne dust emissions. Appropriate mitigative measures would be applied during remedial actions to protect workers and the public. Engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls) would be applied during the implementation phase to minimize short-term risks to the public. Protective equipment and dust suppression techniques would be used to minimize short-term risks to workers. The greatest potential short-term threat to the public and workers would be related to possible fatalities and injuries connected with off-site transport of remediation materials. This threat is directly related to DOT statistics applied to the significant number of rail cars required to ship the material off site. Short-term risk assessments will be conducted during the detailed analysis of alternatives to quantify the magnitude of these risks. Appendix G discusses short-term risk in more detail.

Minimal impacts to wetlands or floodplain areas are anticipated. Approximately 9 to 36 acres of on-property wetlands will be impacted during implementation of these alternatives. A wetland delineation would be conducted to determine whether off-property wetlands, if any, would be adversely affected. Mitigation measures for wetlands would be determined using Clean Water Act Section 404(b)(1) guidelines. There would be short-term impacts to the 100-year and 500-year floodplains of Paddys Run due to excavation activities within and adjacent to the stream. Remediation activities would not alter the flow patterns or uses of the floodplain. Disturbed areas of the floodplain would be regraded to near original contours after excavation.

It is estimated that it will take 22 years to complete remediation of soil and sediment. Much of this extensive time period is the time required for remediation of other FEMP operable units. A significant inventory of contaminated soil is located adjacent to or underlying the production facilities. Gaining access to this soil must be coordinated with the Operable Unit 3 demolition activities. The current

schedule envisions up to 16 years to demolish all FEMP production related facilities. This must be initiated and partially completed before extensive activity can begin on Operable Unit 5 remediation. Groundwater extraction from the Great Miami Aquifer is anticipated to continue for 27 to 75 years until PRLs are achieved. This large range is the result of two scenarios being considered, one with a PRL of 20 ppb of uranium and an extraction period of about 27 years and the other with a PRL of 3 ppb and an extraction period of about 75 years. Wastewater/groundwater treatment is anticipated to be required for up to 27 years for the MCL (20 ppb of uranium) case and up to 75 years for the 3 ppb case.

Screening Criterion - Implementability

The proposed soil and sediment removal and disposal technologies for the "A" alternatives are widely used. Construction of the on-property disposal facility is implementable. The proposed groundwater extraction and treatment technologies are widely used and reliable if properly maintained. No difficulties would be anticipated in excavation of soil and sediment, construction of the disposal facility, installation and maintenance of groundwater extraction systems, or maintenance of the disposal facility and the AWWT or groundwater treatment facility processes. The application of ion exchange to such large anticipated flow volumes would represent an extension of current industry application of the technology. Adopting a modular system approach would preclude scale-up issues. The on-property disposal facility would be designed to minimize long-term maintenance requirements. The maintenance requirements can be accomplished using readily available resources. Groundwater monitoring would be required to observe the progress and effectiveness of groundwater restoration and to evaluate the long-term effectiveness of the disposal facility in containing the soil and sediment contaminants. Monitoring of the treated AWWT and groundwater treatment facility effluents to the Great Miami River would also be required to ensure compliance with discharge limits.

The ability to appropriately verify the footprint of excavation at the 10^{-6} soil PRL off property would be difficult, but implementable. Setting cleanup boundaries would be hindered by the inherent uncertainty in the analytical technique in differentiating above PRL areas from areas exhibiting background.

No additional permits or licenses for on-site activities would be required to implement these alternatives. Regulatory agency approval would be required to site the disposal facility over a sole-source aquifer. The FEMP currently holds an Ohio NPDES permit allowing the discharge of treated water to the Great Miami River. The NPDES permit would need to be substantially modified to include the additional groundwater flows and contaminants, and the discharge of groundwater would be governed by NPDES conditions. The maximum groundwater discharge rate (7500 gpm for Alternative 2A and 4000 gpm for Alternatives 3A and 4A) is less than 10 percent of the historical minimum daily flow rate (76,000 gpm) and less than 0.5 percent of the historical average flow rate (1,483,000 gpm) of the Great Miami River measured at Hamilton, Ohio, which is the nearest USGS gaging station (Shindel et al. 1987).

The transport of low-level radioactive waste from the FEMP to an off-site facility invokes several requirements under EPA and DOT regulations and DOE orders. In addition, compliance with the requirements of each state through which the waste would be transported must be achieved. This would involve obtaining permits and/or notification of the pertinent state agency regarding transport schedules and hauling routes. FEMP waste has been shipped by truck to disposal sites in the western United States, and it is assumed that rail transport would also be acceptable.

Administrative barriers similar to those discussed for Alternative 1 for acquiring access to off-property private land could be expected for risk cases under the "A" alternatives (i.e., Alternative 2A, Case 1) which envision significant off-property excavation.

No special equipment or specialists are required to implement the "A" alternatives. Resources required for maintenance and monitoring should be readily available. The representative commercial facility proposed for disposal of groundwater treatment residuals and contaminated soil and sediment that exceeds the WAC for the on-property disposal facility is permitted to accept low-level radioactive waste, hazardous waste, and mixed waste. The future availability of off-site licensed disposal capacity is not a concern as it was for Alternative 1 because the estimated volumes for off-site disposal (25,000 to 50,000 cubic yards depending on the land use objective and target risk range) are much lower for the "A" alternatives. Thus, should the availability of off-site disposal capacity diminish, or disappear altogether, overall implementation of the "A" alternatives will be affected significantly less than Alternative 1 by the need to substitute a different method for remediation.

Screening Criterion - Cost

The total net present worth cost of Alternative 2A is estimated to range from 720 to 2290 million dollars. The total net present worth cost of Alternative 3A is estimated to range from 580 to 690 million dollars. The total net present worth cost of Alternative 4A is estimated to range from 580 to 610 million dollars. The cost for each alternative depends on the target risk level (i.e., level of protection selected as the remediation goal). Detailed cost estimates appear in Appendix K.

Summary

Alternatives 2A, 3A, and 4A would be effective in reducing the toxicity, mobility, and volume of groundwater contaminants. These alternatives provide no treatment of soil or sediment to reduce toxicity, mobility, or volume, except for treatment necessary to meet LDR treatment standards. Remedial action objectives would be achieved. All of the "A" alternatives are retained for detailed analysis.

4.4.5 Alternatives 2B, 3B, and 4B

Descriptions of the "B" alternatives, excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentration, direct placement in an on-property consolidation

area with cap or shipment to an off-site disposal facility; extraction of Great Miami Aquifer with treatment before discharge, are provided in Section 4.3.4.

Screening Criterion - Effectiveness

These alternatives would be protective of human health and the environment by removing soil and sediment with contaminant levels that exceed PRLs. The PRLs vary depending on the most sensitive receptor to be protected based on the particular land use objective. For Alternative 2B, the most sensitive on-property receptor is the resident farmer. For Alternative 3B, this receptor is an industrial worker or a recreational user of a developed or undeveloped park. For Alternative 4B, this receptor is the expanded trespasser. For all of the "B" alternatives, the most sensitive off-property receptor to be protected is the off-property resident farmer. The soil and sediment with contaminant concentrations less than the WAC would be placed into the consolidation area with multilayer cap. Soil and sediment with contaminant concentrations exceeding these WAC would be disposed of off site. Protection is also achieved by remediating contaminated groundwater so that, when remediation is complete, the groundwater would achieve PRLs.

Under Alternative 2B, all contaminated and uncontaminated perched groundwater zones of sufficient yield to be used as a source of drinking water would be removed. For Alternatives 3B and 4B, only contaminated perched groundwater with a potential for cross-media impacts which exceed groundwater PRLs would be removed.

At the completion of soil and sediment remedial actions under Alternative 2B, portions of the FEMP property, except for the consolidation area with cap, could be available for unrestricted land use. At the completion of soil and sediment remedial actions under Alternative 3B, portions of the FEMP property, except for the consolidation area with cap, could be available for restricted land use, such as industrial or recreational uses. At the completion of soil and sediment remedial actions under Alternative 4B, portions of the FEMP property, except for the consolidation area with cap, could be used for alternate uses, at the discretion of the federal government, on the basis of measured soil concentrations and the results of ongoing environmental monitoring. For all of the "B" alternatives, off-property areas would be available for unrestricted use at the completion of remedial actions for soil and sediment.

These alternatives would attain all chemical-, location-, and action-specific ARARs, except for certain State of Ohio solid waste disposal facility siting requirements (e.g., location above a sole-source aquifer, unsuitable geology) (see Appendix B). A sufficient basis for obtaining a waiver of these siting criteria could not viably be demonstrated for these alternatives due to the reliance of consolidation areas placed on the existing geology in lieu of engineering controls, such as a lining system.

Modeling projections indicate that asymptotic conditions may occur for radium, manganese and arsenic within the Great Miami Aquifer at concentrations which exceed the cleanup criteria (i.e., MCLs, HI =

0.2) for these constituents. Despite the projected pumping duration of more than 27 to 75 years for these alternatives, the projected geochemical properties of these contaminants within the groundwater system (as represented by their distribution coefficients) may preclude their ability to be adequately flushed to attain PRLs. It should be recognized that there is significant uncertainty associated with accurately modeling the desorption process for these constituents. The FEMP would progressively monitor the effectiveness of groundwater restoration activities to verify the modeling assumptions. In the event the performance data indicate that asymptotic conditions have been attained for these parameters and that the benefits with continued recovery activities become disproportionate with the associated costs, a TI waiver would be sought.

For all of the "B" alternatives, the more contaminated soil and sediment would be disposed of in an off-site disposal facility. Less contaminated soil and sediment would be placed in a consolidation area and covered with a multilayer cap. The multilayer cap would be designed for a 1000-year life. The performance of the cap would be measured by a groundwater monitoring system. Regular inspections, repairs, and maintenance of the multilayer cap would be required to ensure the long-term effectiveness and permanence of these alternatives. The cap would reduce the potential for infiltration and contaminant migration. There is increased uncertainty in long-term effectiveness of this system in protecting the underlying aquifer due to sole reliance on existing geologic material and the long design life to aid in the protection of the Great Miami Aquifer.

Soil and sediment with contaminant concentrations that exceed the WAC for the consolidation area with multilayer cap would be permanently removed for disposal at an off-site facility (with the exception of soil containing hazardous waste which would be pretreated to meet the WAC); therefore no long-term action would be required to maintain effectiveness.

The groundwater contaminant concentrations would be reduced to levels below the PRLs (except as previously discussed) after the completion of groundwater restoration. The adoption of conservatively based soil PRLs which accommodate cross-media impact considerations would provide added certainty to the long-term protection of the Great Miami Aquifer.

In general, the "B" alternatives provide no treatment of soil or sediment to reduce toxicity, mobility, or volume. Soil contaminated with hazardous waste as a result of releases from HWMUs that is to be disposed of off site would be treated only as necessary to attain LDR treatment standards. Soil contaminated with hazardous waste envisioned for on-property consolidation with multilayer cap would be treated to the extent necessary to attain the WAC. Groundwater extracted and removed for the perched groundwater zones and the Great Miami Aquifer would be treated, as required, using unit processes installed at the AWWT and/or groundwater treatment facility before being discharged to the Great Miami River.

The predominant short-term impacts associated with these alternatives are connected with the transport of material (soil/sediment and groundwater treatment residuals) to the off-site disposal facility, mechanical hazards to workers during remediation, and the disturbance of soil and the attendant airborne dust emissions. Appropriate mitigative measures would be applied during remedial actions to protect workers and the public. Engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls) would be applied during the implementation phase to minimize short-term risks to the public. Protective equipment and dust suppression techniques would be used to minimize short-term risks to workers. The greatest potential short-term threat to the public and workers would be related to possible fatalities and injuries connected with off-site transport of remediation materials. This threat is directly related to DOT statistics applied to the significant number of rail cars required to ship the material off-site. Short-term risks assessments will be conducted during the detailed analysis of alternatives to quantify the magnitude of these risks. Appendix G discusses short-term risk in more detail.

Minimal impacts to wetlands or floodplain areas are anticipated. Approximately 9 to 36 acres of on-property wetlands will be impacted during implementation of these alternatives. A wetland delineation would be conducted to determine whether off-property wetlands, if any, would be adversely affected. Mitigation measures would be determined using Clean Water Act Section 404(b)(1) guidelines. There would be short-term impacts to the 100-year and 500-year floodplains of Paddys Run due to excavation activities within and adjacent to the stream. Remediation activities would not alter the flow patterns or uses of the floodplain. Disturbed areas of the floodplain would be regraded to near original contours after excavation.

It is estimated that it will take 22 years to complete remediation of soil and sediment. Much of this extensive time period is the time required for remediation of other FEMP operable units. A significant inventory of contaminated soil is located adjacent to or underlying the production facilities. Gaining access to this soil must be coordinated with the Operable Unit 3 demolition activities. The current schedule envisions up to 16 years to demolish all FEMP production-related facilities. This must be initiated and partially completed before extensive activity can begin on Operable Unit 5 remediation. Groundwater extraction from the Great Miami Aquifer is anticipated to continue for 27 to 75 years until PRLs are achieved. This large range is the result of two scenarios being considered, one with a PRL of 20 ppb of uranium and an extraction period of about 27 years and the other with a PRL of 3 ppb and an extraction period of about 75 years. Wastewater/groundwater treatment is anticipated to be required for up to 27 years for the MCL (20 ppb uranium) case and up to 75 years for the 3 ppb case.

Screening Criterion - Implementability

The proposed soil and sediment removal, containment, and disposal technologies for the "B" alternatives are widely used. Construction of the consolidation area and multilayer cap is readily implementable. The proposed groundwater extraction and treatment systems are widely used and reliable if properly maintained. No difficulties would be anticipated in excavation of soil and sediment, construction of the

multilayer cap, installation and maintenance of the groundwater extraction systems, or maintenance of the multilayer cap and the AWWT and groundwater treatment facility processes. The application of ion exchange to such large anticipated fluid volumes would represent an extension of the current industry application of the technology. Adopting a modular system approach would preclude scale-up issues. The multilayer cap would be designed to minimize long-term maintenance requirements. The maintenance requirements can be accomplished using readily available resources. Groundwater monitoring would be required to observe the progress and effectiveness of groundwater restoration and to evaluate the long-term effectiveness of the multilayer cap in controlling the migration of contaminants. Monitoring of the treated AWWT and groundwater treatment facility effluents to the Great Miami River would also be required to ensure compliance with discharge limits.

The ability to appropriately verify the footprint of excavation at the 10^{-6} soil PRL off-property would be difficult, but implementable. Setting cleanup boundaries would be hindered by the inherent uncertainty in the analytical technique in differentiating above-PRL areas from areas exhibiting background.

No additional permits or licenses for on-site activities would be required to implement these alternatives. Regulatory agency approval would be required to consolidate and cap material that contains hazardous and radioactive constituents over a sole-source aquifer. It is not anticipated that approval (i.e., waiver of an ARAR of State of Ohio solid waste disposal facility siting requirements) could be obtained because the equivalent performance could not viably be demonstrated. The FEMP currently holds an Ohio NPDES permit allowing the discharge of treated water to the Great Miami River. The NPDES permit would need to be substantially modified to include the additional groundwater flows and contaminants, and the discharge of treated groundwater would be governed by NPDES permit conditions. The maximum groundwater discharge rate (7500 gpm for Alternative 2B and 4000 gpm for Alternatives 3B and 4B) are each less than 10 percent of the historical minimum daily flow rate (76,000 gpm) and equal to or less than 0.5 percent of the historical average flow rate (1,483,000 gpm) of the Great Miami River measured at Hamilton, Ohio, which is the nearest USGS gaging station (Shindel et al. 1987).

The transport of low-level radioactive waste from the FEMP to an off-site facility invokes several requirements under EPA and DOT regulations and DOE orders. In addition, compliance with the requirements of each state through which the waste would be transported must be achieved. This would involve obtaining permits and/or notification of the pertinent state agency regarding transport schedules and hauling routes. FEMP waste has been shipped by truck to disposal sites in the western United States, and it is assumed that rail transport would also be acceptable.

Administrative barriers similar to those discussed for Alternative 1 for acquiring access to off-property private land could be expected for risk cases under the "B" alternatives which envision significant off-property excavation.

No special equipment or services are required to implement these alternatives. Resources required for maintenance and monitoring should be readily available. The representative commercial facility proposed for disposal of groundwater treatment residuals and contaminated soil and sediment that exceeds the WAC for the consolidation area with multilayer cap is permitted to accept low-level radioactive waste, hazardous waste, and mixed waste. The future availability of off-site licensed disposal capacity is not as much of a concern as for Alternative 1 because the estimated volume for off-site disposal (25,000 to 515,000 cubic yards depending on the land use objective and target risk levels) are much lower for the "B" alternatives. As with the "A" alternatives, should the availability of off-site disposal capacity diminish or disappear altogether, overall implementation of the "B" alternatives will be affected significantly less than Alternative 1 by the need to substitute a different method for remediation.

Screening Criteria - Cost

The total net present worth cost of Alternative 2B is estimated to range from 720 to 2320 million dollars. The total net present worth cost of Alternative 3B is estimated to range from 580 to 690 million dollars. The total net present worth cost of Alternative 4B is estimated to range from 580 to 610 million dollars. The cost for each alternative depends on the target risk level (i.e., level of protectiveness selected as the remediation goal). Detailed cost estimates appear in Appendix K.

Summary

Alternatives 2B, 3B, and 4B would be effective in reducing toxicity, mobility, and volume of groundwater contaminants. These alternatives provide no treatment of soil or sediment to reduce toxicity, mobility, or volume, except for treatment necessary to meet LDR treatment standards. Remedial action objectives would be achieved at the completion of remedial actions; however, there are concerns with the long-term effectiveness and permanence of the cap. This uncertainty arises due to the reliance on existing geologic material to aid in the protection of groundwater combined with the long cap design life of 1000 years. Whereas the engineered facility included in the "A" alternatives provides an opportunity to design the facility bottom to offset the limitations of the existing geology with respect to protection of the underlying aquifer, the multilayered cap over the consolidation area (i.e., without a bottom liner) provides no such opportunity. In addition, it is considered not technically viable to demonstrate the equivalent standard of performance required to obtain the waivers. For these reasons, Alternatives 2B, 3B, and 4B are not retained for detailed analysis.

4.4.6 Alternatives 2C, 3C, and 4C

Descriptions of the "C" alternatives, excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentrations, direct placement in an on-property consolidation area with earthen cover or shipment to an off-site disposal facility; extraction of Great Miami Aquifer with treatment before discharge, are provided in Section 4.3.5.

Screening Criterion - Effectiveness

These alternatives would be protective of human health and the environment by removing soil and sediment with contaminant levels that exceed PRLs. The PRLs vary depending on the most sensitive receptor to be protected based on the particular land use objective. For Alternative 2C, the most sensitive on-property receptor is the resident farmer. For Alternative 3C, this receptor is an industrial worker or a recreational user of a developed or undeveloped park. For Alternative 4C, this receptor is the expanded trespasser. For all of the "C" alternatives, the most sensitive off-property receptor to be protected is the off-property resident farmer. The soil and sediment would be placed into an on-property consolidation area with an earthen cover or shipped off site for disposal, depending on the contaminant concentrations. Media that exceed the WAC for the on-property consolidation area with earthen cover, with the exception of the soil containing hazardous waste which will be pretreated to meet the WAC, would be disposed of off site. Protection is also achieved by remediating contaminated groundwater so that, when remediation is complete, the groundwater would achieve PRLs.

Under Alternative 2C, all contaminated and uncontaminated perched groundwater zones of sufficient yield to be used as a source of drinking water would be removed. For Alternatives 3C and 4C, only contaminated perched groundwater zones with a potential for cross-media impacts which exceed groundwater PRLs would be removed.

At the completion of soil and sediment remedial actions under Alternative 2C, portions of the FEMP property, except for the consolidation area with earthen cover, would be available for unrestricted land use. At the completion of soil and sediment remedial actions under Alternative 3C, portions of the FEMP property, except for the consolidation area with earthen cover, would be available for restricted land use, such as industrial or recreational uses. At the completion of soil and sediment remedial actions under Alternative 4C, portions of the FEMP property, except for the consolidation area with earthen cover, could be available for alternate uses, at the discretion of the federal government, on the basis of measured soil concentrations and the results of ongoing environmental monitoring. For all of the "C" alternatives, off-property areas would be available for unrestricted use at the completion of remedial actions for soil and sediment.

These alternatives would attain all chemical-, location-, and action-specific ARARs except for certain State of Ohio solid waste disposal facility siting requirements (e.g., location above a sole-source aquifer)(see Appendix B). An ARAR waiver (granted by EPA) to the State of Ohio's solid waste disposal siting prohibitions would be required. The State of Ohio has expressed an opinion that the basis for the waiver cannot be met without the incorporation of an engineered disposal facility for excavated soil that remains on site.

Modeling projections indicate that asymptotic conditions may occur for radium, manganese and arsenic within the Great Miami Aquifer at concentrations which exceed the cleanup criteria (i.e., MCLs, HI =

0.2) for these constituents. Despite the projected pumping duration of more than 27 to 75 years for these alternatives, the projected geochemical properties of these contaminants within the groundwater system (as represented by their distribution coefficients) may preclude their ability to be adequately flushed to attain PRLs. It should be recognized that there is significant uncertainty associated with accurately modeling the desorption process for these constituents. The FEMP would progressively monitor the effectiveness of groundwater restoration activities to verify the modeling assumptions. In the event the performance data indicate that asymptotic conditions have been attained for these parameters and that the benefits with continued recovery activities become disproportionate with the associated costs, a TI waiver would be sought.

For all of the "C" alternatives, the more contaminated soil and sediment would be disposed of in an off-site disposal facility. Less contaminated soil and sediment would be placed in a consolidation area, covered with clean soil, and revegetated. Only soil and sediment with contaminant concentrations that are protective of groundwater would be placed in the consolidation area. Regular monitoring and inspections would be conducted to ensure that the soil and vegetative cover remain in place and effective in controlling erosion of slightly contaminated soil and sediment placed beneath the earthen cover.

The groundwater contaminant concentrations would be reduced to levels below the PRLs (except as previously discussed) after the completion of groundwater restoration. The adoption of conservatively based soil PRLs which accommodate cross-media impact considerations would provide added certainty to the long-term protection of the Great Miami Aquifer.

In general, the "C" alternatives provide no treatment of soil or sediment to reduce toxicity, mobility, or volume. Soil contaminated with hazardous waste as a result of releases from HWMUs that is to be disposed of off site would be treated only as necessary to attain LDR treatment standards. Soil contaminated with hazardous waste envisioned for on-property consolidation would be treated to the extent necessary to attain the WAC. Groundwater extracted and removed from the perched groundwater zones and the Great Miami Aquifer would be treated, as required, using unit processes installed at the AWWT and/or groundwater treatment facility before being discharged to the Great Miami River.

The predominant short-term impacts associated with these alternatives are connected with the transport of material (soil/sediment and groundwater treatment residuals) to the off-site disposal facility, mechanical hazards to workers during remediation, and the disturbance of soil and the attendant airborne dust emissions. Appropriate mitigative measures would be applied during remedial actions to protect workers and the public. Engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls) would be applied during the implementation phase to minimize short-term risks to the public. Protective equipment and dust suppression techniques would be used to minimize short-term risks to workers. The greatest potential short-term threat to the public and workers would be related to possible fatalities and injuries connected with off-site transport of remediation materials. This

threat is directly related to DOT statistics applied to the significant number of rail cars required to ship the material off site. Short-term risks assessments will be conducted during the detailed analysis of alternatives to quantify the magnitude of these risks. Appendix G discusses short-term risk in more detail.

Minimal impacts to wetlands or floodplain areas are anticipated. Approximately 9 to 36 acres of on-property wetlands will be impacted during implementation of these alternatives. A wetland delineation would be conducted to determine whether off-property wetlands, if any, would be adversely affected. Mitigation measures for wetlands would be determined using Clean Water Act Section 404(b)(1) guidelines. There would be short-term impacts to the 100-year and 500-year floodplains of Paddys Run due to excavation activities within and adjacent to the stream. Remediation activities would not alter the flow patterns or uses of the floodplain. Disturbed areas of the floodplain would be regraded to near original contours after excavation.

It is estimated that it will take 22 years to complete remediation of soil and sediment. Much of this extensive time period is the time required for remediation of other FEMP operable units. A significant inventory of contaminated soil is located adjacent to or underlying the production facilities. Gaining access to this soil must be coordinated with Operable Unit 3 demolition activities. The current schedule envisions up to 16 years to demolish all FEMP production-related facilities. This must be initiated and partially completed before extensive activity can begin on Operable Unit 5 remediation. Groundwater extraction from the Great Miami Aquifer is anticipated to continue for 27 to 75 years until PRLs are achieved. This large range is the result of two scenarios being considered, one with a PRL of 20 ppb of uranium and an extraction period of about 27 years and the other with a PRL of 3 ppb and an extraction period of about 75 years. Wastewater/groundwater treatment is anticipated to be required for up to 27 years for the MCL (20 ppb uranium) case and up to 75 years for the 3 ppb case.

Screening Criterion - Implementability

The proposed soil and sediment removal, containment, and disposal technologies for the "C" alternatives are widely used. Construction of the consolidation area with earthen cover is readily implementable. The proposed groundwater extraction and treatment technologies are widely used and reliable if properly maintained. No difficulties would be anticipated in excavation of soil and sediment, installation and maintenance of groundwater extraction systems, or maintenance of the earthen cover and the AWWT and groundwater treatment facility processes. The application of ion exchange to such large anticipated fluid volumes would represent an extension of the current industry application of the technology. Adopting a modular system approach would preclude scale-up issues. Groundwater monitoring would be required to observe the progress and effectiveness of groundwater restoration. Although material placed in the consolidation area would have contaminant concentrations that are protective of groundwater, groundwater monitoring would be implemented to evaluate the long-term effectiveness of the consolidation area because of the long 1000-year design life of alternatives for Operable Unit 5. Monitoring of the treated AWWT

and groundwater treatment facility effluents to the Great Miami River would also be required to ensure compliance with discharge limits.

The ability to appropriately verify the footprint of excavation at the 10^{-6} soil PRL off property would be difficult, but implementable. Setting cleanup boundaries would be hindered by the inherent uncertainty in the analytical technique in differentiating above-PRL areas from areas exhibiting background.

No additional permits or licenses for on-site activities would be required to implement these alternatives. Regulatory agency approval may be required to consolidate lightly contaminated material that contains hazardous and radioactive constituents over a sole-source aquifer. It is anticipated that such approval would be granted, because only soil and sediment with contaminant concentrations that are protective of groundwater would be placed in the consolidation area. The risk-based WAC for the consolidation area with earthen cover would be very stringent. The FEMP currently holds an Ohio NPDES permit allowing the discharge of treated water to the Great Miami River. The NPDES permit would need to be substantially modified to include the additional groundwater flows and contaminants, and the discharge of treated groundwater would be governed by NPDES permit conditions. The maximum groundwater discharge rate (7500 gpm for Alternative 2C and 4000 gpm for Alternatives 3C and 4C) is less than 10 percent of the historical minimum daily flow rate (76,000 gpm) and less than 0.5 percent of the historical average flow rate (1,483,000 gpm) of the Great Miami River measured at Hamilton, Ohio, which is the nearest USGS gauging station (Shindel et al. 1987).

The transport of low-level radioactive waste from the FEMP to an off-site facility invokes several requirements under EPA and DOT regulations and DOE orders. In addition, compliance with the requirements of each state through which the waste would be transported must be achieved. This would involve obtaining permits and/or notification of the pertinent state agency regarding transport schedules and hauling routes. FEMP waste has been shipped by truck to disposal sites in the western United States, and it is assumed that rail transport would also be acceptable.

Administrative barriers similar to those discussed for Alternative 1 for acquiring access to off-property private land could be expected for risk cases under the "C" alternatives which envision significant off-property excavation.

No special equipment or services are required to implement these alternatives. Resources required for maintenance and monitoring should be readily available. The representative commercial facility proposed for disposal of soil, sediment, and groundwater treatment residuals is permitted to accept low-level radioactive waste, hazardous waste, and mixed waste. Discussions with the disposal facility and State of Utah officials have indicated that the representative facility could potentially be expanded to provide the needed capacity for the "C" alternatives. This facility has an available permitted capacity of 1.5 million cubic yards of disposal capacity with the potential to add an additional 15 million cubic yards of disposal

capacity. The implementability of these alternatives becomes more uncertain in the future because of unknown future availability of off-site licensed disposal capacity to accommodate Operable Unit 5 waste volumes for these alternatives (1.12 to 9.35 million cubic yards depending on the land use objective and target risk level) over the more than 20-year duration of soil-related remedial actions. Much more soil and sediment would be disposed off site under the "C" alternatives than in the "A" or "B" alternatives because of the restrictive risk-based WAC that would be applied to the consolidation area with earthen cover.

Screening Criteria - Cost

The total net present worth cost of Alternative 2C is estimated to range from 910 to 4330 million dollars. The total net present worth cost of Alternative 3C is estimated to range from 770 to 880 million dollars. The total net present worth cost of Alternative 4C is estimated to range from 780 to 800 million dollars. The cost for each alternative depends on the target risk level (i.e., level of protectiveness selected as the remediation goal). Detailed cost estimates appear in Appendix K.

Summary

Alternatives 2C, 3C, and 4C would be effective in reducing toxicity, mobility, and volume of groundwater contaminants. These alternatives provide no treatment of soil or sediment to reduce toxicity, mobility, or volume, except for treatment necessary to meet LDR treatment standards. Remedial action objectives would be achieved. Alternatives 2C, 3C, and 4C are retained for detailed analysis.

4.5 ALTERNATIVES RETAINED

Table 4-20 summarizes the screening of alternatives that was described in the preceding section. All of the alternatives, except for the "B" alternatives, passed the screening process. The alternatives that passed the screening process are as follows:

- No-Action Alternative - No further action beyond any removal or remedial action that has already occurred
- Alternative 1 - Excavation of soil (including perched groundwater zones) with off-site disposal; extraction of Great Miami Aquifer water with treatment before discharge
- Alternatives 2A, 3A, and 4A - Excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentrations, direct placement in an on-property cell or shipment to an off-site disposal facility; extraction of Great Miami Aquifer water with treatment before discharge
- Alternatives 2C, 3C, and 4C - Excavation of soil (including perched groundwater zones) with segregation and, depending on contaminant concentrations, direct placement in an on-property consolidation area with earthen cover or shipment to an off-site disposal facility; extraction of Great Miami Aquifer water with treatment before discharge.

The alternatives that passed the screening process are described and analyzed in more detail in Section 5.0. Section 6.0 presents a comparative analysis of the candidate remedial alternatives for Operable Unit 5.

TABLE 4-20
SUMMARY OF REMEDIAL ALTERNATIVES SCREENING

Alternative	Screening Criteria and Comments: Effectiveness	Screening Criteria and Comments: Implementability	Screening Criteria and Comments: Cost (million $, net present worth)	Retained for Detailed Analysis
No Action	Not protective of human health and the environment for any land use objective. Would not comply with all applicable or relevant and appropriate requirements (ARARs). Not effective in the long term. No treatment of soil or groundwater to reduce toxicity, mobility, or volume. No short-term impacts. This alternative is retained as required by the National Contingency Plan.	No implementability problems other than potential public resistance.	0	Yes
1	Protective of human health and the environment for Land Use Objective 1. Complies with all ARARs. No long-term action would be required following the remediation of soil and groundwater. No soil treatment to reduce toxicity, mobility, or volume (except necessary treatment to meet land disposal restriction [LDR] criteria). Extracted groundwater treated at groundwater treatment facility before discharge. Manageable short-term impacts.	Soil removal and disposal methods and groundwater treatment methods are widely used. Required resources, including commercial disposal site, are available.	1240 to 4340	Yes
2A, 3A, 4A	Protective of human health and the environment for respective land use objectives. Complies with all ARARs, except for certain State of Ohio solid waste facility siting requirements. Waiver of siting requirements would be needed and could be justified, based on a demonstration of equivalent performance. Regular inspections, repairs, maintenance, and monitoring of the disposal cell would be required to ensure long-term effectiveness and permanence. No long-term action required after remediation of groundwater. No soil treatment to reduce toxicity, mobility, or volume (except necessary treatment to meet LDR criteria). Extracted groundwater treated at groundwater treatment facility before discharge. Manageable short-term impacts.	Soil removal and disposal methods and groundwater treatment methods are widely used. Approval required for siting of disposal facility. Required resources, including those for maintenance and monitoring, are available. Commercial disposal site is available.	2A 720 to 2290 3A 580 to 690 4A 580 to 610	Yes

TABLE 4-20 (Continued)

Alternative	Screening Criteria and Comments: Effectiveness	Implementability	Cost (million $, net present worth)	Retained for Detailed Analysis
2B, 3B, 4B	Protective of human health and the environment for respective land use objectives. Complies with all ARARs, except for certain State of Ohio solid waste facility siting requirements. Waiver of siting requirements could not be justified, because equivalent performance could not be demonstrated. Regular inspections, repairs, maintenance, and monitoring of the consolidation area with multilayer cap would be required to ensure long-term effectiveness and permanence. Increased uncertainty in long-term effectiveness due to reliance on existing geologic material to aid in groundwater protection combined with long design life. Alternatives rely solely on cap to maintain effectiveness. No long-term action required after remediation of groundwater. No soil treatment to reduce toxicity, mobility, or volume (except necessary treatment to meet LDR criteria). Extracted groundwater treated at groundwater treatment facility before discharge. Manageable short-term impacts.	Soil removal, containment, and disposal methods and groundwater treatment methods are widely used. Approval required for siting of capped consolidation area. Required resources, including those for maintenance and monitoring, are available. Commercial disposal site is available.	2B 720 to 2320 3B 580 to 690 4B 580 to 610	No
2C, 3C, 4C	Protective of human health and the environment for respective land use objectives. Complies with all ARARs. Only material with contaminant concentrations that attain the waste acceptance criteria would be placed in consolidation area with earthen cover. No long-term actions required after remediation of groundwater. No soil treatment to reduce toxicity, mobility, or volume (except necessary treatment to meet LDR criteria). Extracted groundwater treated at groundwater treatment facility before discharge. Manageable short-term impacts.	Soil removal, containment, and disposal methods and groundwater treatment methods are widely used. Approval required for siting of consolidation area with earthen cover. Required resources, including those for maintenance and monitoring, are available. Commercial disposal site is available.	2C 913 to 4330 3C 770 to 880 4C 780 to 800	Yes

4.6 MODIFICATION OF REMEDIAL ALTERNATIVES FOLLOWING INITIAL SCREENING

The potential remedial alternatives described and screened in the preceding sections are each based on the application of representative process options identified in Section 3.0. As part of the steps leading to the identification of representative process options, several potential process options were determined to be suitable for service as either "support" or "primary" elements of remedial alternatives. Those determinations were based on conditions existing at the time this document was prepared. The conditions in question are as specific as the current capability and cost effectiveness of individual treatment technologies, and as general as factors connected with the national economy. It is reasonable to anticipate that research and development will refine the capabilities and performance of treatment technologies and that factors affecting the national economy will move through many cycles during the 22-year remedial period. DOE will continue to support the development of environmentally acceptable technologies that have cost-effective application potential for achieving volume reduction through waste minimization. As part of each alternative, DOE has committed to examine emerging technologies for potential application to contaminated environmental media at the FEMP.

During discussions between DOE and EPA, Operable Unit 5 agreed to perform treatability studies and develop work plans during the remedial design/remedial action (RD/RA) time period. DOE commits to supporting the development of environmentally acceptable innovative technologies such as magnetic separation, tall-column flotation, geochemical barrier materials, and others that may prove to have application potential.

Technology development activities are needed for supporting other areas of major interest that are common to all the identified primary remedial alternatives. A concerted effort must be directed toward the continued development of technologies that support precision excavation, field analysis, laboratory analyses, gravel separation as a clean fraction, and the separation for containing organic materials and debris generated by excavation or any treatment process option.

The following items illustrate the types of changes that could affect the relative attractiveness of process options over the duration of the Operable Unit 5 remediation.

- Techniques may be developed for optimizing treatment processes which are currently considered technically effective, but costly. For instance, ongoing developments connected with physical separation may allow the Operable Unit 5 remedial effort to separate the most highly contaminated soil and sediment fraction from the remaining material, thus allowing remediation resources to provide the greatest benefit by focusing on the most contaminated soil/sediment fraction.

- With further study, treatment processes currently in the conceptual or early development stage may evolve to become suitably dependable and cost effective. Although the data currently available from soil washing treatability studies does not support its use as a primary process option for remedial alternative development purposes, studies connected with the process continue. Means may yet be identified to improve the effectiveness of the process and\or allow the process to operate less expensively.

- An increase in transportation costs (e.g., as the result of an oil embargo) may be sufficient to cause currently more costly treatment-based alternatives to become comparatively more cost effective as a result of the higher transportation costs. Vitrification, which will be used by Operable Unit 4 on a scale smaller than is necessary for general use by Operable Unit 5, may prove viable as a mechanism for small-scale reduction of the soil and sediment volume requiring shipment to an off-site disposal facility.

- Off-site disposal capacity may be consumed, or increased demand for disposal space may drive up the cost sufficiently to cause currently more costly treatment-based alternatives to become a comparatively cost-effective means for remediating material that would otherwise be shipped from the site. Under those conditions, process options such as cement stabilization or vitrification may prove to be viable options for remediating the contaminated material that would otherwise be shipped from the site.

- Monitoring and testing conducted during groundwater remediation may indicate the opportunity or need to examine approaches for enhancing the rate and/or effectiveness of groundwater extraction technologies. Possible means might include reinjection, pulse pumping or air sparging.

The above list is not necessarily comprehensive, but it serves to illustrate potential factors that may cause the selected Operable Unit 5 remedy to be less than optimal at the time of implementation. To account for the uncertainties that exist as a result of the long Operable Unit 5 remediation duration, the descriptions of the potential remedial alternatives passing the initial screening in Section 4.0 have been modified to include the following.

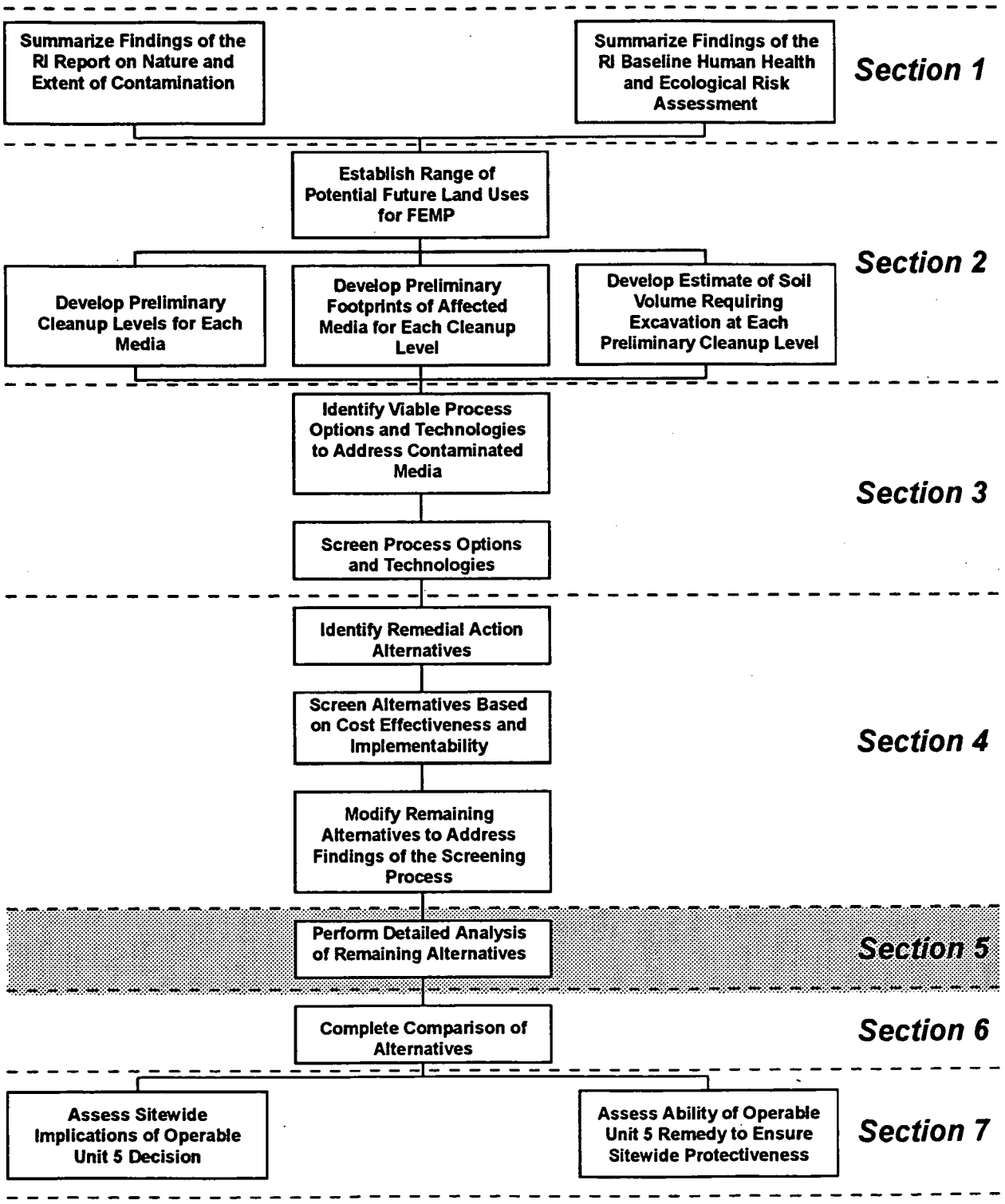
- Verification of the availability of off-site disposal capacity

- Review of the potential for improving remediation cost effectiveness by including support treatment technologies to reduce contaminant levels

- Examination of the status of emerging technologies for the potential to improve remediation cost effectiveness at the time of remedial design

- Commitment to examine the potential application of reinjection to enhance contaminant recovery

- Commitment to perform engineering studies on physical or magnetic separation and phosphate amendment to assess their application at the FEMP.


Summarize Findings of the RI Report on Nature and Extent of Contamination
Summarize Findings of the RI Baseline Human Health and Ecological Risk Assessment
Section 1
Establish Range of Potential Future Land Uses for FEMP
Develop Preliminary Cleanup Levels for Each Media
Develop Preliminary Footprints of Affected Media for Each Cleanup Level
Develop Estimate of Soil Volume Requiring Excavation at Each Preliminary Cleanup Level
Section 2
Identify Viable Process Options and Technologies to Address Contaminated Media
Screen Process Options and Technologies
Section 3
Identify Remedial Action Alternatives
Screen Alternatives Based on Cost Effectiveness and Implementability
Modify Remaining Alternatives to Address Findings of the Screening Process
Section 4
Perform Detailed Analysis of Remaining Alternatives
Section 5
Complete Comparison of Alternatives
Section 6
Assess Sitewide Implications of Operable Unit 5 Decision
Assess Ability of Operable Unit 5 Remedy to Ensure Sitewide Protectiveness
Section 7

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analysis of the seven remedial action alternatives that passed the screening process conducted in Section 4.0. Features comprising the seven alternatives retained for detailed analysis were summarized in Table 4-20.

The detailed analysis of alternatives is presented in five parts: Section 5.1 summarizes the purpose of the detailed analysis; Section 5.2 summarizes the four land use objectives, provides a descriptive overview of the seven alternatives retained for detailed analysis, and identifies the remedial action components which are common across alternatives; and Section 5.3 describes the criteria against which each alternative was evaluated and summarizes the approach used by this Feasibility Study (FS) to apply each of the U.S. Environmental Protection Agency (EPA) criteria to a remedial action alternative. Section 5.4 provides the individual analyses of alternatives and evaluates each of them against the National Contingency Plan (NCP) criteria. Finally, Section 5.5 summarizes the irreversible and irretrievable commitment of resources projected as a result of implementing any of these remedial alternatives.

5.1 PURPOSE OF DETAILED ANALYSIS

The detailed analysis includes a presentation and assessment of relevant information that provide the basis for selecting an alternative and preparing a Record of Decision (ROD). Building upon the development and screening of alternatives, the detailed analysis presents more in-depth information, including groundwater modeling, fate and transport modeling, and pertinent remedial investigation (RI) data which are used in the assessment of alternatives relative to the NCP criteria. Following the detailed analysis, a comparative analysis of the alternatives is presented in Section 6.0.

Seven of the nine NCP evaluation criteria are used in the FS to conduct the detailed analysis. The remaining criteria (i.e., State and Community Acceptance) will be incorporated into the decision making process following the public comment period for the FS.

5.2 LAND USE OBJECTIVES, REMEDIAL ACTION ALTERNATIVES AND COMPONENTS

This section provides a brief overview of the land use objectives, the remedial action alternatives retained for detailed analysis, and the components which make up those remedial action alternatives. Figure 5-1 shows the relationship of land use objectives, which determine the volume of media to be remediated, to remedial action alternatives, which determine the ultimate disposition of contaminated media. It is intended to summarize information that was provided in prior sections and present how that information, used in conjunction with the remedial alternatives retained from Section 4.0, determines the final disposition of soil. As shown in Figure 5-1, the land use objectives, which are

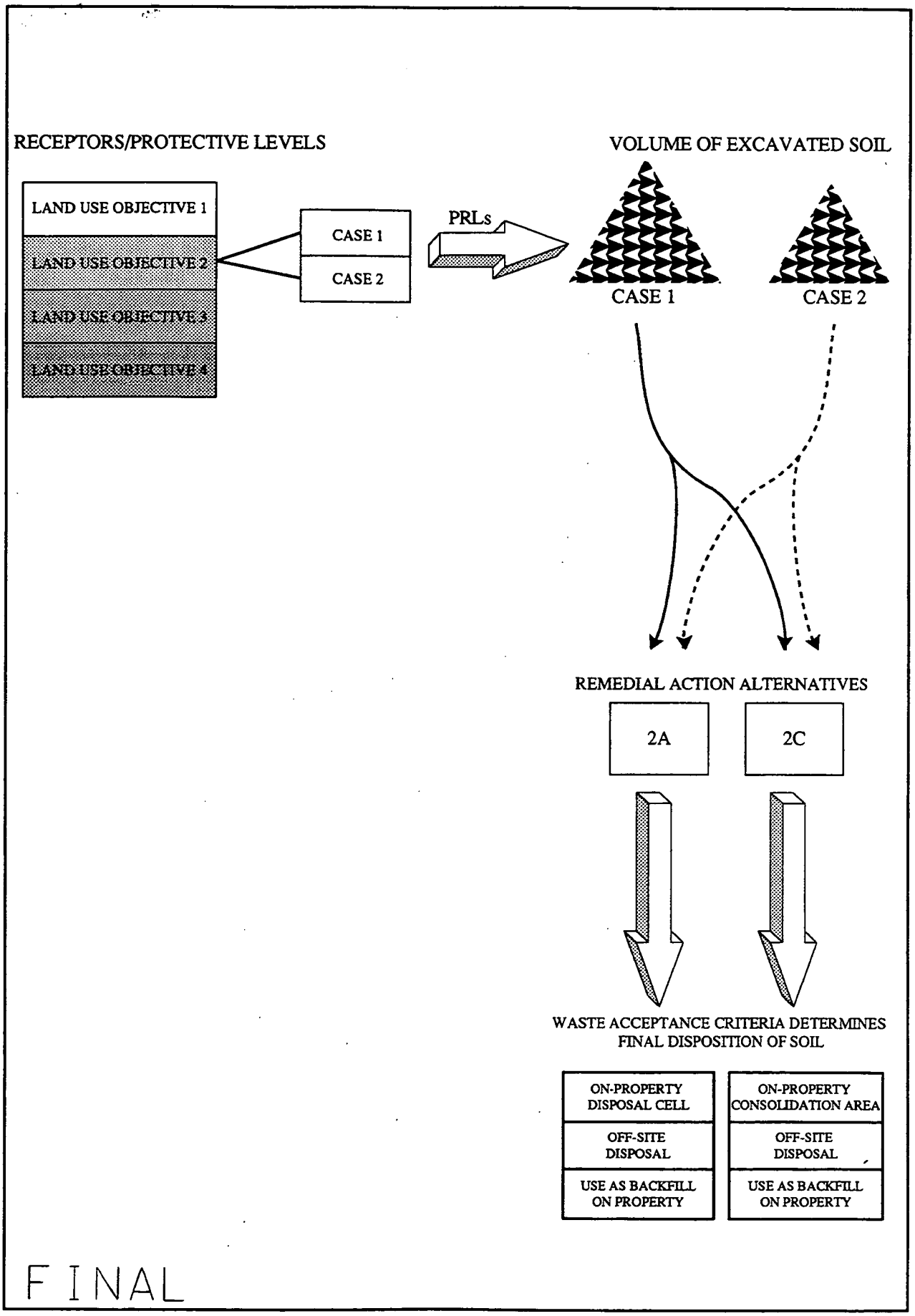


FIGURE 5-1. EXAMPLE FLOW DIAGRAM OF REMEDIAL ACTION PROCESS

000391

\ILLUS\OU-5\PO-1135-REM ACT PROCESS

combinations of receptors and protective levels, determine the preliminary remediation levels (PRLs). The PRLs, in turn, determine the volume of soil to be excavated (both on and off property) or the length of time required to extract and treat groundwater. Different risk scenarios, referred to as cases, were evaluated under each land use objective. Once an excavated volume of soil was determined for a given case, the concentration of contaminants in that soil was compared to the waste acceptance criteria for a designated remedial action (e.g., off-site disposal facility, on-property disposal facility, on-property consolidation area). The waste acceptance criteria represent the maximum concentration of a constituent of concern (COC) which can be remediated in a particular fashion (i.e., off-site disposal, on-property disposal facility, etc.,) and still be protective at a specified risk level. Thus, the waste acceptance criteria ultimately define the final disposition of the soil. Conversely, the PRLs define the length of time required to extract and treat groundwater.

The following sections are intended to provide the reader with a basis for evaluation of the action to be taken under each remedial alternative.

5.2.1 Land Use Objectives

Each of the seven remedial action alternatives retained for detailed analysis is designed to achieve one of four land use objectives. The land use objectives, shown in Table 5-1, dictate the receptors to be considered in determining proposed remediation levels for the FEMP.

The land use objectives and the assumptions used to form each of these land use objectives were discussed in greater detail in Section 2.2.

5.2.2 Overview of Alternatives

The land use objectives described in the previous section will be achieved using one of seven remedial action alternatives retained for detailed analysis. Table 5-2 shows the key elements of each alternative.

As shown in Table 5-2, the key elements which make up the remedial actions performed under Alternatives 2A, 3A and 4A are similar, differing only in the volume of contaminated media which must be addressed to achieve the land use objectives associated with each. For example, Alternative 2A, which corresponds to Land Use Objective 2, would require remediation of a larger volume of media in order to release a large portion of the FEMP for unrestricted land use. In contrast, Alternative 4A, which corresponds to Land Use Objective 4, would require the remediation of a lesser volume of media because the entire FEMP would remain under continued federal ownership with no consideration for alternative land uses for on-property areas.

TABLE 5-1

RECEPTORS AND ALTERNATIVES CONSIDERED UNDER EACH OF THE FOUR LAND USE OBJECTIVES

Land Use Objective	Receptor	Alternatives
1 Full unrestricted land use	On property: RME[a] resident farmer Off property: RME resident farmer	1
2 Maximum consolidation of contaminated media to free the majority of the site for unrestricted land use	On property (in consolidation area): expanded trespasser On property (outside consolidation area): RME resident farmer Off property: RME resident farmer	2A, 2C
3 Maximum consolidation of contaminated media to free the majority of the site for restricted land use. Restricted land uses evaluated include industrial use and recreational use in the form of a developed or undeveloped park.	On property (in consolidation area): expanded trespasser. On property (outside consolidation area): industrial user or recreational user (developed or undeveloped park) Off-Site: RME resident farmer	3A, 3C
4 Continued federal ownership of the entire FEMP with consolidation of a portion of the contaminated media but no consideration of the release of a portion of the property for alternate land uses	On property: expanded trespasser. Off property: RME resident farmer	4A, 4C

[a] Reasonable maximum exposure

5.2.2.1 No Action Alternative

The no-action alternative, considered here as required by CERCLA, provides a baseline against which other alternatives can be evaluated. Under this alternative the site is considered to be left "as is," without the implementation of additional containment, removal, treatment, or other mitigating actions. This alternative does not provide for ongoing monitoring of soil, perched groundwater, or the Great Miami Aquifer within the scope of Operable Unit 5 and does not provide for any additional active or passive institutional controls to reduce the potential for exposure (e.g., physical barriers, deed restrictions). In addition, it is assumed that all existing remedial activities, monitoring programs, and institutional controls would be discontinued and the property would be released for unrestricted use.

TABLE 5-2

KEY ELEMENTS FOR REMEDIAL ACTION ALTERNATIVES

Remedial Action Alternatives	Description
1	Pump and treat Great Miami Aquifer groundwater to achieve 10^{-6} ILCR[a] or MCLs[b]. Excavate soil and sediment and ship for disposal at an off-site commercial disposal facility.
2A, 3A and 4A	Pump and treat Great Miami Aquifer groundwater to achieve 10^{-6} ILCR or MCLs. Excavate soil and sediment and consolidate in an on-property disposal facility. For soil and sediment with contaminant concentrations that exceed the waste acceptance criteria for the disposal facility, ship the material for disposal at an off-site disposal facility.
2C, 3C and 4C	Pump and treat Great Miami Aquifer groundwater to achieve 10^{-6} ILCR or MCLs. Excavate soil and sediment and consolidate in an on-property consolidation area with an earthen cover. For soil and sediment with contaminant concentrations that exceed the waste acceptance criteria for the consolidation area, ship the material for disposal at an off-site disposal facility.

[a] Incremental lifetime cancer risk
[b] Maximum concentration level

5.2.2.2 Alternative 1 - Excavation and Off-Site Shipment

Alternative 1 includes excavation of on- and off-property contaminated soil/sediment (including on-property perched groundwater zones) exceeding the PRLs for Land Use Objective 1 and disposal of the soil/sediment off site. Soil containing hazardous waste constituents greater than land disposal restricted concentrations would be excavated, treated for removal of the restricted contaminants to levels meeting the waste acceptance criteria for off-property disposal, and shipped off site for disposal. Clean material and topsoil would be used to backfill and revegetate the excavated areas.

On- and off-property Great Miami Aquifer groundwater exceeding the PRLs would be extracted, treated at a groundwater treatment facility, and discharged to the Great Miami River. On-property storm water, remediation systems wastewater, and perched groundwater recovered from excavated soil would be treated by the advanced wastewater treatment (AWWT) facility before discharge to the Great Miami River. Waste sludge generated by the water treatment processes would be dewatered at the AWWT dewatering system and shipped off site for disposal. Spent treatment media (e.g.,

exhausted ion exchange resin and activated carbon) and concentrated contaminant residues would be cement stabilized and shipped off site for disposal.

5.2.2.3 Alternatives 2A, 3A and 4A - Engineered Disposal Facility

Alternatives 2A, 3A and 4A are the same with respect to the key elements which make up the alternatives. These alternatives include excavation of on- and off-property contaminated soil/sediment (including on-property perched groundwater zones) exceeding proposed remediation levels for Land Use Objectives 2, 3 or 4, depending upon the land use objective being considered. Soil/sediment containing hazardous waste constituents greater than PRLs would be excavated and treated for removal or stabilization of the restricted components to levels meeting the waste acceptance criteria for on- or off-property disposal. Excavated contaminated soil/sediment would be segregated according to its contaminant concentrations and consolidated in an on-property disposal facility. Soil/sediment not meeting the waste acceptance criteria of the on-site disposal facility would be shipped off site for disposal. Clean material and topsoil would be used to backfill and revegetate the excavated areas. The disposal facility would be maintained under continued federal ownership.

On- and off-property Great Miami Aquifer groundwater, on-property storm water, remediation systems wastewater, and perched groundwater recovered from excavated soil would be remediated as described under Alternative 1. Groundwater would be routinely sampled and analyzed to monitor the long-term effectiveness of the remedial actions. Five-year reviews would be conducted by EPA to monitor the continued protectiveness of the disposal system.

5.2.2.4 Alternatives 2C, 3C and 4C - Off-Site Shipment

Alternatives 2C, 3C and 4C are the same with respect to the key elements which make up the alternatives. These alternatives include excavation of on- and off-property contaminated soil (including on-property perched groundwater zones) exceeding PRLs for Land Use Objectives 2, 3 or 4, depending upon the land use objective being considered. Soil/sediment containing hazardous waste constituents greater than PRLs would be excavated and treated for removal of the restricted component to levels meeting the waste acceptance criteria for on- or off-property disposal. Excavated soil/sediment would be segregated based on contaminant concentrations and placed in an on-property consolidation area with an earthen cover or shipped off site for disposal. Clean material and topsoil would be used to backfill and revegetate the excavated areas. The consolidation area would be maintained under continued federal ownership.

On- and off-property Great Miami Aquifer groundwater, on-property storm water, remediation systems wastewater, and perched groundwater recovered from excavated soil would be remediated as described under Alternative 1. Groundwater would be routinely sampled and analyzed to monitor the

long-term effectiveness of the remedial actions. Five-year reviews would be conducted by EPA to monitor the continued protectiveness of the consolidation area.

5.2.3 Remedial Action Components

As can be seen from the alternatives overview and Table 5-3, each of the seven remedial action alternatives retained for detailed analysis contain components which are common with those contained in at least one other alternative. These common components form the basis for cost estimating. For example: soil would be excavated in all of the alternatives; at least a portion of the excavated soil would be shipped off site for disposal in each of the seven alternatives; excavated soil would be disposed of in an on-property disposal facility in three alternatives; excavated soil would be consolidated with an earthen cover in three alternatives; Great Miami Aquifer groundwater would be extracted and treated in all alternatives; wastewater generated by remedial actions would be treated in all alternatives; and contaminated soil would require interim storage in all alternatives.

Table 5-4 provides a brief description of the subelements of the remedial components. Appendix L describes the components in greater detail.

TABLE 5-3

MATRIX OF REMEDIAL ACTION COMPONENTS MAKING UP THE SEVEN ALTERNATIVES

Land Use Objective	1	2		3		4	
Remedial Alternative	1	2A	2C	3A	3C	4A	4C
Media							
Soil							
Excavation	X	X	X	X	X	X	X
Consolidation beneath an earthen cover			X		X		X
Consolidation in an on-site disposal facility		X		X		X	
Backfill	X	X	X	X	X	X	X
Central storage facility	X	X	X	X	X	X	X
Groundwater							
Great Miami Aquifer groundwater extraction	X	X	X	X	X	X	X
Groundwater and wastewater treatment	X	X	X	X	X	X	X
Other							
Long-term environmental monitoring		X	X	X	X	X	X

TABLE 5-4

REMEDIAL ACTION COMPONENT SUBELEMENTS

Remedial Action Component	Primary Subelements
Soil excavation	Verification surveys Excavation/excavation control surveys Storm water control/transfer to AWWT Soil segregation RCRA soil pretreatment (if required) Stockpile for backfill/loading (depending on contaminant concentration) Transportation Final certification surveys Decontamination and demolition
Off-site disposal	Interim soil storage Loading onto rail cars or trucks Decontamination/certification of rail cars or trucks Transport to commercial disposal facility or NTS Return rail cars or trucks to FEMP for reuse Decontamination and demolition
Central storage facility	Wheel washing Interim soil storage Decontamination and demolition
Consolidation	Site preparation Waste placement Placement of earthen cover Storm water control measures Maintenance/institutional requirements Decontamination and demolition
On-property disposal facility	Cell design and construction Waste placement Maintenance/institutional requirements Decontamination and demolition
Backfill	Backfill material stockpiling Backfill placement Storm water control measures Maintenance/institutional requirements Decontamination and demolition
Great Miami Aquifer groundwater extraction	Extraction system design Extraction well/pump/valve/pipeline installation Maintenance/institutional requirements Decontamination and demolition
Groundwater treatment	Equalization Chemical feed system Filtration Activated carbon adsorption Ion exchange/regeneration/precipitation Backwash thickening Spent media stabilization/transport Effluent monitoring Discharge to Great Miami River or recycle to FEMP process water Decontamination and demolition
Long-term environmental monitoring	Monitoring during remedial actions Long-term groundwater monitoring

5.3 NATIONAL CONTINGENCY PLAN CRITERIA FOR EVALUATING REMEDIAL ALTERNATIVES

Specific statutory requirements for remedial actions are specified under CERCLA 121, as amended. These requirements include protection of human health and the environment, compliance with applicable or relevant and appropriate requirements (ARARs), a preference for permanent solutions which incorporate treatment as a principal element (to the maximum extent practicable), and cost-effectiveness. To assess whether alternatives meet the requirements, EPA has identified nine criteria in the NCP which must be evaluated for each alternative retained through the screening stage [Section 300.430(e)(9)(iii)]. This section provides a summary of the factors that comprise the nine criteria and an overview of the approach taken by this FS to address those criteria.

Figure 5-2 shows the relationship between the screening criteria used in Section 4.0 and the seven evaluation criteria used in Section 5.0 for the detailed analysis of each alternative. The first two criteria, overall protection of human health and the environment and compliance with ARARs, are known as threshold criteria in that each alternative must meet them. Assessments against these two criteria relate directly to statutory findings that must ultimately be made in the ROD. The next five criteria are known as primary "balancing factors." They are grouped together because they represent the primary criteria upon which the detailed analysis is based. The final two criteria, state agency acceptance and community acceptance, will be addressed following public comment in the responsiveness summary in the ROD.

5.3.1 Overall Protection of Human Health and the Environment

This evaluation criterion provides an assessment of whether the alternative achieves and maintains adequate protection of human health and the environment in accordance with the remedial action objectives established in Section 2.0. Because the scope of this criterion is broad, it also reflects the discussions of the four criteria which follow. Evaluation of this criterion should describe how site risks, posed through each pathway addressed by the FS, are eliminated, reduced, or mitigated through treatment, engineering, or institutional controls. The acceptable risk levels, under CERCLA, for members of the public for known or suspected carcinogens are generally concentration levels in environmental media that represent an upper bound of the incremental lifetime cancer risk (ILCR) to an individual of between 10^{-4} to 10^{-6}. The remedial action objectives previously identified in Section 2.12 were developed consistent with this criteria.

As previously described in Section 2.0, each of the remedial alternatives considers the attainment of a range of PRLs for the environmental media. The PRLs, once adopted as final in the ROD, establish the health protective, quantitative goals of the Operative Unit 5 remedial activities. The development of PRLs, as presented in Section 2.1, considers not only the direct exposure route to human or environmental receptors, but also provides for long-term environmental protection through

*\ILLUS\OU-5\PO-113\SCREEN EVAL CRITERIA.EPS

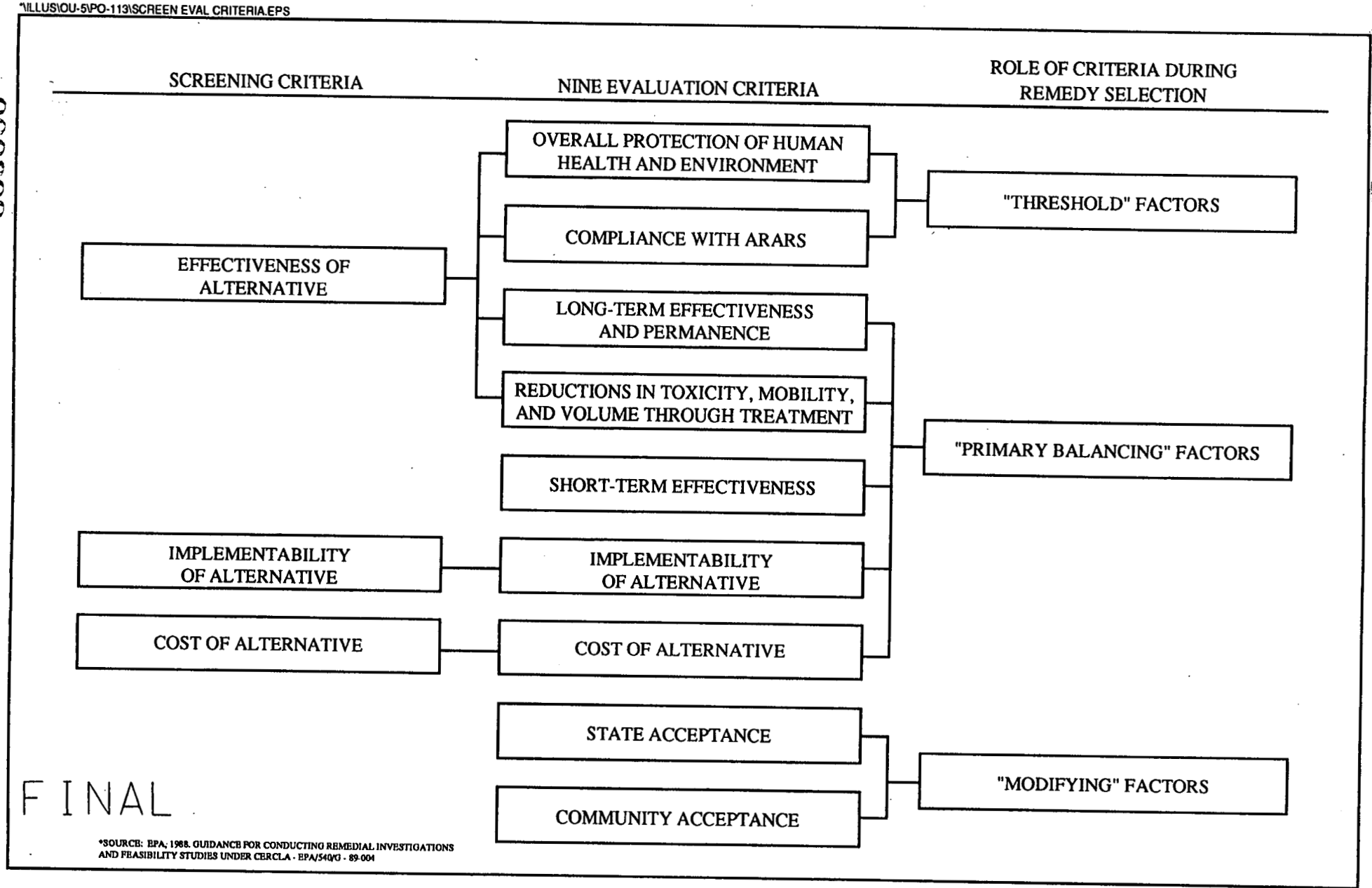


FIGURE 5-2. RELATIONSHIP OF SCREENING CRITERIA TO THE NINE EVALUATION CRITERIA

000399

consideration of cross-media impacts. Each alternative, as discussed in Section 4.0 and Appendix L, includes direct measurements and sample analyses to verify the boundaries of required excavations or aquifer restoration and to certify that cleanup levels have been attained following remedial actions. It is through this certified completion of cleanup to the PRLs that the overall protection of human health would be achieved and maintained.

The evaluation of the protection of human health and the environment criteria assumes that the PRLs are attained as an objective of each remedial alternative, and considers the long-term effectiveness of any engineering or institutional controls applied as part of the remedy. Also considered is the effectiveness of the cell/ consolidation area and the associated institutional controls; the ability of the remedy to comply with ARARs; the results of a short-term risk assessment; and reductions in toxicity, mobility or volume achieved by implementation of the alternative.

5.3.2 Compliance with ARARs

This criterion addresses the attainment of promulgated federal and state environmental or facility siting requirements. If an alternative cannot meet a requirement, a determination can be made that a waiver under CERCLA may be appropriate and a basis justifying the waiver discussed.

In addressing a requirement that may affect a remedial action being considered for a site, a determination is made regarding its relationship to: 1) the location of the action; 2) the contaminants involved; and 3) the specific components of the action, such as factors unique to a certain technology. Three types of ARARs result from the process: location specific, chemical specific, and action specific. These are described in detail in Section 2.4 and Appendix B of this document.

ARARs that significantly impact whether an alternative will be in compliance include those related to Ohio's siting criteria for on-property disposal, the corrective action management unit (CAMU) rule, and nonzero maximum contaminant level goals (MCLGs) or MCLs for groundwater. A discussion of these potential impacts is provided in Appendix B. The detailed analysis of alternatives section evaluates how compliance with the ARARs can be achieved by addressing the components of each alternative.

Summary tables of the chemical-, location-, and action-specific ARARS are also included in Appendix B, Tables B-1 through B-3. Table B-5 summarizes potential compliance with ARARS for the alternatives provided in Tables B-1 through B-3.

The criteria to be considered (TBCs) identified in Tables B.1 through B.3 are not included in the compliance table because they are not ARARs. Compliance with TBCs is not considered except where a TBC would be useful in explaining how compliance could be met for a given alternative in the absence of other promulgated requirements. If a TBC criterion is included in the Operable Unit 5 ROD, then it will become enforceable, and compliance must be achieved.

5.3.3 Long-Term Effectiveness and Permanence

This criterion evaluates the extent to which an alternative achieves an overall reduction in risk to human health and the environment after the response objectives have been met. It considers the degree to which the alternative provides long-term controls and reliability sufficient to maintain exposures to human and environmental receptors within protective levels. The principal factors addressed by this criterion include magnitude of residual risk, adequacy and reliability of controls and long-term environmental impacts as defined by the National Environmental Policy Act. Also discussed are the uncertainties associated with both of these factors.

This FS addresses the magnitude of residual risk to human health through an evaluation of the level of protection offered by the PRLs considered for the alternative. The magnitude of residual risk to environmental receptors is assessed in a qualitative manner by describing the potential long-term environmental impacts of the alternative on soil and geology, water quality and hydrogeology, air quality, biotic resources, and wetlands and floodplains. Impacts on socioeconomics, land use, and cultural resources are also considered.

The evaluation of adequacy and reliability of controls assesses the effectiveness of treatment, containment or institutional measures which are part of the alternative. Factors considered include performance characteristics, maintenance requirements, and expected durability. Information and data from performance models, past performance, and similar technology applications are incorporated into the evaluation as appropriate. Institutional controls are considered where they might improve the effectiveness of engineered measures.

5.3.4 Reduction of Toxicity, Mobility, or Volume

This criterion reflects the statutory preference for remedial action alternatives containing a principal component which substantially reduces toxicity, mobility, or volume of hazardous substances. The evaluation considers the extent to which remedial action process technologies can effectively and irreversibly fix, transform, immobilize, and/or reduce the volume of waste materials and contaminated media.

5.3.5 Short-Term Effectiveness

This criterion addresses the expected effects of implementing each alternative on human health. Specifically, a short-term risk assessment was conducted that evaluated the frequencies of physical injury and fatality as well as carcinogenic and noncarcinogenic health effects of the actions required to implement the alternative. This short-term risk assessment, presented in Appendix G, provides an evaluation of short-term risks to both remedial and nonremedial workers, as well as the public, under various scenarios associated with an alternative's operations.

Potential short-term risks to workers include dust and direct radiation exposure during removal, treatment and transport of waste materials, construction and operation of support facilities, and operation of heavy equipment. Potential short-term risks to the public include exposure to fugitive dust and radiation emissions released during waste removal, treatment, off-site transportation, and disposal operations. The parameters examined in the short-term risk assessment for each receptor group (i.e., workers and the public) include physical injury, death, noncarcinogenic health effects (i.e., hazard index [HI]), and ILCRs. The alternative analysis also includes the impacts of mitigative measures such as engineering and institutional controls that are expected to lessen potential risks to the public and workers.

5.3.6 Implementability

This criterion examines the technical and administrative factors affecting implementation of an alternative and considers the availability of services and materials required during implementation. Technical factors to be assessed include the ease and reliability of initiating construction and operations, the prospects for implementing any needed future actions, and the adequacy of monitoring systems to detect failures. Administrative factors examined include permitting and coordination requirements among the lead agency and regulatory agencies. Services and materials considerations include: treatment, storage and disposal capacities; equipment and operator availability; and prospective technology applicability or development requirements.

Where proven technologies are proposed, an assessment of technical feasibility examines the performance history of the technologies in direct applications, or considers the expected performance for similar applications. For innovative technologies, data from bench-scale tests are evaluated for expected scale-up performance characteristics. Uncertainties associated with construction, operation, and performance monitoring are also addressed.

The evaluation of administrative feasibility includes a discussion of those actions required to coordinate with regulatory agencies to establish the framework for complying with key substantive technical requirements which must be attained by an alternative. Additionally, alternatives involving

off-site transportation are reviewed to assess the feasibility of implementing interstate transportation and disposal.

The availability of services and materials is addressed by analyzing the material components of the proposed technologies to determine the locations and quantities of those materials and by reviewing process operations to identify special services, operator skills, or training required to readily implement the process.

5.3.7 Cost

The approach adopted by this FS for the cost criterion includes a presentation of costs developed for each major component listed in Table 5-4. The cost estimates include construction costs, operations and maintenance costs, postremediation costs, and the total project cost. Construction costs include expenditures for equipment, labor, materials, and indirect costs necessary to construct and install remedial actions. Operations and maintenance costs are postconstruction costs necessary to remove, treat, and/or dispose of contaminated media. Postremediation costs include decontamination and decommissioning of remedial action facilities and equipment after remediation goals have been met, and the associated long-term environmental monitoring and maintenance of on-property contaminated media disposal areas. The total cost (nonescalated) is the sum of the construction, operations and maintenance, and postremediation costs for each component (in 1995 dollars). The total cost includes risk budget and contingency (see Appendix K).

Component cost estimates were developed in current (1995) dollars. The anticipated annual costs over the established durations for each component are summarized and a present worth analysis is conducted on the annual distributions of each component. The present worth analysis uses the real discount rates established by the Office of Management and Budget, which include the adjustments for varying interest rates and effects of inflation on annual constant-worth cash flows. Net present worth costs are presented at the alternative cost summary level adjacent to the total costs for the remedial components for each alternative. An average discount rate of 2.8 percent has been used for the component present worth analysis.

In addition to the present worth analysis, the total annual constant-dollar expenditures for each component have been escalated to present the impact of inflation (real dollars) in the year the costs are actually incurred. This estimate is the total escalated cost of the project. An average escalation rate of 3.7 percent was used in the analysis. The rate is based on the August 1994 economic escalation indices for DOE construction projects established by the Office of Infrastructure Acquisition.

Key assumptions were made to establish a consistent approach to developing the component cost estimates. These assumptions along with the cost estimating methods are described in the cost estimate appendix (Appendix K).

A risk budget and contingency analysis was performed for each component using a computer program based on Monte Carlo simulations. The program input was developed as follows:

- Within each component, major cost elements related to construction, operation and maintenance, and postremediation were identified.
- Each cost element was then weighed against cost driver factors, such as labor efficiency, material pricing, class (and extent) of contamination, new technology, new laws and regulations, quantity variation, and project definition. Low and high percentage ranges were assigned to each cost driver factor. The low and high cumulative totals were then used as input to the computer simulations.

Risk budget and overrun analysis were developed separately for each component. The risk budget percentage was based on a 50 percent chance of overrun. The contingency was based on the difference between the 5 percent and 50 percent chance of overrun. The risk budget and contingency percentages were then applied to the sum of component construction, operations and maintenance, and postremediation costs.

A cost curve was developed for each component. The curve represents a relative correlation between cost and a volume of contaminated media. Four different volume scenarios were selected, cost estimates were made, and a curve was fitted to the data points. Cost curves were not developed for the Great Miami Aquifer groundwater extraction and groundwater treatment components since they are the same for each remedial alternative and land use objective.

Soil and groundwater modeling was performed to determine the volumes of contaminated media to be remediated. Solid block modeling determined the volumes of contaminated soil which would be handled by each remedial action alternative; volumes differed depending upon the risk levels. The solid block modeling results are discussed in detail in Section 2.0. The modeling results were used along with the component cost curves to develop a component cost for each remedial action alternative and risk level. The sum of all component costs for each remedial action alternative represents the total cost of a given alternative.

5.4 INDIVIDUAL ANALYSIS OF ALTERNATIVES

This section provides a detailed description of each alternative based upon the components presented in Appendix L. Following each description, an assessment of the alternatives against the seven NCP

criteria is presented. Because the first two criteria relate directly to statutory findings that must be made in the ROD, additional detail is provided in the discussions. Where appropriate, reference is made to related discussions elsewhere in this report.

5.4.1 No-Action Alternative

The no-action alternative is provided as a basis for comparison only.

5.4.1.1 Detailed Description

Under this alternative the site is considered to be left as is, without the implementation of any additional containment, removal, treatment, or other mitigating actions. This alternative does not provide for ongoing monitoring of soil, perched groundwater, or the Great Miami Aquifer within the scope of Operable Unit 5 and does not provide for any additional active or passive institutional controls to reduce the potential for exposure (e.g., physical barriers, deed restrictions). In addition, it is assumed that all existing remedial activities, monitoring programs, and institutional controls would be discontinued and the property would be released for unrestricted use.

5.4.1.2 Assessment

5.4.1.2.1 Overall Protection of Human Health and the Environment

The no-action alternative does not meet the remedial action objectives for Operable Unit 5. The Operable Unit 5 baseline risk assessment calculated the risks to a number of representative receptors for current and future land use scenarios. These risks are summarized in Section 2.0 and Appendix H of this FS report. The results of the baseline risk assessment indicated that the no-action alternative would result in risks exceeding the generally accepted ILCR range of 10^{-4} to 10^{-6} for carcinogens or a HI of 1.0 for noncarcinogens for one or more receptors under certain land use scenarios. Therefore, the no-action alternative would not be protective of human health.

Erosion of contaminated soil or storm water runoff could result in contaminant migration to Paddys Run which could impact environmental receptors such as aquatic biota. Resuspension and redeposition of contaminants from contaminated soil could also result in contamination of additional habitats. Therefore, the no-action alternative would not be protective of the environment.

5.4.1.2.2 Compliance with ARARs

CERCLA Section 121 cleanup standards, including compliance with ARARs, apply only to remedial actions that EPA determines should be taken under the authority of CERCLA Sections 104 and 106. A no-action decision can only be made when no remedial action is necessary to reduce, control, or mitigate exposure because the site is already protective of human health and the environment. If the

alternative meets the protectiveness threshold criteria, then compliance with ARARs is not pertinent to the selection of the no-action alternative.

The no-action alternative would not meet certain ARARs for Operable Unit 5. With no further action (per the Operable Unit 5 Baseline Risk Assessment), continued release of contaminants could result in exceedance in airborne emissions of radionuclides under 40 CFR 61, Subparts H and I, and exposure limits to the public established under DOE Order 5400.5. Release of radionuclides, as well as organic and inorganic contaminants, would violate State of Ohio water quality standards (OAC 3745-1) for receiving surface waters. Drinking water MCLs and MCLGs would also be exceeded in the long term if the released material were to continue to migrate into the Great Miami Aquifer.

5.4.1.2.3 Long Term Effectiveness and Permanence

Magnitude of Residual Risk

The no-action alternative provides a long-term solution that is neither effective nor permanent. The baseline risks due to carcinogenic and noncarcinogenic contaminants present within Operable Unit 5 exceed accepted regulatory limits (10^{-6}) for more than one receptor under a range of land use scenarios.

Under the no-action alternative continued migration of contaminants from Operable Unit 5 can be expected that would lead to increased contamination levels in the perched groundwater and in the Great Miami Aquifer. Increased contamination levels in the perched groundwater would cause higher concentrations of contaminants in Paddys Run surface water and sediment. These increased concentrations of contaminants in the environmental media of Operable Unit 5 would pose additional overall risk to human and environmental receptors.

Adequacy and Reliability of Controls

The no-action alternative provides no controls for existing contamination. Therefore, the no-action alternative would not have any effect on existing risks.

Deterioration of site surface features would be expected to increase the concentration of contaminants in surface water, thereby impacting adjacent biotic resources. Migration of soil contaminants to the Great Miami Aquifer would cause the concentration of COCs in the great Miami Aquifer to exceed MCLs or proposed MCLs.

Long-Term Environmental Impacts

The no-action alternative would not be protective of human health and the environment in the long term because it is not protective against potential exposure to waste materials. The absence of waste containment could increase contamination levels in the Great Miami Aquifer, the on-property perched groundwater zone, surface water and sediment, the 100- and 500-year floodplain of Paddys Run, and wetland areas within Operable Unit 5. Sloan's crayfish (*Orconectes sloanii*), a species included on the state's list of threatened species, is found to occur in Paddys Run, and may be adversely affected by conditions within the study area under the no-action alternative.

5.4.1.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility or volume through treatment is not applicable to the no-action alternative.

5.4.1.2.5 Short-Term Effectiveness

Under the no-action alternative, no remedial action would be taken; therefore there would be no increase in short-term risks to human health and no short-term environmental impacts due to remediation activities.

5.4.1.2.6 Implementability

Under the no-action alternative, no remedial action would be taken. Therefore, there would be no difficulties nor uncertainties associated with construction.

5.4.1.2.7 Cost

There are no costs associated with the no-action alternative.

5.4.2 Alternative 1 - Excavation and Off-Site Shipment

Alternative 1 is the only remedial action alternative considered under this FS which contemplates the release of the entire on-property area of the FEMP for unrestricted use. The achievement of this objective requires the treatment of groundwater from the Great Miami Aquifer and excavation and off-site transport and disposal of contaminated soil.

5.4.2.1 Detailed Description

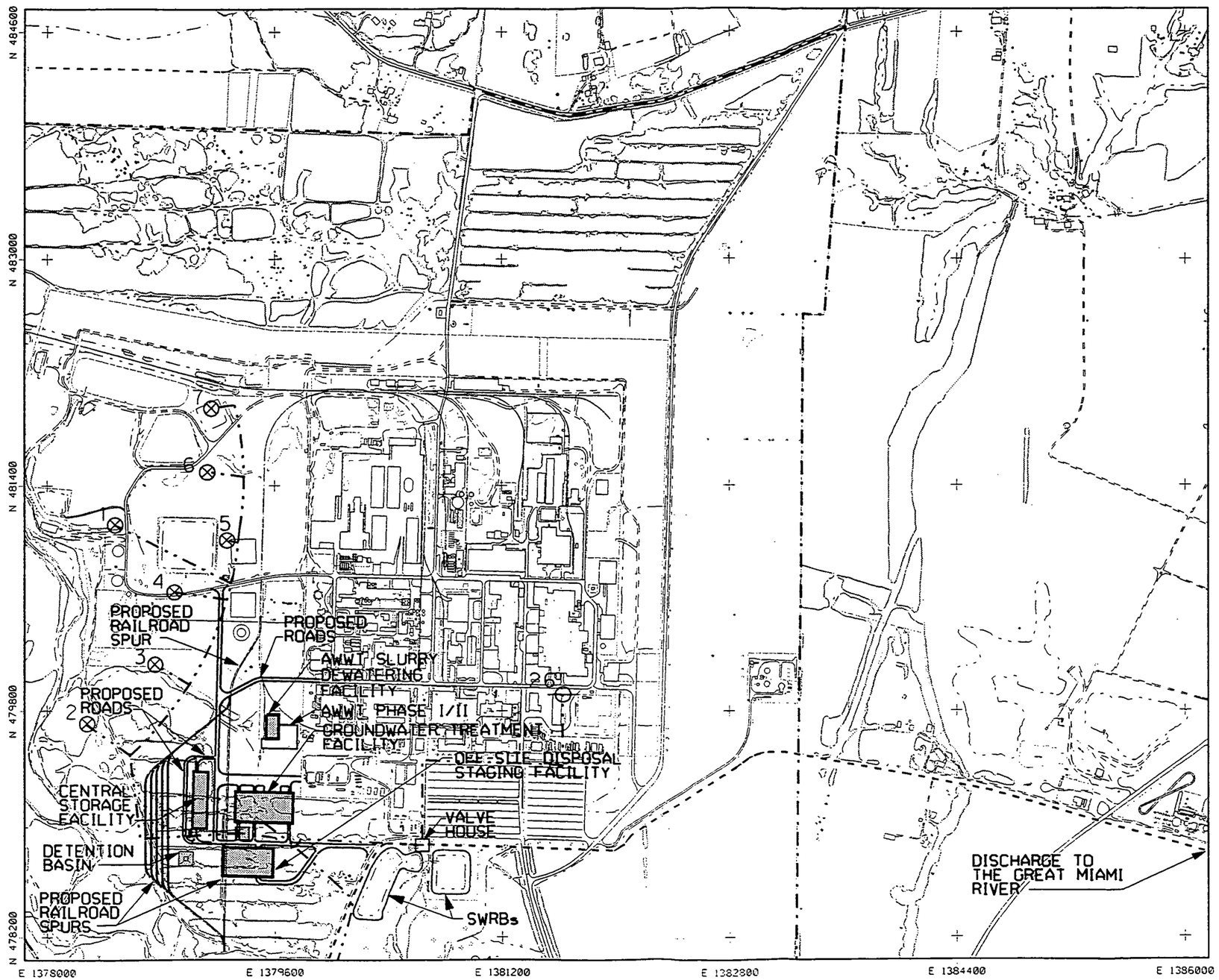
Alternative 1 is comprised of the following remedial activities:

- Excavating contaminated soil, production-area gravel, and sediment exceeding PRLs; excavating contaminated perched groundwater zones identified as presenting an unacceptable ingestion risk or a potentially unacceptable risk to the Great Miami Aquifer

- Backfilling excavated areas and regrading of the site to achieve desired drainage patterns and controls
- Pretreating soil exhibiting concentrations of constituents regulated under the Resource Conservation and Recovery Act (RCRA) to meet land disposal restrictions (LDRs) for off-site disposal
- Dispositioning contaminated materials to an off-property, permitted commercial disposal facility
- Extracting contaminated groundwater from the Great Miami Aquifer until target concentrations of COCs are attained
- Treating all collected storm water, wastewater and groundwater, as required
- Discharging storm water, wastewater and recovered groundwater to the Great Miami River following any required treatment
- Decontaminating and demolishing required support facilities following completion of remedial actions, with off-property disposal of the contaminated debris at a commercial disposal facility
- Releasing all areas within and around the FEMP, at the discretion of the federal government, for full unrestricted use including farming and/or residential development

To ensure that a full range of residual risk conditions are evaluated, Alternative 1 was evaluated for two different risk scenarios referred to as Case 1 and Case 2 (see Table 2-18). Case 1 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property and off-property target receptors (i.e., the RME resident farmer). Case 2 assumes that the FEMP is remediated to achieve an ILCR of 10^{-5} to these same receptors. Table 5-5 provides a concise summary of the target receptors and associated risk levels for soil and groundwater considered under each case.

A conceptual site plan depicting the necessary support structures and disposal facilities for Alternative 1 is presented in Figures 5-3 and 5-3a. The site plan displays a configuration necessary to address the anticipated volume of material required to be excavated to achieve the target risk levels defined above. Remediation facilities depicted in the site plan include a central storage facility for interim storage of contaminated material, a staging facility and rail spur for off-site shipment of bulk soil, groundwater extraction systems, the AWWT slurry dewatering and water treatment facility and a groundwater treatment facility.



LEGEND

EXISTING		PROPOSED
	BUILDING/TRAILER	
	PAVED ROADWAY	
	UNPAVED ROADWAY	
	FENCE	
	RAILROAD	
	TREE	
	TREE LINE	
	DITCH FLOW	
	EXTRACTION PIPELINE	
	SOUTHPLUME RECOVERY PIPELINE	
	SYSTEM 3 EXTRACTION WELL	
	WASTE PIT AREA EXTRACTION WELL	

NOTES:

1. SURFACE FEATURES BASED ON 1992 FLYOVER.
2. BORROW AREA WILL BE LOCATED IN THE SOUTHEASTERN PORTION OF THE FEMP PROPERTY.

400 0 400 800 1200

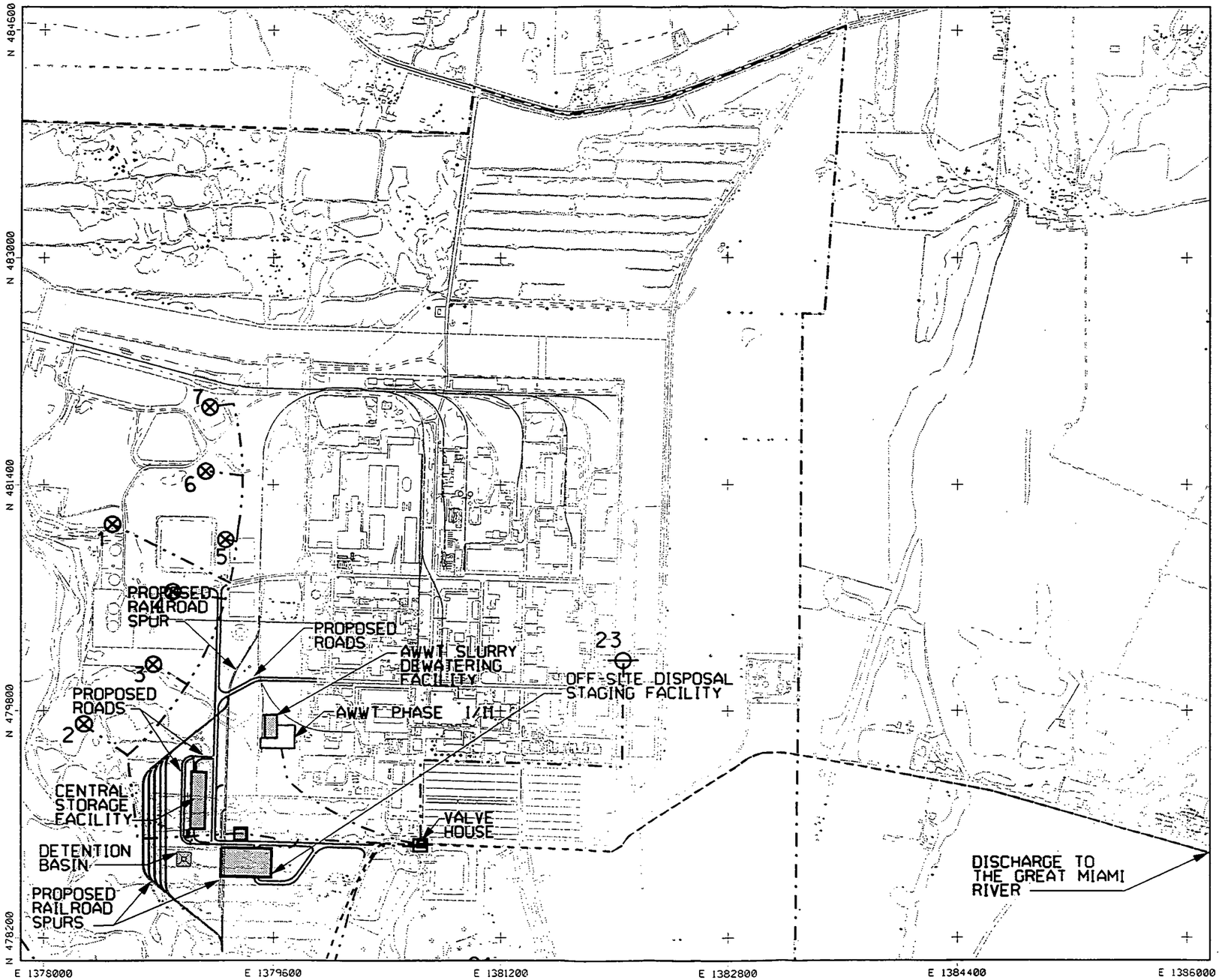
SCALE IN FEET

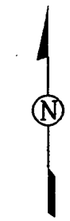
STATE PLANAR COORDINATE SYSTEM 1927

P0113/0/sk-g02897.Jun/005

FINAL

FIGURE 5 3. SITE PLAN ALTERNATIVES 1-1 AND 2C-1





LEGEND

EXISTING		PROPOSED
	BUILDING/TRAILER	
	PAVED ROADWAY	
	UNPAVED ROADWAY	
	FENCE	
	RAILROAD	
	TREE	
	TREE LINE	
	DITCH FLOW	
	EXTRACTION PIPELINE	
	SOUTHPLUME RECOVERY PIPELINE	
	SOUTHFIELD EXTRACTION WELL	
	WASTE PIT AREA EXTRACTION WELL	

NOTES:

1. SURFACE FEATURES BASED ON 1992 FLYOVER.
2. THIS FIGURE PROVIDES THE DISPOSAL CELL AND CONSOLIDATION AREA CONFIGURATION FOR MATERIAL AT THE 10E-5 RISK LEVEL. TEXT OF REPORT CONTAINS ADDITIONAL INFORMATION FOR THESE COMPONENTS AT DIFFERING RISK LEVELS.
3. THE STORMWATER CONTROL DITCH SHALL BE INSTALLED FOR THE DISPOSAL CELL/CONSOLIDATION AREA. SEDIMENT CONTROL MEASURES SHALL BE INSTALLED THROUGHOUT DITCH.
4. 43 PAIRS OF PROPOSED 1000 AND 2000 SERIES MONITORING WELLS AROUND DISPOSAL CELL AND CONSOLIDATION AREA PERIMETER.
5. BORROW AREA WILL BE LOCATED IN THE SOUTHEASTERN PORTION OF THE FEMP PROPERTY.

400 0 400 800 1200

SCALE IN FEET

STATE PLANAR COORDINATE SYSTEM 1927

P0113/B/ak,j03562.dgn/OU5

FINAL

FIGURE 5-3a. SITE PLAN ALTERNATIVE 1-2

000440

TABLE 5-5

TARGET RECEPTORS AND ASSOCIATED RISK LEVELS FOR ALTERNATIVE 1

	On-Property Soil and Sediment		Off-Property Soil and Sediment		Groundwater	
Risk Case	Receptor	Risk Level	Receptor	Risk Level	Receptor	Risk Level
1	Resident farmer	10^{-6}	Resident farmer	10^{-6}	Resident farmer	10^{-6}
2	Resident farmer	10^{-5}	Resident farmer	10^{-5}	ARARs*	Proposed MCLs

* At a residual risk level of 10^{-5} to the resident farmer, the MCLs and proposed MCLs are more restrictive and are therefore used in lieu of the risk-based limits.

The PRLs were previously presented in Section 2.11. For Alternative 1, the PRLs listed in Tables 2-12, 2-13, 2-14, and 2-15 are based upon the assumption that a farmer could be permitted to establish residence on the land in the future.

Figure 4-6 presented a conceptual block flow diagram of the remedial activities associated with Alternative 1. Detailed discussions on each of the components comprising the alternative are presented in Appendix L. The following subsections describe the unique aspects of each component as they apply to Alternative 1.

Excavation and Backfill

Contaminated soil, production-area gravel, sediment, and soil from perched zones not meeting PRLs would be excavated using conventional construction equipment. Excavated material would be loaded into roll-off containers and transported to the off-site disposal staging facility. Contaminated soil would be loaded into 100-ton rail cars for shipment off site. For purposes of this FS, a representative commercial disposal facility was selected for developing and evaluating the viability of off-property disposal.

Excavated soil and sediment determined (through HWMU and process operations history, excavation control surveys, and verification sampling) to contain RCRA-listed or characteristic wastes would be pretreated to meet LDR treatment standards. Treated media contaminated with listed constituents

would then be disposed of off site as subtitle C mixed waste. Conversely, treated media contaminated with characteristic waste would be disposed of off site as subtitle D waste.

On-property and off-property areas to be excavated for Alternative 1 to achieve an ILCR of 10^{-6} to the resident farmer are presented in Figures 2-10 and 2-6, respectively. On-property and off-property areas to be excavated to achieve an ILCR of 10^{-5} to the resident farmer are presented in Figures 2-11 and 2-7, respectively. The areas to be excavated include the contaminated rubble along the Great Miami River near the outfall line, contaminated soil under pipelines, and affected soil in the area of the FEMP's former underground storage tanks. The Operable Unit 5 excavation footprints and soil volumes also include the incremental soil excavation necessary to complete remedial activities within the boundaries of the other operable units.

Table 5-6 provides estimated in situ soil volumes (including on-property perched zones) which would be excavated, both on- and off-property, under Alternative 1 to achieve the target risk levels. The on-property backfill represents that volume of soil that does not exceed PRLs but must be excavated in order to reach more contaminated soil beneath it. As this soil does not exceed PRLs, it can be used as clean backfill in the area from which it was excavated. The table also shows the number of rail cars which would be required to support off-site disposal, assuming a bulk density of 1.76 tons per cubic yard of in situ material. The calculations assume 100 tons of soil per rail car and 50 rail cars per train. An excavation period of 22 years is assumed. This time period is based upon the necessity to interface with remedial activities in Operable Unit 3 to gain access to contaminated soil underlying the former production facilities.

The volume projections presented in Table 5-6 are based upon an engineering evaluation of available data that was prepared for purposes of developing and evaluating remedial alternatives. Final excavation footprints and volumes for all affected media would be established through completion of a preexcavation verification survey. This verification survey would be conducted before and during remedial actions to confirm the locations of excavation footprints, resolve outlier data, and to guide the excavation process as it proceeds in the field. A detailed description of the verification sampling program is contained in the component description for excavation provided in Appendix L.

Certification sampling, which is conducted at the completion of remedial activities, will be necessary to confirm that remedial action objectives have been achieved. For both the verification and the certification sampling programs, the suite of analytical parameters used to define compliance with PRLs will include all of the COCs, in addition to total uranium.

Excavated areas would be backfilled, as necessary, to reestablish original grade. Vegetative cover would be reestablished in the backfilled areas.

TABLE 5-6

REMEDIAL ACTION ALTERNATIVE 1 SOIL VOLUMES

	Risk Case	
	1	2
Risk Goal		
On-property		
Receptor	Resident farmer	Resident farmer
Risk level	10^{-6}	10^{-5}
Off-Property		
Receptor	Resident farmer	Resident farmer
Risk level	10^{-6}	10^{-5}
Soil Volume Requiring Excavation (yd^3)		
On-property[a]	4,450,000	2,340,000
Off-property	5,200,000	400,000
Total	9,650,000	2,740,000
Remedial Action (in situ soil volume in yd^3)		
On-property backfill	300,000	340,000
Off-site disposal	9,350,000	2,400,000
Total	9,650,000	2,740,000
Transportation Capacity		
Rail cars	165,000	42,240
Train loads	3300	845
Trains per month	13	4

[a] Includes 175,000 cubic yards of gravel from production area

Great Miami Aquifer Restoration

Contaminated groundwater from the Great Miami Aquifer would be extracted through additional recovery wells, continuing until such time as the target concentration levels for COCs are attained as described in the groundwater recovery component of Appendix L. On the basis of modeling projections presented in Appendix F, the target concentration level for uranium at a residual risk level of 10^{-6} (e.g., 3 ppb total uranium) would be attained at all points in the aquifer within 75 years at a maximum pumping rate of 7500 gpm. Based on modeling projections, the target concentration associated with attaining a 10^{-5} ILCR or MCL would be achieved in 27 years of active pumping at a maximum pumping rate of 4000 gpm. This pumping rate is anticipated to diminish as portions of the aquifer attain the target concentrations. Recovery well locations, configurations, and pumping rates would be finalized during remedial design.

High density polyethylene pipeline would be installed to transfer recovered groundwater to the groundwater treatment facility. Contaminated groundwater would be extracted at a rate of 1500 gpm and treated, on an interim basis, at the AWWT facility through 1999. Beginning in 2000, the groundwater treatment facility is expected to be operational. At this time, contaminated groundwater would be extracted at 7500 gpm or 4000 gpm for the 75 year and 27 year extraction periods, respectively, and treated at the groundwater treatment facility. The AWWT facility would then provide treatment for recovered perched groundwater, collected storm water, and process wastewater generated by FEMP remedial activities only. Process wastewater, storm water, and recovered groundwater streams associated with both aquifer restoration cases would be treated and discharged to the Great Miami River until such time as the PRLs are attained.

Following startup of the groundwater treatment facility and the development of the increased treatment capacity, the maximum loading of uranium to the Great Miami River is anticipated to be approximately 450 and 300 pounds per year for the 27- and 75-year extraction periods, respectively. Projected uranium discharges to the Great Miami River throughout the operation of the Great Miami Aquifer groundwater recovery system are shown in Figure 5-4.

Sediment sludge, regenerate sludge, spent ion exchange resins, carbon filter media, and other miscellaneous waste streams generated by the operation of the AWWT facility and the groundwater treatment facility would be dewatered, stabilized (if required) and dispositioned at an off-site disposal facility. For cost estimating purposes, cementation was employed as the stabilization technology. Cement stabilization would be performed by a vendor-supplied sludge stabilization service or through installation of an annex to the treatment facility.

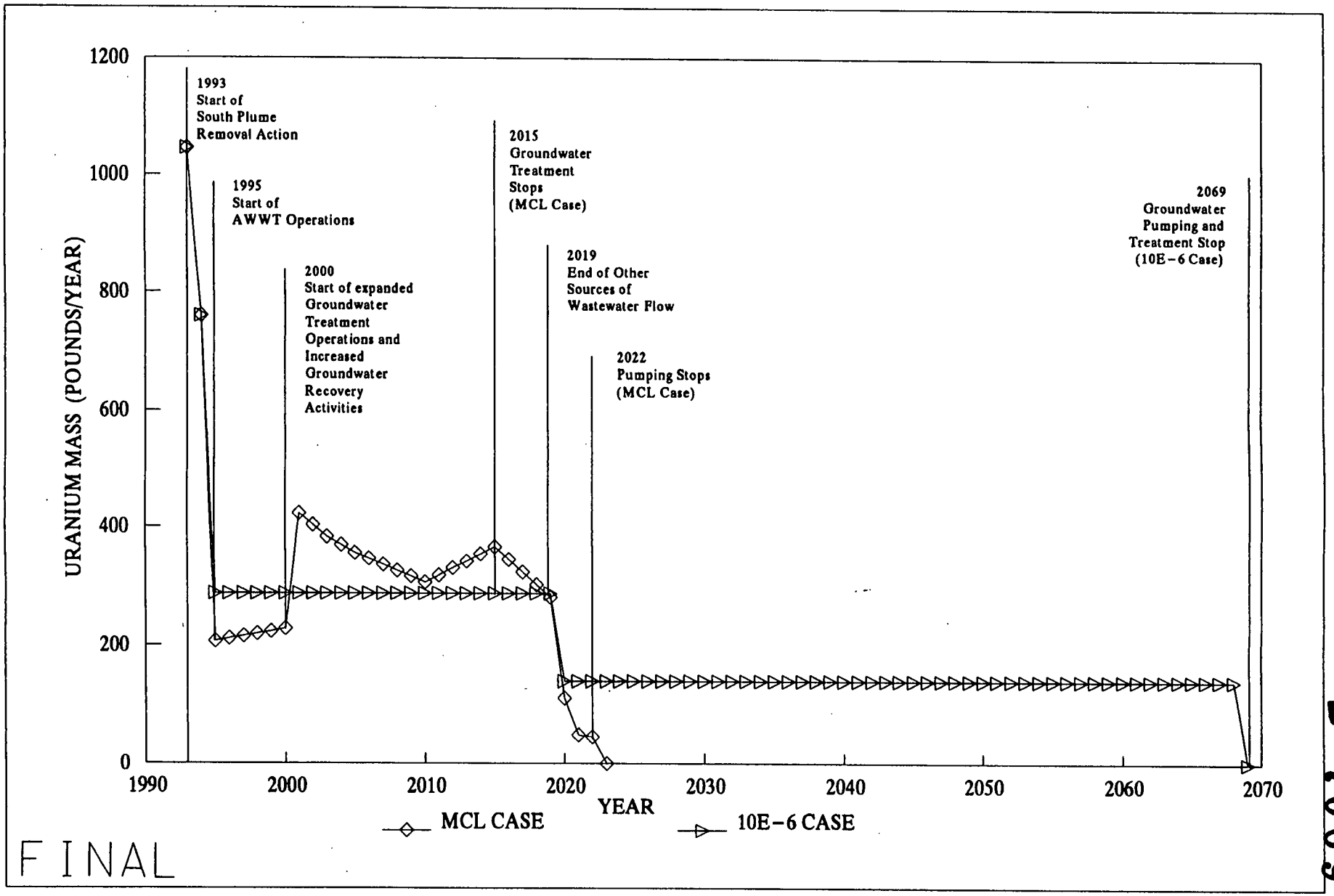


FIGURE 5-4. ESTIMATED URANIUM DISCHARGE TO THE GREAT MIAMI RIVER

000445

7069

Storm Water Management

Storm water control would continue throughout the period required to remediate soil and sediment in the source operable units (i.e., Operable Units 1, 2 ,3 and 4). Storm water would continue to be collected and directed to the existing storm water retention basin (SWRB). Following attainment of remedial action objectives associated with the source operable units, the SWRB would be removed using the excavation methods described above. Sedimentation sludge from the SWRB would be dewatered at the AWWT facility, characterized, and dispositioned off site. If required, the sludge would be cement-stabilized before dispositioning the materials. For cost estimating purposes, it was assumed that these materials would not require stabilization.

Decontamination and Demolition

Following attainment of remedial action objectives, support facilities (including the planned groundwater treatment facility, the AWWT facility, interim staging facilities, miscellaneous roadways, and rail spurs) would be decontaminated and demolished. Construction materials would be recycled, to the extent practical. Contaminated rubble would be dispositioned off site at a commercial disposal facility. The pumps and transmission lines associated with the recovery wells would be removed and dispositioned off site. Wells would be abandoned in accordance with State of Ohio requirements.

Resultant Land Use Potential

As previously indicated, the remedial action alternatives were developed to achieve a range of target land use objectives and ensure the protection of the underlying Great Miami Aquifer. Alternative 1 targeted release of the entire FEMP site for unrestricted use. The achievement of this objective requires the treatment of groundwater from the Great Miami Aquifer and excavation and off-site transport and disposal of contaminated soil.

Institutional and Administrative Control Requirements

Administrative controls employed during the implementation of Alternative 1 would include providing alternative water supplies to effected users whose wells exhibit concentrations exceeding the PRLs, pending the completion of the Great Miami Aquifer remedial actions. The Hamilton County Department of Public Works is presently installing a public water supply (partially funded by the DOE) in the Fernald area. For costing purposes, this system is assumed to be installed and operational during the duration of the aquifer restoration period. Upon the completion of Alternative 1 remedial actions, all areas within and around the FEMP would be, at the discretion of the federal government, released for full unrestricted use. Potential land uses include farming, residential development, industrial development or recreational use. Because achievement of Alternative 1 objectives would achieve EPA-specified risk levels for potential receptors incurring the highest risk (i.e., the on-property resident farmer) and because remedial actions include the off-site transport and

disposal of media containing above-PRL concentrations of COCs, no further institutional controls would be required following completion of remedial actions.

5.4.2.2 Assessment

5.4.2.2.1 Overall Protection of Human Health and the Environment

Alternative 1 meets the remedial action objectives for Operable Unit 5 and would be protective of human health and the environment. Implementation of this alternative would prevent direct access to contaminated soil and sediment by removal of these media to health-based levels and disposal at an off-site location. Implementation of Alternative 1 would mitigate the migration of contaminants in soil and sediment to the air and groundwater. Moreover, implementation of Alternative 1 would prevent the consumption or use of groundwater containing FEMP contaminants above an ILCR of 10^{-6} for Case 1 or above MCLs or proposed MCLs (or a 10^{-5} ILCR/HI of 0.2 for COCs without an MCL or proposed MCL) for all other cases. Exposure to direct radiation above protective levels would also be prevented.

The primary actions that would be used to meet the remedial action objectives of Alternative 1 are: excavation of contaminated soil and sediment exceeding PRLs and dispositioning these materials at an off-site waste disposal facility, backfilling excavated areas with clean borrow and topsoil, and extraction and treatment of contaminated groundwater from the Great Miami Aquifer until remedial goals are attained. Excavation and disposition of soil contaminated above PRLs would ensure that the risks to the hypothetical resident farmer would not exceed those considered health protective. Moreover, the absence of soil contaminants at concentrations above the PRLs would ensure that future contaminant concentrations in the Great Miami Aquifer would not increase to levels that exceed PRLs or proposed PRLs within the 200- to 1000-year period considered under this FS. It is assumed that the design, siting and permitting of the off-site commercial disposal facility will preclude a corresponding increase in residual risk at that location.

Backfilling excavated areas with clean backfill and topsoil would prevent direct contact with residual contamination (i.e., below PRL levels of contamination remaining in the soil following excavation) and would prevent the potential spread of residual contamination through the air pathway. The establishment of a vegetative cover would minimize future erosion. Extraction and treatment of Great Miami Aquifer groundwater would clean up existing groundwater contamination. Remediation of the aquifer combined with the remediation of other media would ensure that PRLs would not be exceeded in the Great Miami Aquifer in the future.

The most significant short-term risks associated with the implementation of Alternative 1 are the risks associated with the transport of contaminated media to an off-site waste disposal area. In addition, increased worker risks would be expected throughout implementation of this alternative. Through the

implementation of a worker health and safety plan in compliance with 29 CFR 1910.120, exposures would be kept to below regulatory limits and would comply with DOE orders. These risks are discussed further in Section 5.4.2.2.5.

Following implementation of Alternative 1, no institutional controls would be required. All FEMP land could, at the discretion of the federal government, be made available for alternative land uses.

5.4.2.2.2 Compliance with ARARs

Compliance with the chemical-, action-, and location-specific ARARs is discussed below. Detailed discussion of the principal ARARs and TBCs is presented in Section 2.4 and Appendix B. The complete list of ARARs/TBCs is presented in Appendix B.

Chemical-Specific ARARs

Alternative 1 would comply with the chemical-specific ARARs/TBCs identified in Table B.1 of Appendix B. ARARs associated with penetrating radiation and potential releases of contaminants to air, surface water, and groundwater would be met through the removal of a contaminated material from the site. The material would be disposed of at a permitted, off-site commercial disposal facility. On-property pretreatment, storage, and manifesting requirements would be performed to meet the waste acceptance criteria of the off-site disposal facility.

Water encountered during pumping and excavation would be treated to meet the Ohio Water Quality Standards (OAC 3745-1), described in Table B.1 of Appendix B.

Location-Specific ARARs/TBCs

Location-specific requirements associated with this alternative relate to the protection of four principal natural features or resources: floodplains, wetlands, endangered species, and the sole-source aquifer underlying the FEMP site. A summary of the location-specific ARARS is provided in Appendix B, Table B.2.

Restrictions on activities conducted in wetlands and floodplains are specified in 40 CFR 6.302, 10 CFR 1022 and Executive Orders 11990 and 11988. Compliance with these requirements would be met through the prior assessment of potential impacts associated with activities conducted in these locations, and the implementation of mitigative measures. This assessment would result in appropriate planning, siting, design, and operational procedures.

The methods for handling dredged and excavated material would comply with the provisions of 33 CFR 323 and 40 CFR 230, which state that dredged or excavated material will not be discharged into waters of the United States.

Protection of endangered species is mandated by 16 U.S.C 1531, 50 CFR 17 and 402, and O.R.C. 1531.25, 1518.02 and OAC 1501:18-1. Studies are being conducted to determine the presence of individuals and potential habitats of several federally and state-listed animal and plant species. If habitats or individuals are found, appropriate mitigative measures would be taken.

The provisions of 16 U.S.C. 469, 36 CFR 800, 40 CFR 6.301; 42 U.S.C. 1996 and 43 CFR 7 require federal agencies undertaking an action to implement measures to avoid adverse impacts to historic and cultural properties. Alternative 1 would comply with these provisions because any cultural resources identified would be either avoided or managed appropriately.

Action-Specific ARARs

Alternative 1 would comply with all pertinent action-specific ARARs identified in Appendix B for waste removal, treatment and off-site disposal.

As previously discussed under chemical-specific ARARs, the specific measures and engineered controls incorporated into Alternative 1 would be in compliance for all action-specific ARARs regarding air quality from 40 CFR 50.6 and OAC 3745-17-08. These ARARs would be pertinent during remedial actions and the postclosure care period.

Waste removal actions would be conducted in compliance with 40 CFR 192.02(b) and 192.12 to provide reasonable assurance that residual radioactive materials do not exceed the specified concentrations above PRLs. During implementation of the remedial action (including waste removal, facility construction and waste treatment), appropriate engineered features and procedures would be implemented to comply with the requirements of the Clean Air Act, 40 CFR 50.6, and Ohio's requirements for fugitive dust control, OAC 3745-17-08. Operable Unit 5 media containing greater than 50 ppm of polychlorinated biphenyl (PCBs) require compliance with 40 CFR 761, Subpart G.

Any listed or characteristic hazardous wastes to be disposed of off site would have to meet the waste acceptance criteria for off-site disposal, including the treatment standards appropriate for the LDRs under RCRA (40 CFR 268.40 through 268.44). All storage, containment, management, and manifesting requirements for listed and characteristic hazardous waste would be performed in accordance with 40 CFR 261, 262, and 265 (40 CFR 264 [permitted facility] requirements are also considered where similar 265 [interim status facility] requirements are not specified).

Soil destined for off-site disposal would be classified as low-level radioactive waste/residual material. Soil also containing hazardous waste would be considered as low-level mixed waste. An evaluation of the ability of the Operable Unit 5 waste materials to meet the waste acceptance criteria for off-site disposal is provided in Appendix E.

5.4.2.2.3 Long-Term Effectiveness and Permanence

Magnitude of Residual Risk

It is anticipated that Alternative 1 would provide the highest level of long-term effectiveness, because the scope of the alternative involves the excavation and off-site disposal of the contaminated soil and sediment. Through the completion of a preexcavation verification sampling program and a postcleanup certification process, the alternative would be assured of achieving the PRLs for the COCs in soil and sediment.

Groundwater Residual Risk - As previously discussed, all alternatives provide for the extraction of contaminated groundwater from the regional aquifer while the perched zones would be removed as a part of the soil excavation process. Contaminated groundwater would be removed from the regional aquifer until the PRLs for the COCs are attained. Modeling was completed to predict the remaining concentration of uranium and other COCs (Table 2-3) in the aquifer. For the pumping scenario designed to attain the 10^{-6} PRLs in the aquifer, modeling projections indicate that approximately 75 years of pumping would be required to attain the PRLs. For the pumping scenario designed to achieve the proposed uranium MCLs (i.e., 20 ppb uranium), modeling indicates that the uranium concentration in the Great Miami Aquifer can be reduced to below 20 ppb after 30 years of pumping. This projection is dependent upon the input parameter (K_d) used to establish the desorptive capability of the silt, sand and gravel comprising the aquifer and its ability to release uranium and other contaminants. Sensitivity runs completed for uranium indicate that as much as 60 ppb could remain in select portions of the aquifer following 75 years of pumping if the desorption K_d were increased by an order of magnitude. The Great Miami Aquifer remedial actions contemplated for Alternative 1, and all other alternatives, are based upon the base case projections of mass reduction in the aquifer developed through the modeling effort. The FEMP, through evaluation of performance data during implementation, would continue to examine modification to the extraction system, such as reinjection of treated water to enhance contaminant recovery. Such modification would only be applied following approval by the EPA.

Soil Residual Risk - As presented in Section 2.0, footprints for soil excavation were based upon the use of total uranium as an indicator parameter. The footprints were then expanded to capture other COCs whose concentrations in soil exceeded their respective PRLs. Because initiating soil excavation activities, verification sampling would be performed to confirm the excavation footprints. Continual monitoring would be performed to help direct excavation activities. Upon completion of excavation

activities in a given area, certification sampling would be performed to confirm that soil PRLs were attained. Long-term effectiveness and permanence would be assured because those materials exceeding PRLs would be removed and transported for disposal at an off-site facility.

Adequacy and Reliability of Controls

In Alternative 1, the contaminated sediment and soil would be excavated and transported off site to a permitted commercial disposal facility. This facility would be responsible for long-term monitoring and maintenance activities. As a result, no long-term management at the FEMP site would be necessary. The selected commercial disposal facility would have to hold a current license for disposal of low-level radioactive and mixed wastes. Therefore, the institutional controls and maintenance activities at the facility are assumed to be adequate and reliable.

This alternative also calls for extraction and treatment of contaminated groundwater from the Great Miami Aquifer with off-site disposal of groundwater treatment residuals. During the treatment phase, groundwater monitoring would be conducted to provide data on the performance of the extraction component. Groundwater modeling indicates that contaminant levels in the Great Miami Aquifer could be reduced to the proposed MCL of 20 ppb for uranium in 27 years of active pumping. A risk level of 10^{-6} for a residential receptor, which corresponds to a uranium concentration of 3 ppb in the aquifer, can be achieved in 75 years of extraction and treatment. However, modeling results indicate that the PRLs for radium-226, arsenic, and manganese are not achieved in either the 27- or the 75-year pumping time frame. Due to the relative immobility of these constituents, current projections suggest that continued pumping beyond the 27- (or the 75-) year period would provide marginal benefit in the long term. The EPA has recently (October 1993) issued guidance which formally recognizes that where groundwater cannot be restored to ARAR-based cleanup levels in a reasonable time frame, a technical impracticability (TI) waiver may be requested under CERCLA. In the event that attainment of target remedial goals is not achieved during actual remediation, the FEMP may need to propose the use of asymptotic recovery limits as the ultimate basis for system shutoff. Thus, once long-term extraction system performance data is available, the FEMP may need to seek a TI waiver determination to allow pumping to cease.

Because all soil and sediment with above-PRL concentrations of COCs would have been removed from the site, the potential for recontamination of the aquifer from FEMP operations would not exist. Therefore, no long-term groundwater monitoring beyond the Great Miami Aquifer remediation time frame is required.

Groundwater treatment will be conducted through the AWWT facility for perched groundwater, and through the groundwater treatment facility for Great Miami Aquifer groundwater; both systems would use well-demonstrated technologies. Based on EPA's primary drinking water regulations both activated carbon (40 CFR 141.61) and ion exchange (40 CFR 161.62) are considered best demonstrated available technology (BDAT) for removal of organic and inorganic constituents from contaminated groundwater. An ion exchange resin specifically developed for uranium removal would be used in the treatment system. The treatment system is expected to achieve effluent concentrations of approximately 5 ppb of uranium. As an added control to ensure that the process effluent will meet the required performance specifications, the treated groundwater would be pumped to one of two monitoring tanks. At a minimum, the pH and uranium concentrations would be monitored at these tanks to verify that the treated water is suitable for discharge to the Great Miami River.

Long-Term Environmental Impacts

The following paragraphs discuss long-term impacts to the environment for Alternative 1, Case 1. A compilation of the irreversible and irretrievable commitment of resources associated with this alternative is presented in Section 5.5. For a detailed description of the environmental setting associated with the representative commercial disposal facility, refer to Appendix I.

Soil and Geology - Site soil and sediment containing above-PRL concentrations of COCs would be excavated and placed into rail cars for transport to a commercial disposal facility. Excavated areas would be backfilled, as needed, using clean fill, regraded to original contours, and revegetated. Runoff/run-on controls would minimize contaminant transport through storm water runoff to uncontaminated areas.

For Alternative 1, Case 1 approximately 170 acres at a representative permitted commercial disposal facility would be permanently disturbed for disposal of FEMP materials. Approximately 44 acres of land would be impacted under Case 2. Depths to the groundwater beneath the disposal facility vary from 20 to 30 feet. This groundwater is a Class III aquifer due to extremely high total dissolved solids. The hydraulic gradient in the groundwater is small, limiting the velocity of groundwater movement away from the site to a maximum of 0.6 feet per year (DOE 1984). The design of the disposal facility and the high evapotranspiration rate characterized in the area would also reduce the potential for contaminant transport.

Water Quality and Hydrology - Surface water and groundwater in the vicinity of the FEMP would be protected as a result of contaminant source removal associated with Operable Unit 5. Removal of contaminated sediment would eliminate the exposure of aquatic and terrestrial organisms to FEMP COCs.

Upon completion of remedial activities associated with Operable Unit 5, the affected area would be regraded to near original contours promoting proper runoff and drainage. Surface water runoff would be routed to the appropriate collection/treatment system; therefore, no long-term impacts to water quality and hydrology at the FEMP are anticipated.

The disposal of waste at the off-site disposal facility (i.e., Envirocare) is not expected to impact water quality or hydrology. The prevailing arid climate affects the surface water regime. The facility lies within the Great Salt Lake Drainage Basin; however, the closest perennial water body is 23 miles away. Long-term impacts to nearby surface water bodies are expected to be minor.

Air Quality - The long-term impacts on air quality at the FEMP site from Alternative 1 would be minor because the source for airborne releases associated with contaminated soils and sediment would be removed. Soil and sediment removed from Operable Unit 5 and disposed of at the representative permitted commercial disposal facility are not expected to impact the existing air quality at that facility.

Biotic Resources - Long-term impacts to biotic resources at the FEMP would be positive because removal of contaminated soil and sediment would reduce exposure to FEMP COCs. Negative, long-term impacts would also occur due to the loss of habitat and associated organisms. Distinct habitats at the FEMP have been classified by Facemire et al. (1990) and include early and mid-successional woodlots, riparian woodlots, pine plantations, and introduced grasslands. Excavation of contaminated soil would result in the loss of 100.1 acres of early to mid-successional woodlands, 98 acres of riparian habitat, and 69.6 acres of pine plantation. Under Case 1, approximately 40 acres of riparian habitat would be lost, along with 50 acres of pine plantation habitat. Also, approximately 10 acres of early to mid-successional woodlands would be eliminated by implementation of Case 2. These habitats support a wide variety of organisms that are typical of local flora and fauna. Revegetation would restore introduced grassland habitat, except for 10.3 acres that would be lost due to the construction of railroad spurs, storage areas and staging facilities. Mitigative measures, such as revegetation with native species, would greatly reduce adverse long-term impacts to terrestrial habitats at the FEMP.

Habitats at the FEMP are sufficient to support several federal and state threatened and endangered species, including the federally listed endangered Indiana bat (*Myotis sodalis*), and the state-listed endangered cave salamander (*Eurycea lucifuga*). Restoration of these habitats, and specific measures for individual species, would reduce the loss of threatened and endangered species habitat.

Excavation of sediment and soil would impact aquatic habitats at the FEMP, including Paddys Run and its tributaries, the storm sewer outfall ditch (SSOD), and jurisdictional wetlands. The loss of these habitats would impact both aquatic and terrestrial species found at the FEMP. Approximately 9240 feet of Paddys Run would be impacted by soil excavation activities under Case 1; approximately 2800 feet of Paddys Run would be impacted under Case 2. Permanent alteration of Paddys Run and the SSOD may occur, thus impacting the state-threatened Sloan's crayfish (*Orconectes sloanii*) in the long term. Control of sediment deposition and restoration of stream habitat in excavated areas would partially mitigate this impact along with excavation during low flow conditions in Paddys Run. Individual Sloan's crayfish may be lost due to excavation in pooled areas where the species retreats during dry periods in Paddys Run. Relocation of this species upstream or to another suitable habitat before excavation would mitigate this impact.

Most of the land scheduled for off-property excavation is used for agriculture. A variety of off-property local habitats would be lost, however, including early to mid-successional woodlots, riparian habitats, wetlands, and introduced grasslands. Threatened and endangered species habitat and individuals would also be impacted, such as the state-listed cave salamander (*Eurycea lucifuga*). Mitigation, including revegetation would reduce these impacts.

Long-term impacts to biotic resources are expected to be minimal as a result of implementing mitigative measures discussed above and in the short-term effectiveness section for this alternative. Long-term impacts to biotic resources that would not be reduced through mitigative measures would be considered irreversible and irretrievable commitments of resources, as discussed in Section 5.5.

The vegetation at the representative permitted off-site commercial disposal facility is a homogeneous, semidesert low shrubland, primarily composed of shadscale (*Atriplex confertifolia*). Plant communities identified on the site are Shadscale-Gray Molly (*Kochia americana var. vestita*), a transitional community type of Shadscale-Gray Molly-Black Greasewood (*Sarcobatus vermiculatus*), and Black Greasewood-Gardner Saltbush (*Atriplex nuttalii*). Vegetation patterns are correlated with salinity and corresponding shifts in presence or abundance of species. No plant species are unique nor particularly valuable.

Approximately 171 acres of the existing plant community (Shadscale-Gray Molly) and its attendant habitat at the representative permitted commercial disposal facility would be displaced or disturbed as a result of the implementation of Case 1 for Alternative 1. Approximately 50 acres of the same habitats would be affected under Case 2. This type of plant community is neither unique nor particularly valuable. The flora or fauna in the potentially disturbed area are neither endangered nor threatened.

Wetlands and Floodplains - A wetlands delineation for the FEMP was conducted in December 1992 (Ebasco Environmental 1993) and approved by the U.S. Army Corps of Engineers, Louisville District in August, 1993. The delineation identified 27 acres of palustrine forested wetlands, 7 acres of drainage ditches/swales, and 2 acres of isolated persistent emergent and scrub/shrub wetlands which would be lost due to remedial activities under Case 1. Total on-site wetland areas to be impacted by Case 1 would be 36 acres and for Case 2, 17 acres. Mitigation for wetland impacts would be determined using the 404(b)(1) guidelines of the Clean Water Act. A wetlands delineation would be required to determine the presence of wetlands outside the 1050 acre site boundary. If wetlands are identified off-site, mitigation would be determined using the 404(b)(1) guidelines of the Clean Water Act.

Remedial activities are not expected to alter flow patterns or uses of the 100- and 500-year floodplain of Paddys Run because disturbed areas would be backfilled and regraded to near original contours. A floodplain/wetland assessment has been performed in accordance with 10 CFR 1022 requirements and is included in Appendix J. No wetlands or floodplains exist within the boundaries of the off-site disposal facility.

Socioeconomics and Land Use - Minor long-term social and economic impacts would be expected with the implementation of Alternative 1. For data analysis purposes, those counties in close proximity to the FEMP, and those most likely to be effected by remedial activities, were grouped into a 13-county region referred to as a consolidated metropolitan statistical area (CMSA). The CMSA consists of Brown, Butler, Clermont, Hamilton, and Warren counties in Ohio; Boone, Campbell, Gallatin, Grant, Kenton, and Pendleton counties in Kentucky; and Dearborn and Ohio counties in Indiana. Excluding public perception differences, any impacts resulting from the implementation of Alternative 1 would result from the purchase of materials for remedial activities and fluctuations in the work force population. Assuming all resources, excluding transportation and disposal costs, were purchased within the 13-county region, minor increases to the collective wealth of the CMSA would be expected.

Land Use Objective 1 examines the viability of returning the entire on-property area to full unrestricted use following cleanup. This objective considers the potential for establishing a hypothetical family farm on any portion of the FEMP property. For this, and all other land use objectives, affected off-property areas were examined only in context of the existing land use in the region, residential farming.

Work force fluctuations are expected throughout the duration of the project; however, they are expected to be limited. Efforts to mitigate these impacts include a combination of job relocation/activity reassignment programs, availability of formal educational opportunities, and

financial support for environmental programs at local community colleges. With the implementation of these programs, efforts will continue to limit social and economic impacts as a result of Alternative 1.

Social and economic impacts occurring at the off-site commercial disposal facility as a result of the implementation of Alternative 1 would be minor. Excess revenue gained by the State of Utah from disposal costs paid by the FEMP are expected to have extremely limited economic impacts. The work force population at the commercial disposal facility is expected to remain the same, resulting in minor to no impact.

The representative commercial disposal facility is located in Toole County, Utah. The county encompasses 700 square miles within the state and had a population in 1990 of 26,000 representing approximately 1.5 percent of the population of Utah. (The population of Utah was 1,723,000 in 1990.) Most lands within a 10-mile radius of the site are very rarely used because of their remoteness from urbanized areas, poor soil qualities, and sparse vegetative characteristics. Sheep grazing and recreational vehicle driving are the primary land use in the area, but are apparently infrequent. Interstate 80 and the Union Pacific System railway pass within 2.5 miles and 1 mile north, respectively, of the site. Disposal activities associated with Alternative 1 would not impact the representative commercial disposal facility.

Cultural Resources - A Phase 1 Cultural Resource Survey would be performed for the areas to be impacted by Operable Unit 5 remedial activities. A Phase 2 survey and data recovery would also be performed, if necessary. Cultural resource areas would be managed consistent with the requirements of the National Historic Preservation Act (NHPA), Archaeological Resources Protection Act, American Indian Religious Freedom Act, and the Native American Graves Protection and Repatriation Act.

Phase 1 and 2 surveys would be performed to determine the presence of historic and pre-historic (archaeological) sites eligible for the National Register of Historic Places (NRHP). If an undertaking is found to have an adverse impact, consultation with the Advisory Council on Historic Preservation and the State Historic Preservation Office (SHPO) would be required under the NHPA Section 106 process. If an adverse impact to a cultural resource cannot be avoided, a memorandum of agreement or programmatic agreement would be negotiated among the Advisory Council, the SHPO, and DOE, which would identify mitigative measures to be taken.

Significant cultural resources are located in and around the areas surrounding the FEMP property. For example, there are two sites east of the FEMP that could be impacted from remedial activities. Site 33-HA-438 is a historic and prehistoric site consisting of 19th century objects and Late and Early Archaic components. Materials recovered consist of historic domestic debris, prehistoric lithics and human remains. Site 33-HA-404 is a prehistoric site with an unassigned affiliation. Lithics have been recovered from surface collection. Extensive data recovery would be required in these areas because excavation to remove any artifacts and recover necessary information.

An estimated eight unassigned sites are located east of the FEMP. These include both single- and multicomponent sites representing prehistoric occupations ranging from Paleo through Late Prehistoric periods.

No events of historical significance are known to have occurred at the representative off-site commercial disposal facility. A cultural resource inventory for the facility was performed in August 1981 by the Archaeological Environmental Research Corporation (DOE 1984). No cultural resource sites were found. The ground to air pilotless aircraft launch site and blockhouse are listed in the NRHP and are approximately 10 miles west of the facility. To the southeast of the facility (approximately 23 miles) is the site of the Iosepa Settlement Cemetery. These are the nearest historical sites to the disposal facility and are not expected to be impacted from the implementation of Alternative 1.

5.4.2.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

No reduction of toxicity, mobility or volume of soil contaminants through treatment would be provided by this alternative. However, the toxicity, mobility, and volume of contaminated soil on site would be eliminated through transportation and disposal at an off-site commercial disposal facility.

For purposes of the FS, an estimate was completed of the quantity (an estimated 28,000 cubic yards) of soil containing RCRA hazardous, PCB, and petroleum wastes. This soil would be treated at the excavation site using mobile cement stabilization or thermal desorption units, depending on the contaminants present in the excavated soil, to meet LDR restrictions for off-site disposal. Thermal desorption would not generate treatment residuals, with the exception of the off-gas which would be treated using scrubbers. Any wastewater generated would be sent to the AWWT facility. Therefore, the toxicity, mobility, and volume of organic contaminants treated with the mobile thermal desorption unit would be reduced.

The relatively small volume of soil containing RCRA inorganic contaminants would be treated using a mobile cement stabilization unit. This technology converts soil into a matrix that prevents

contaminants from leaching. Thus, the mobility of the inorganic contaminants would be reduced. The stabilized soil would then be shipped off site for disposal.

Under this alternative, perched groundwater zones would be excavated. Collected contaminated water during excavation would be transported to the AWWT for treatment resulting in a corresponding volume reduction. The characteristics of the perched water and other wastewater to be treated in the AWWT are addressed in Appendix L.

Modeling indicates that the proposed MCL for uranium in the Great Miami Aquifer could be achieved in 30 years. Based on 30 years of continuous extraction and treatment at a capacity of 6300 gpm, an estimated 87 x 10^9 gallons of contaminated groundwater would be extracted and treated. To achieve a concentration of 3 ppb of uranium in the aquifer, which corresponds to a 10^{-6} risk level, an estimated 260 x 10^9 gallons of contaminated groundwater would be extracted and treated. Extracted groundwater from the Great Miami Aquifer would be treated in the groundwater treatment facility. Using conservative assumptions, the total cumulative mass of uranium that would be removed from the Great Miami Aquifer after 27 and 75 years is approximately 9500 and 19,100 pounds, respectively. Additionally, the mobility of the contaminants in the environment would be reduced by pumping and treating the contaminated groundwater. Essentially, the contaminants are removed from the groundwater and immobilized (i.e., as sludge, ion exchange resins and activated carbon). Pumping for 27 years would generate an estimated 13,000 cubic yards of treatment residuals. Taking into account the increase in volume from stabilization, a total of 17,000 cubic yards of waste would be shipped off site for disposal from contaminated Great Miami Aquifer groundwater treatment. Pumping for 75 years would generate an estimated 29,000 cubic yards of treatment residuals. The corresponding stabilized volume would be 39,000 cubic yards.

5.4.2.2.5 Short-Term Effectiveness

Protection of the Community During Remedial Actions

Through implementation of a combination of engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls), the short-term risks to members of the community associated with Alternative 1 would be minimized. A short-term risk assessment was conducted to assess the potential short-term risks to the public associated with the implementation of remedial actions for this alternative. The results, which appear in Appendix G, are based on the following pathways:

- Exposures to members of the public residing near the FEMP associated with the inhalation of contaminants (e.g., resuspended dust, and diesel exhaust)

- Mechanical hazards from accidents during transportation of materials (e.g., train derailments during off-site disposal operations)
- External radiation exposures to members of the public located along the transportation route used for off-site disposal
- External radiation exposures to members of the public located along the off-site disposal route in the event of an accident (e.g., train derailment).

Using historical transportation statistics, an estimated 23 fatalities and 86 injuries for Case 1 and 6 fatalities and 22 injuries for Case 2 can be expected to members of the public for Alternative 1 due to mechanical type hazards associated with accidents during transportation. These fatalities and injuries are associated with off-site disposal operations of excavated soil and sediment during the 22 years of remedial activities.

The estimated ILCR to hypothetical receptors, representing members of the public near the FEMP, due to external radiation and inhalation associated with releases during remedial actions are estimated at 6.6×10^{-7} for Case 1 and 4.2×10^{-7} for Case 2. ILCRs to members of the public located along the transportation route are 4.6×10^{-7} for Case 1 and 1.1×10^{-7} for Case 2.

Protection of Workers During Remedial Actions

Alternative 1 involves the handling of contaminated materials and, therefore, presents several potential pathways of exposure or injury for workers. Occupational injury, direct radiation, inhalation, and transportation accidents could pose risks to workers involved in remedial activities both on and off site, as well as to nonremediation workers at the site. Workers directly involved in the conduct of remedial actions would be required to perform work in accordance with the provisions of a task-specific health and safety plan (29 CFR 1910.120) and may be required to use personal protective equipment (PPE) that could include Tyvek suits and respirators to control exposures to site contaminants. It has been assumed in this analysis that workers are protected from dermal exposures by PPE and from ingestion of contaminants by administrative controls. It is assumed that non-remediation workers, who are on site during the implementation of remedial actions, do not use PPE. Nonremediation workers are assumed to have the potential to be exposed to dust released during excavation and transportation of materials on the site. Dust suppression techniques applied during remedial actions are anticipated to minimize the potential for exposures to resuspended, contaminated soil and sediment. A detailed analysis of the short-term risks associated with Alternative 1 is presented in Appendix G.

The ILCR for remediation workers for Case 1 is estimated at 2.3×10^{-3} for excavation activities and 4.6×10^{-3} for off-site disposal activities. For Case 2, the ILCR for excavation activities is 1.3×10^{-3}

and 2.9 x 10^{-3} for off-site disposal activities. For both cases, the dominant risk is from the inhalation of radioactive contaminants. These risk levels are less than those extrapolated from the maximum allowable exposure limits for workers, so that these risks do not exceed worker standards (10 CFR 835 and 29 CFR 1910).

Short-Term Environmental Impacts

Soil and Geology - Approximately 930 acres of land within the 1050-acre site boundary (outside the other operable units) would be disturbed from removing contaminated soil and sediment and excavating perched groundwater zones as part of Case 1. Approximately 485 acres would be disturbed under Case 2. Soil disturbances would also result from the construction of roads, construction and operation of support facilities and operation of heavy equipment. These activities would disturb approximately 10.3 acres of land within the site boundary. All remedial action alternatives would use on-site borrow material from the southeast portion of the FEMP and would temporarily disturb approximately 32 acres of soil.

Construction materials would be recycled to the extent practicable. Contaminated rubble from support facilities and pumps and transmission lines associated with recovery wells would be dispositioned off site at a representative commercial disposal facility.

Short-term impacts to soil would result from excavation and construction activities. Increased erosion and generation of fugitive dust would result. Erosion control measures such as straw bales and berms would be used to minimize potential erosion from exposed areas. Fugitive dust emissions from heavy equipment would be controlled using surface wetting or dust suppressants as appropriate. Following completion of all construction and excavation activities, disturbed areas would be regraded with clean backfill and revegetated with native grasses.

Approximately 6446 acres of land outside the FEMP site boundary would be disturbed by removing contaminated soil required to achieve a 10^{-6} ILCR to the off-property resident farmer. Approximately 500 acres of land outside the FEMP boundary would be disturbed under Case 2. Short-term impacts to soil at the representative commercial disposal facility are the same as those discussed under the long-term impacts identified for this alternative.

Water Quality and Hydrology - Removal of contaminated regional groundwater and treatment at the groundwater treatment facility would impede the migration of the plume. The groundwater pumping rate is anticipated to diminish as portions of the aquifer attain target concentrations. Removal and treatment of the perched groundwater in the former production area would reduce migration within the glacial overburden. For specific groundwater pumping rates, durations, and groundwater clean-up

levels refer to Section 5.4.2.1. Surface water from excavated areas and support facilities would also be collected and treated through the use of the AWWT facility to meet the parameters of the FEMP's National Pollutant Discharge Elimination System (NPDES) permit.

Waste sludge generated by the water treatment processes would be dewatered at the AWWT dewatering system and shipped off site for disposal. Spent treatment media (e.g., exhausted ion exchange resin and activated carbon) and concentrated contaminant residues would be cement-stabilized and shipped off site for disposal.

Short-term impacts to surface water due to sediment deposition would be minimized through erosion control. Erosion control measures include: berms and silt fences and covering surfaces with straw, riprap, or geotextile membranes. Surface water runoff from the FEMP would be monitored in accordance with existing permits during the remedial action period. A change in the level of constituents detected would result in appropriate action to control further contaminant migration. Short-term impacts to human health resulting from exposure to Paddys Run would be minimal due to the implementation of engineering controls to minimize sediment deposition during remedial activities (Appendix G, Section G.2.2.2.1). Therefore, short-term impacts to ecological receptors within Paddys Run would be minimal.

Excavation of contaminated sediment during the dry season would minimize impacts to surface water. While Paddys Run and the SSOD are dry much of the summer, heavy precipitation can cause rapid flow of water through these streams. Areas under excavation could suddenly be subjected to flow conditions, thus causing increased sediment loading downstream. The installation of a temporary flow control device, such as a storm water pipe, would reduce this impact.

Spills or releases associated with Operable Unit 5 remedial activities would be addressed by response actions. Any wastewater generated during the removal or treatment of waste material as a result of a spill or release would be treated by the AWWT facility before discharge.

Subsidence is not expected to occur as a result of dewatering sand, silt, or clay in the Great Miami Aquifer. Groundwater fills pore spaces and does not provide a support structure; therefore, dewatering would not change the engineering capacity of sediment to support its own weight or overburden. In addition, groundwater elevations naturally fluctuate from season to season without subsidence occurring.

Impacts to water quality and hydrology at the commercial disposal facility would be minor. No surface water exists within 23 miles of the facility, thus no impact to surface water is expected. The

groundwater is saline and unsuitable for human consumption and domestic use. No short-term impacts to water quality or hydrology would result with the implementation of Alternative 1.

Air Quality - The remedial activities proposed for Alternative 1 involve several activities that could impact air quality at the FEMP site. Short-term impacts are associated with the removal and transport of waste materials, construction and operation of support facilities, and operation of heavy equipment.

The excavation of soil and sediment could increase airborne particulates. Proper engineering practices (e.g., wetting, tarping, revegetating) would be used to minimize particulate increases from fugitive dust. Ongoing monitoring activities would be used to detect increases in particulate and other airborne pollutants.

The shipment of waste to the off-site disposal facility would result in minor increases in emissions related to exhaust from locomotives during transportation and heavy equipment operation at the disposal facility. Air quality impacts due to an accident occurring during rail transport of material to a representative commercial disposal facility would be minimal.

Disposal of material at the facility would not result in major air quality impacts. Minor increases in fugitive dust due to equipment operation and excavation activities may be experienced. Engineering controls and ongoing monitoring activities would be used to control air quality impacts.

Biotic Resources - Significant short-term disturbance of on-property vegetation and wildlife habitat under Alternative 1 would result from activities associated with excavation and removal of contaminated soil and sediment. Short-term impacts to biotic resources at the FEMP include the loss of approximately 344 acres of introduced grassland habitat due to excavation of contaminated soil under Case 1. Under Case 2, approximately 172 acres of introduced grassland habitat would be impacted. Regrading and revegetation of most of these areas would restore the introduced grassland habitat. This type of habitat would actually increase in area, because revegetation activities would convert other habitats at the FEMP into introduced grassland habitat.

Other short-term impacts associated with excavation of contaminated soil include increased sediment deposition in Paddys Run. This would impact the state-threatened Sloan's crayfish (*Orconectes sloanii*), as well as other aquatic species in Paddys Run. Also, extensive displacement of wildlife would occur during excavation of contaminated soil. Mitigative measures such as sediment control structures are available to minimize short-term erosional impacts during remediation. Such measures would be developed and incorporated into the remedy as necessary during remedial design.

The presence of threatened and endangered species on FEMP property and outside the 1050-acre property boundary would be determined by performing threatened and endangered species surveys. If threatened and endangered species are determined to be present, mitigative measures would be implemented in consultation with appropriate federal and state agencies, thereby reducing long-term impacts. For example, the restoration of riparian habitat and the placement of loose-bark tree species would mitigate most long-term impacts to the Indiana bat.

Short-term impacts to the vegetative community at the representative commercial disposal facility would be minimal as discussed in the long-term impacts for this alternative.

Wetlands and Floodplains - Short-term impacts to wetlands and floodplains would be as described for long-term impacts.

Socioeconomics and Land Use - Minor socioeconomic impacts would be expected with the implementation of Alternative 1, Case 1. To better assess short-term impacts, it is assumed all resources needed to implement Alternative 1, excluding transportation and disposal costs, would be purchased within the CMSA. Rather than addressing each individual county and the resources they are capable of supplying, each county's public and private expenditures were combined, yielding a collective wealth for the CMSA of approximately $805,000,000 for fiscal year 1992 to 1993. Total estimated capital cost, not including the cost of disposal, of implementing Alternative 1, Case 1 would be $2,345,000,000. The collective wealth of the CMSA would increase 13 percent annually over a period of 22 years excluding the costs of the items listed above and assuming the 1994 value of the dollar. With the continued treatment the Great Miami Aquifer, the annual increase would slow to 2.5 percent annually for the remaining 53 years. Consequently, economic impacts would result from the implementation of Alternative 1. The collective wealth of the CMSA would increase approximately 5 percent annually both the first 22 years, and 1.7 percent annually for the next 8 years under Case 2.

Other issues that merit discussion related to socioeconomic impacts are noise and transportation (see Appendix I). Due to the large area to be excavated, some increase in noise levels in areas immediately adjacent to the FEMP will occur. In addition, traffic levels are expected to remain constant on local roads. Minor impacts to local communities are expected.

Four factors were used in determining the background noise level within a 5 mile radius of the FEMP site. They include: population density, land use, noise levels of highways bordering the FEMP, and existing noise level data collected by the FEMP in 1991. The measurements of noise are expressed in a logarithmic ratio of sound pressure referred to as the "sound pressure level" (SPL), and are

quantified using the term "decibel" (dB). To obtain a representative sound level containing a wide range of frequencies that humans respond to, the SPL is A-weighted resulting in the term dBA. Population density (917 residents/square mile) and the presence of industry in the area yielded an operational noise level of 50 dBA, a classification of quiet residential/agricultural (Canter 1977). The average traffic noise levels of the bordering highways were averaged at 79 dBA. Data collected by the FEMP revealed noise levels 50 feet from the northern boundary of the FEMP at 50 dBA in 1991. Combined, these four factors yielded an average background noise level of approximately 60 dBA at the boundary of the FEMP, decreasing with increasing distance from the site.

It is expected that noise levels will fluctuate according to the type of activity being conducted. Using a logarithmic formula, the highest noise levels promulgating outside the boundaries of the FEMP, with the potential of affecting the nearest resident, were calculated to be 85 dBA. The occupational limit set by the Occupational Health and Safety Administration (OSHA 1910.95) is 90 dBA time weighted average/8 hour work day. Noise levels in excess of this limit require the implementation of mitigative measures (e.g., hearing protection, sound barriers).

Noise impacts, experienced by the nearest resident during the normal 8 hour work day, would be no greater than 90 dBA depending on cleanup levels. Consequently, the potential for noise impacts would be evaluated during the remedial design phase. If unacceptable noise levels are confirmed during that process, measures to mitigate noise impacts may be implemented.

The implementation of Alternative 1, Case 1 would result in some disruption of local land-use patterns due to the need to excavate extensive off-property areas while the implementation of Case 2 would cause only minor disruption. Most of this area is currently either grazing land or pasture and use of the land for these practices would need to be postponed until remedial activities were complete. Appropriate access agreements with all affected landowners would need to be secured before implementation of remedial action.

Short-term land-use impacts to the representative commercial disposal facility would be minor. Due to the area's population density and limited recreation or industrial use, the area would not be affected by the implementation of Alternative 1, Case 1 or Case 2.

Cultural Resources

Excavation to attain the PRLs for Case 1 would result in significant cultural resource impacts outside the site boundary and would require large scale cultural resource surveys and data recovery. Some 40 to 50 sites have been reported in the Great Miami floodplain and overlooking bluffs. Six prehistoric and one historic archaeological site(s) were identified in a portion of the Great Miami Valley south of the village of Ross. Sixty-nine sites have been identified in the area of the New

Haven Trough connection to the Great Miami and Whitewater River drainages. The Ohio Archaeological Inventory lists 44 sites within a 1-mile radius of the FEMP. These include both single- and multi-component sites and represent prehistoric occupations ranging from the Paleoindian through Late Prehistoric periods. The NRHP indicates two archeological districts are located within one mile of the FEMP. There is potential for the existence of unrecorded prehistoric cultural resources on the lower terrace in the vicinity of Paddys Run and near the horseshoe bend in the vicinity of the Great Miami River. Surveys would be conducted in affected areas. If artifacts are discovered, data recovery activities would reduce long-term impacts to cultural resources. Minor or no impacts would be expected by the implementation of Case 2.

Cultural resources are not expected to be impacted at the representative commercial disposal facility, as indicated under the long-term impact discussion for this alternative.

Time Period to Achieve Remedial Action Objectives

Physical, substantial and continuous on-site activities for soil remediation would be initiated within 15 months following issuance of the ROD. The estimated time to excavate and disposition contaminated soil to achieve remedial action objectives under Alternative 1 is 22 years. This time frame includes the transport of contaminated soil to an off-site commercial disposal facility. The 22-year schedule assumes that soil excavation and off-site transport would be performed on a five day per week, one shift per day basis.

Operation of the Great Miami Aquifer groundwater recovery system is projected to continue until target PRLs are achieved and maintained in the aquifer. For Case 1 this corresponds to 75 years of extraction and treatment. For Case 2, modeling suggests that target risk levels would be reached in 27 years. Treated groundwater from the recovery system would be discharged to the Great Miami River over the life of the extraction system.

5.4.2.2.6 Implementability

Technical Feasibility

The excavation of contaminated soil and sediment would use standard construction equipment. A variety of equipment such as front-end loaders, backhoes, and hydraulic excavators may be used and are readily available. A staging facility would be built to provide interim storage of materials before loading for shipment off site; space is readily available. Excavated material would be transported off site by rail. Consequently, a rail spur would be constructed from the existing site rail spur to the staging facility. It is assumed that any necessary rail upgrades, both on- and off-property, would be completed by others before implementation of this alternative. On-property rail upgrades would be

provided by the FEMP and off-site upgrades would be the responsibility of the CSX Railroad. Coordination between these parties and DOE to outline funding and construction needs would be required.

As indicated in Table 5-6, Case 1 would require that 13 trains per month leave the FEMP. The logistics of handling and coordinating an average of three trains per week with 50 rail cars each would be significant. Case 2 would require three trains per month and would be manageable.

The commercial disposal facility would need to be accessible by rail. Shipping requirements as outlined in 49 CFR 173.425(c) would be met. These requirements include: average estimated radioactivity not to exceed 0.001 millicurie per gram of material and external radiation levels not to exceed 200 mrem/hour at any point on the external surface.

Soil disposed of at the off-site commercial disposal facility would not be treated or stabilized before disposal, with the exception of soil that contains hazardous, PCB, or petroleum wastes. This soil would be treated with portable units on FEMP property. Mobile thermal desorption and soil stabilization units are readily available from several vendors.

Groundwater flow and solute transport modeling results indicate that the risk goals for uranium, the predominant contaminant in the Great Miami Aquifer, can be met for the 27-year and 75-year pumping designs. However, the proposed extraction system may not be completely effective in restoring the aquifer for 3 constituents, radium-226, arsenic and manganese. This is primarily due to the expected low constituent mobility which is a function of constituent solubility and K_d value. For these constituents with moderate to large K_d values, extensive migration is not expected. In general, reducing concentrations to the PRLs for these three constituents may not be possible through hydraulic measures alone. However, technology may become available in the future which may allow removal of these constituents to satisfy the PRLs. In the event that it is not possible to attain the PRLs, a TI waiver may be necessary to allow for system shutoff.

The AWWT facility is currently under construction and is expected to have available capacity to handle all of the perched groundwater. Under this alternative, the perched groundwater zones would be excavated and the intercepted groundwater would be pumped or hauled to the AWWT facility for treatment, using pretreatment where required to remove listed RCRA-regulated substances. Trained personnel and equipment are readily available.

The contaminated groundwater to be extracted from the Great Miami Aquifer would be treated in the groundwater treatment facility. This treatment facility would be constructed in modules. On the basis of modeling, the FS adopted final treatment capacities of 1500 gpm or 7500 gpm for the 27-year

and 75-year extraction designs, respectively. The treatment facilities are composed of well-established, reliable technologies including thickeners, ion exchange and carbon absorption vessels which are readily available from vendors. The expected life of the major process components such as the large outdoor tanks, smaller indoor tanks, multimedia filters, carbon adsorption and ion exchange vessels, and thickener are estimated to be 50 years, while the life of the sulfuric acid and caustic tanks is estimated to be 30 years. Thus, replacement of major technical components is not expected to impact groundwater treatment for the 27-year treatment scheme. Additionally, redundancy and spares would be built into the system to minimize the impacts of equipment failure. The thickener drive and pumps, which are relatively easy to replace, have an expected life of 20 years. Both ion exchange and carbon adsorption are proven technologies that have been used in many different applications. If treatment were continued for 75 years, replacement of all components of the treatment facility would be required.

Administrative Feasibility

The implementability of this alternative depends on the ability of DOE to negotiate a contract with a representative off-site commercial disposal facility to accept material from Ohio. Because there is a precedent for the commercial disposal facility, located near Clive, Utah (i.e., Envirocare), to accept low-level radioactive waste from DOE sites, it is assumed that commercial facilities would accept FEMP waste. Compliance with provisions of the applicable Interstate Compact on Low-Level Waste Management must be met.

The contract with a commercial disposal facility would have to contain provisions to ensure continued capacity availability over the 22-year remediation time period. Alternately, disposal capacity would need to be evaluated periodically to verify continued availability as existing capacity diminishes with time. Alternate options for disposal would need to be identified, if necessary.

As discussed above, the remediation period to excavate contaminated soil and sediment is estimated to cover a 22 year period. Based on a range of approximately 2.4 to 9.4 million cubic yards of contaminated material (depending on risk level), it is estimated that during the 22-year remediation period, an average of between 115 and 30 trains per year (consisting of 50 rail cars each) would leave the FEMP site for the 1900-mile trip to the commercial disposal facility for Case 1 and Case 2, respectively. A substantial amount of coordination between DOE, EPA, the commercial disposal facility, and the states through which the waste may travel would be necessary, particularly for Case 1.

Transportation of low-level radioactive waste from the FEMP to an off-site disposal facility invokes several requirements under EPA and the U.S. Department of Transportation (DOT) regulations and DOE orders. In addition, compliance with the requirements of each state through which the waste would be transported must be achieved. This would involve obtaining permits (as required) and notifying the pertinent state agency regarding transportation schedules and routes through that state. FEMP waste has been shipped via truck to disposal sites in the west and it should be assumed that rail would also be acceptable.

A modification to the existing NPDES permit would be required to discharge treated groundwater to the Great Miami River. It is also expected that additional monitoring of the outfall would be required under the NPDES and CERCLA programs (see Appendix L).

Availability of Services and Materials

The implementability of this alternative would depend on the availability of adequate disposal capacity at an off-site commercial disposal facility. The representative facility selected for the purpose of evaluating this alternative under the FS is a permitted commercial disposal facility located near Clive, Utah. This facility has an available permitted capacity of approximately 1.5 million cubic yards, with the potential to bring under permit approximately 15 million cubic yards in additional capacity. The FS assumes that this projected future capacity could accommodate the total volume of soil designated for off-site shipment (including full excavation and shipment of that volume of soil required to achieve full unrestricted land use). Coupled with the uncertainty of future capacity is future cost, based on supply and demand. Currently, there are few facilities in the United States which are permitted to accept low-level or mixed waste. This detailed analysis of alternatives factors capacity uncertainties into the assessment of implementability and long-term reliability for those alternatives which use off-property disposal. As mentioned previously, clean backfill would be required for excavated areas. It is expected that this material is available on property.

Qualified personnel needed to successfully implement the excavation component of this alternative include field personnel to conduct contamination surveys, heavy equipment operators, laborers, laboratory personnel, and administrative personnel, all of whom are available.

Mobile thermal desorption and soil stabilization systems are currently available from several vendors. Trained personnel with experience in handling, sampling, and analyzing radioactive and hazardous materials are also readily available. Mobile systems are generally truck mounted and have minimal field erection and installation requirements.

Construction of the groundwater treatment facilities would involve purchase and installation of standard process equipment, process chemicals/materials, piping and instruments, and controls. Some engineering support would be required during construction and startup. Qualified personnel, available locally, are required for operation and maintenance of the groundwater treatment facilities. The treatment residuals stabilization system would be a low volume, skid-mounted system that is available from several different vendors.

5.4.2.2.7 Cost

The cost to implement Alternative 1 includes the cost to construct remediation facilities, the cost to operate and maintain (O&M) remedial actions, and postremediation costs, which include decontamination and decommissioning of remediation facilities. Table 5-7 summarizes the costs (in 1995 dollars) of Alternative 1, for Cases 1 and 2.

It also contains the corresponding present worth and escalated costs. The present worth cost is calculated using a discount rate of 2.8 percent. The total cost (escalated) is calculated using an average escalation rate of 3.7 percent. Total cost (escalation) presents the total project cost in real dollars (including inflation).

TABLE 5-7

ALTERNATIVE 1 COSTS

	$ (million)	
	Case 1	Case 2
Costs	10^{-6} Risk/On-Property Resident Farmer 10^{-6} Risk/Off-Property Resident Farmer	10^{-5} Risk/On-Property Resident Farmer 10^{-5} Risk/Off-Property Resident Farmer
Construction	700	230
Operations and maintenance	5700	1490
Postremediation	70	40
Total cost (1995 dollars)	6470	1760
Present worth cost	4330	1240
Total cost (escalated)	13,870	3020

The construction cost of Alternative 1 includes: verification surveys to establish the boundaries of excavation areas; the acquisition of earth moving equipment; excavation operations; storm water controls; construction of haul roads, wheel washing and radiological screening stations, the off-site disposal staging facility, the Great Miami Aquifer groundwater extraction system, and the groundwater treatment facility; and backfill operations.

The O&M costs for Alternative 1 include: the labor, materials, fuel, utilities, chemicals, and parts required to operate and maintain remediation actions; sampling and analysis; and transportation and disposal of contaminated material. For Case 1 the groundwater treatment system would operate for 75 years. For Case 2, the groundwater treatment system would operate for 27 years.

Postremediation costs for Alternative 1 include: the decontamination and decommissioning of remediation facilities; decontamination and free-release of equipment; and long-term environmental monitoring.

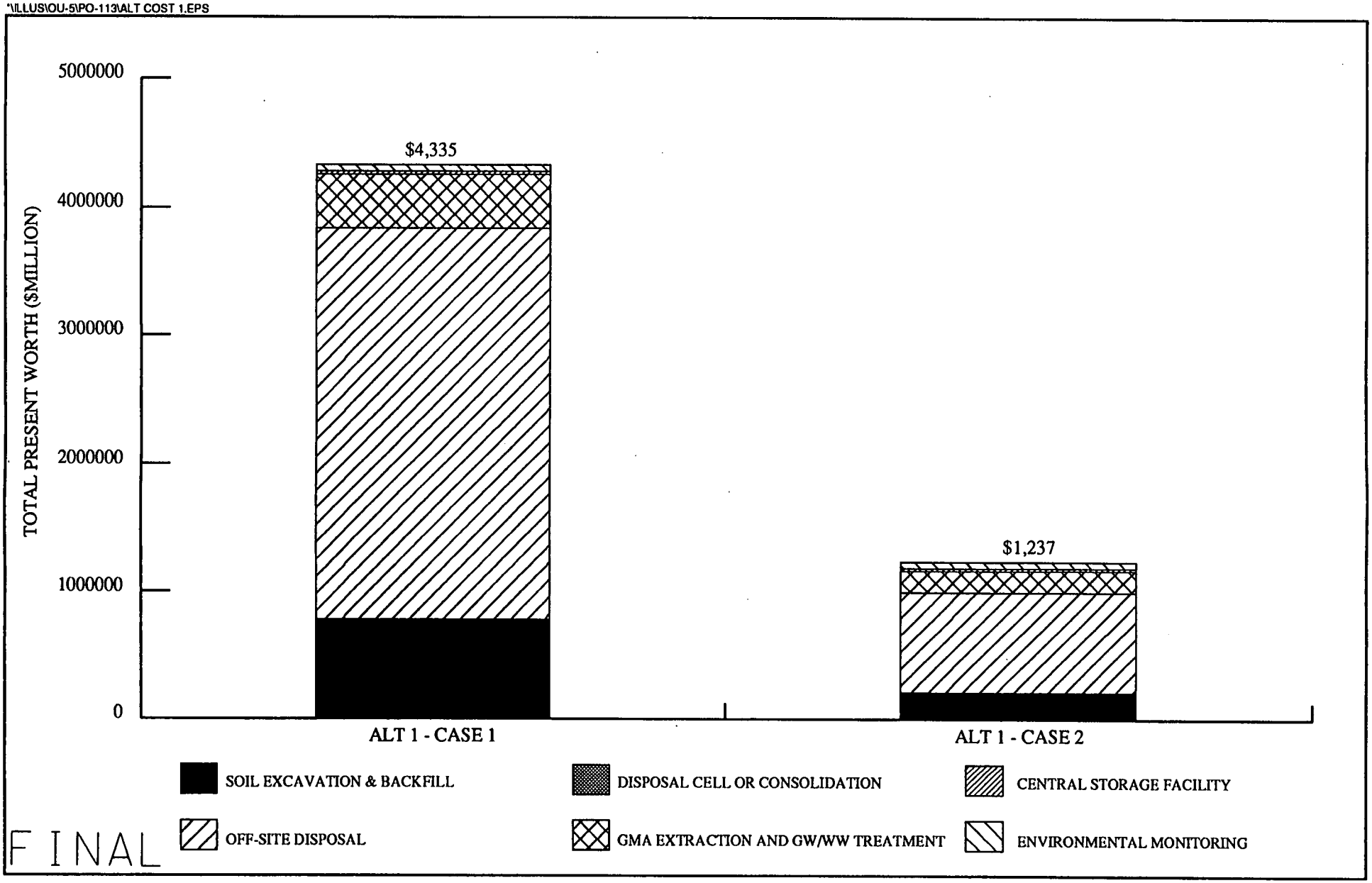
Figure 5-5 shows the present worth cost of Alternative 1, for each of the cases segmented into its remedial action components. As shown in the figure, the predominant costs are associated with the off-site disposal of soil. Off-site disposal contributes 74 percent and 62 percent of the present worth cost for Cases 1 and 2, respectively.

Appendix K provides the cost basis and estimates for the remedial action components which comprise Alternative 1.

5.4.3 Alternative 2A - Engineered Disposal Facility

Under Alternative 2A, soil and sediment exceeding PRLs would be excavated and placed in an on-property disposal facility or, depending on contaminant concentration levels, shipped to an off-site disposal facility. Contaminated groundwater from the Great Miami Aquifer would be extracted until PRLs for all COCs are attained.

Alternative 2A differs from Alternative 1 in two ways. First, Alternative 2A would restrict future use of that portion of the FEMP property occupied by the disposal facility. The presence of soil and sediment exceeding PRLs in this consolidation area would be protective of the expanded trespasser, but would not be protective of the on-property resident farmer. Second, institutional controls including groundwater monitoring and deed restrictions would be needed to ensure continued protectiveness. FEMP property outside the disposal facility area could be, at the discretion of the federal government, released for unrestricted use, such as residential or industrial development.



FINAL

FIGURE 5-5. ALTERNATIVE 1 COSTS BY COMPONENT

000441
6902
600027

5.4.3.1 Detailed Description

Alternative 2A is comprised of the following remedial activities:

- Excavating contaminated soil, production-area gravel, and sediment exceeding PRLs, excavating perched groundwater zones identified as presenting an unacceptable ingestion risk or unacceptable cross-media risk to the Great Miami Aquifer
- Backfilling excavated areas and regrading the site to achieve desired drainage patterns and controls
- Consolidating excavated material in an on-property, abovegrade engineered disposal facility
- Dispositioning contaminated material exceeding the waste acceptance criteria for the on-property disposal facility to an off-property disposal facility
- Pretreating soil with concentrations of RCRA-regulated constituents above the waste acceptance criteria established for these constituents
- Extracting contaminated groundwater from the Great Miami Aquifer until target concentrations of COCs are attained
- Treating all collected storm water, wastewater and groundwater, as required
- Discharging storm water, wastewater, and recovered groundwater to the Great Miami River following any required treatment
- Decontaminating and demolishing required support facilities following completion of remedial actions with off-property disposal of the contaminated debris at an off-site disposal facility
- Operating a groundwater monitoring network to assess the continued performance of the disposal facility
- Maintaining federal ownership of, at a minimum, the disposal facility area. At the discretion of the federal government, releasing the area of the FEMP property outside of the facility for alternative uses including farming, industrial development, or recreational use.
- Performing 5-year reviews (by EPA, in consultation with the State of Ohio and the DOE) to assess the continued performance of the completed remedial action.

To ensure that a full range of residual risk conditions are evaluated, Alternative 2A was evaluated for two different risk scenarios, Case 1 and Case 2 (see Table 2-18). Case 1 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property and off-property target receptors (i.e., an expanded trespasser in the consolidation area and the RME resident farmer in all other areas). Case 2

assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to an expanded trespasser within the disposal facility and an ILCR of 10^{-5} to the RME resident farmer in all other areas. Table 5-8 provides a concise summary of the target receptors and associated risk levels through the soil and groundwater pathways considered under each case.

A conceptual site plan depicting the necessary support structures and disposal facilities for Alternative 2A, Case 1 is presented in Figure 5-6. The conceptual site plan for Alternative 2A, Case 2 is presented in Figure 5-7. These figures represent the configuration of remedial facilities necessary to address the anticipated volumes of materials required to be excavated to achieve the target risk levels. Remedial support facilities depicted in the site plan include a central storage facility for contaminated material, an engineered disposal facility, a cap material storage area, and treatment facilities required to address collected wastewater, storm water and recovered groundwater.

TABLE 5-8

TARGET RECEPTORS AND ASSOCIATED RISK LEVELS FOR ALTERNATIVE 2A

Risk Case	On-Property Soil and Sediment		Off-Property Soil		Groundwater	
	Receptor	Risk Level	Receptor	Risk Level	Receptor	Risk Level
1	Resident* farmer	10^{-6}	Resident farmer	10^{-6}	Resident farmer	10^{-6}
2	Resident* farmer	10^{-5}	Resident farmer	10^{-5}	ARARs**	Proposed MCLs

* This case assumes a residual risk level of 10^{-6} to the expanded trespasser inside the consolidation area containing the disposal facility.
** At a residual risk level of 10^{-5} to the resident farmer, the MCLs and proposed MCLs are more restrictive and are therefore used in lieu of the risk-based limits.

The PRLs were previously presented in Section 2.0. For Alternative 2A, the PRLs for areas outside the disposal area (Figures 5-6 and 5-7) would be those listed in Tables 2-12, 2-13, 2-14 and 2-15 for unrestricted land use. For areas outside the disposal area, the PRLs are based upon the presumption that a resident farmer could be permitted to establish residence on the land in the future. For the disposal area, the PRLs would be those listed in these same tables for continued federal ownership. The PRLs for the disposal area are based upon the presumption that the area is under continued

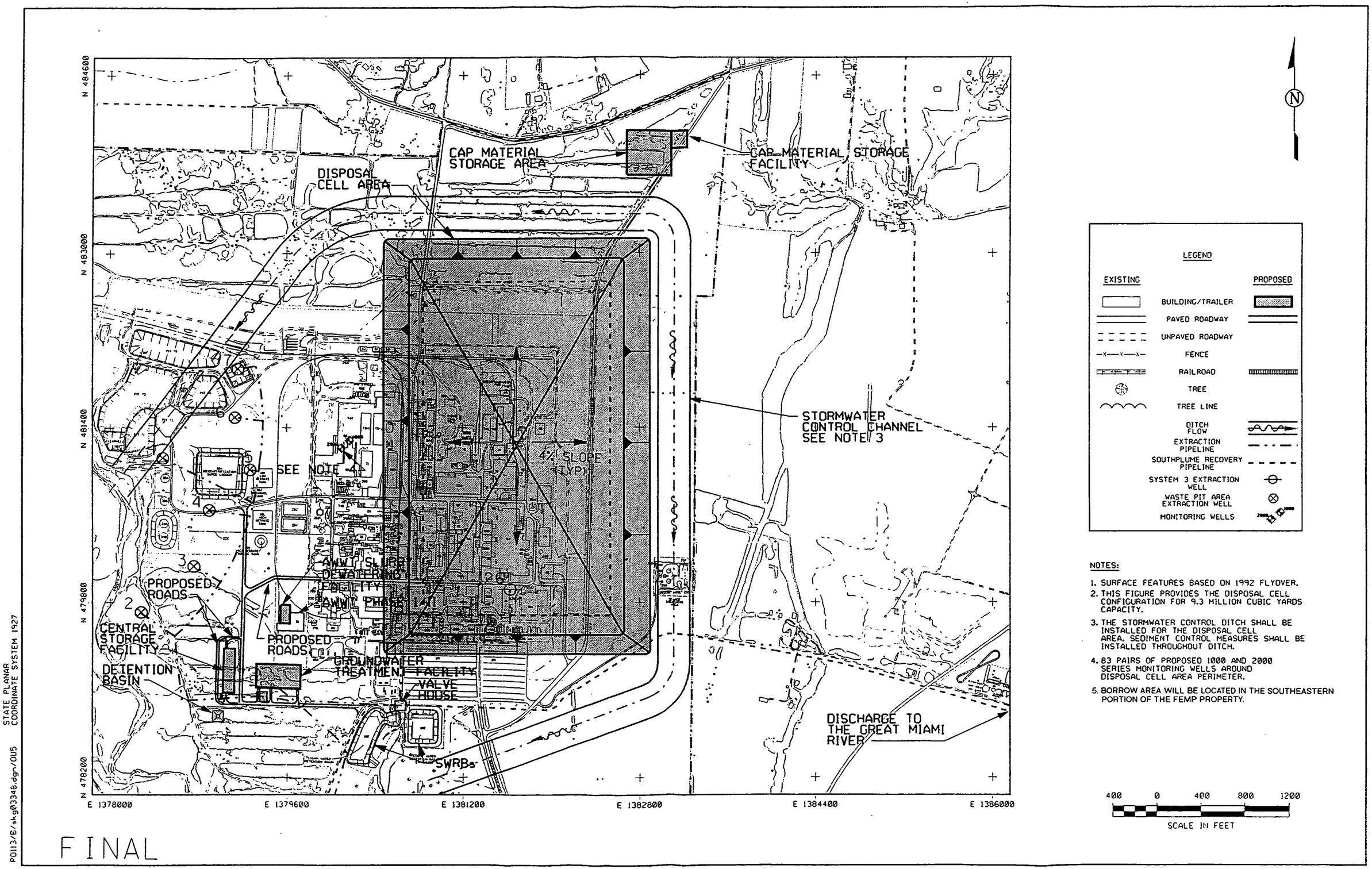
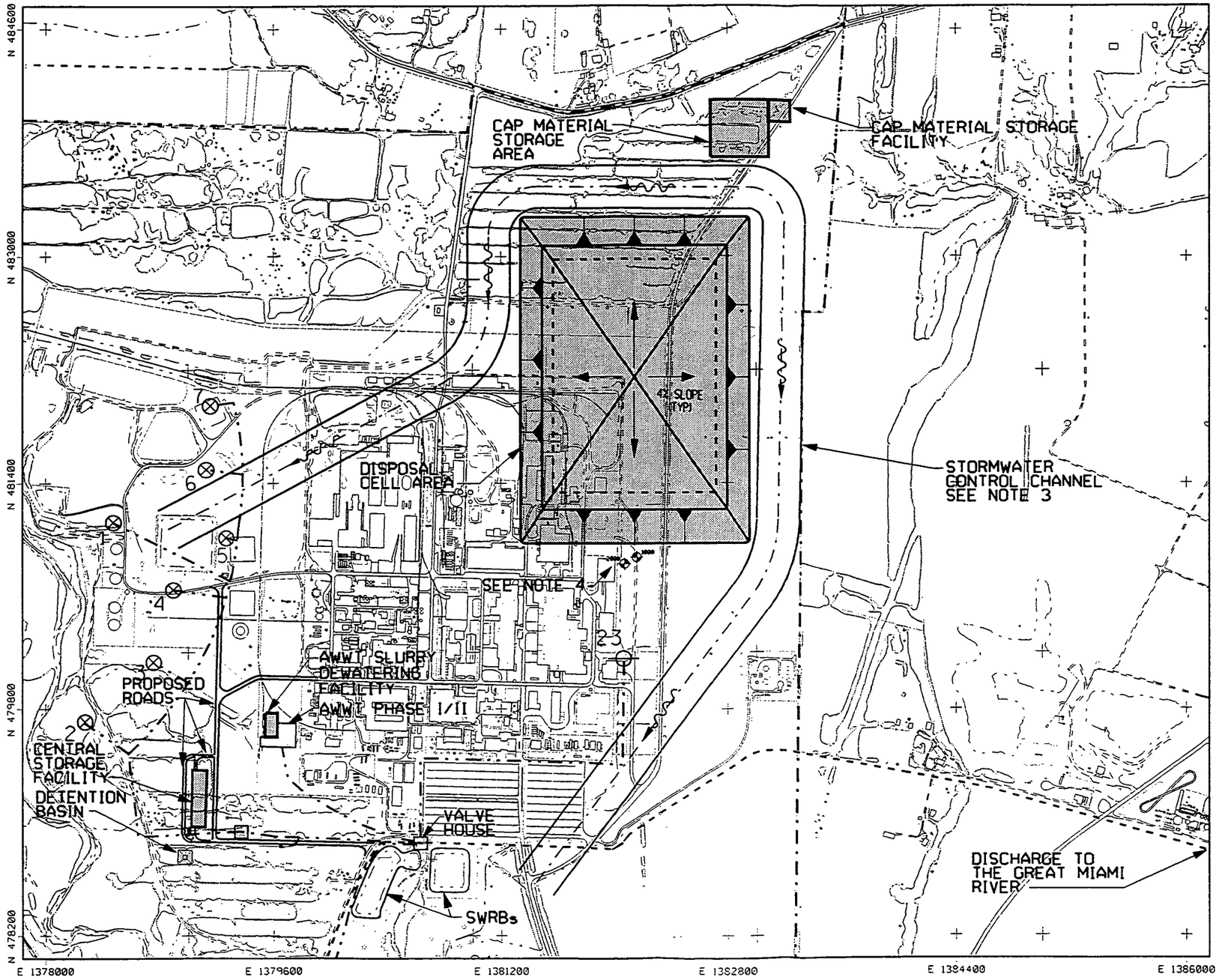


FIGURE 5-6. SITE PLAN ALTERNATIVE 2A-1



LEGEND

EXISTING		PROPOSED
	BUILDING/TRAILER	
	PAVED ROADWAY	
	UNPAVED ROADWAY	
—x—x—x—	FENCE	
	RAILROAD	
	TREE	
	TREE LINE	
	DITCH FLOW	
	EXTRACTION PIPELINE	
	SOUTHPLUME RECOVERY PIPELINE	
	SYSTEM 3 EXTRACTION WELL	
	WASTE PIT AREA EXTRACTION WELL	
	MONITORING WELLS	

NOTES:

1. SURFACE FEATURES BASED ON 1992 FLYOVER.
2. THIS FIGURE PROVIDES THE DISPOSAL CELL CONFIGURATION FOR 2.4 MILLION CUBIC YARDS CAPACITY.
3. THE STORMWATER CONTROL DITCH SHALL BE INSTALLED FOR THE DISPOSAL CELL. SEDIMENT CONTROL MEASURES SHALL BE INSTALLED THROUGHOUT DITCH.
4. 50 PAIRS OF PROPOSED 1000 AND 2000 SERIES MONITORING WELLS AROUND DISPOSAL CELL AREA PERIMETER.
5. BORROW AREA WILL BE LOCATED IN THE SOUTHEASTERN PORTION OF THE FEMP PROPERTY.

400 0 400 800 1200
SCALE IN FEET

STATE PLANAR COORDINATE SYSTEM 1927

P0113/B/ak g03356.dgn/OU5

FINAL

FIGURE 5-7. SITE PLAN ALTERNATIVES 2A-2 AND 3A-3

ownership of the government and would have access restricted by a properly maintained fence with signs.

Figure 4-7 presented a conceptual block flow diagram of the remedial activities associated with Alternative 2A. Detailed discussions on each of the components comprising the alternatives are presented in Appendix L. The following subsections present a brief description of the unique aspects of the remedial action components as they pertain to Alternative 2A.

Excavation and Backfill

Contaminated soil, sediment, and production-area gravel not meeting PRLs would be excavated using conventional construction equipment. The areas to be excavated include the contaminated rubble along the Great Miami River near the outfall line, contaminated soil under pipelines, and affected soil in the area of the FEMP's former underground storage tanks. The Operable Unit 5 excavation footprints and soil volumes also include the incremental soil excavation necessary to complete remedial activities within the boundaries of the other operable units. Excavated materials determined to meet the waste acceptance criteria for the Alternative 2A disposal facility would be loaded into trucks or roll-off containers and transported to the facility. Materials destined for disposal in the engineered facility would be staged, as necessary, in an interim soil storage facility. Material requiring off-site disposal would be staged, loaded into trucks and covered for transport to an off-site disposal facility.

Excavated soil and sediment determined (through HWMU history, process operations knowledge, excavation control surveys and verification sampling) to contain RCRA-listed or characteristic wastes would be pretreated as discussed in Section 4.0 under the strategy for managing RCRA-regulated constituents. These materials would be pretreated to meet the site-specific waste acceptance criteria developed for the RCRA-based COCs and would subsequently be placed in the on-site disposal facility. Materials that do not meet the waste acceptance criteria for the facility would be disposed of off site.

Footprints of the projected excavations required to attain the PRLs for Alternative 2A, Cases 1 and 2, are presented in Figures 2-10 and 2-11, respectively. Table 5-9 provides the estimated soil volumes which would be excavated, both on and off property, under Alternative 2A for the two risk cases considered. The table also presents the quantity of excavated soil that meets the waste acceptance criteria for the disposal facility and the quantity of soil requiring off-site disposal. Within this table, the on-property backfill represents that volume of soil which does not exceed the PRLs, but which must be excavated in order to reach more contaminated soil located beneath it. Because this soil does not exceed PRLs, it can be used as "clean" backfill in the area from which it was excavated. The

volume projections presented in the table are based upon an engineering evaluation of available data which were completed for purposes of developing and evaluating remedial alternatives. Final excavation footprints and volumes would be established through completion of a preexcavation verification survey. This verification survey was discussed in Section 5.4.2.1 under Alternative 1 and is discussed further in the description of the soil excavation component presented in Appendix L.

On-Property Disposal

Contaminated soil and sediment requiring on-property disposal would be placed in an engineered disposal facility. Figures 5-6 and 5-7 present a conceptual layout of the disposal facility for Case 1 and Case 2, respectively. Design details for the disposal facility are found in the component descriptions in Appendix L. Table 5-10 presents the expected size of the disposal facility for the excavated material meeting the waste acceptance criteria for this facility.

Construction of the disposal facility would occur in phases to accommodate the varying schedules of soil remediation and the demolition of structures in the former production area (as managed under Operable Unit 3). As described in Appendix L, the disposal facility would be built and filled in modules, with each module closed with an intermediate cover until completion of all planned modules. The final cover would then be constructed over the intermediate cover.

In general, construction of the disposal facility is assumed to begin at a location 1200 feet north and 1000 feet east of the FEMP production area. Decommissioning activities would begin in the northeast portion of the production area, proceed to the southwest portion of the production area, and finish near the planned location of the AWWT plant (Building 51). This would permit the existing storm sewer system (which flows from northeast to south) to be used during decontamination and demolition (D&D) activities to prevent run-on of contaminated surface water as construction progresses. Runoff from the partially completed disposal facility would be directed to the SWRB in order to provide overall containment until final closure.

The unoccupied area northeast of the production area would serve as the initial subunit of the disposal facility. Upon construction of the liner in this area, the facility could begin receiving soil and debris from existing interim storage facilities, stockpiles, off-site areas, Operable Unit 2 materials and rubble and soil from future facility expansion. As additional adjacent areas of the production area are made available through advancement of Operable Unit 3 activities, they would be developed into new disposal modules. This sequence of activities would be repeated until the entire site was decommissioned.

TABLE 5-9

REMEDIAL ACTION ALTERNATIVE 2A SOIL VOLUMES

	Risk Case	
	Case 1	Case 2
Risk Goal		
On-Property		
Receptor	Resident farmer	Resident farmer
Risk level	10^{-6}	10^{-5}
Off-Property		
Receptor	Resident farmer	Resident farmer
Risk level	10^{-6}	10^{-5}
Soil Volume Requiring Excavation (yd^3)		
On-property[a]	4,450,000	2,340,000
Off-property	5,200,000	400,000
Total	9,650,000	2,740,000
Remedial Action (in situ soil volume in yd^3)		
On-property backfill	300,000	340,000
On-site disposal facility	9,300,000	2,370,000
Off-site disposal	50,000	25,000
Total	9,650,000	2,740,000

[a] Includes 175,000 cubic yards of gravel from the production area. Excavated areas would be backfilled to reestablish original grade; a vegetative cover would be reestablished on the backfilled areas.

TABLE 5-10

ALTERNATIVE 2A DISPOSAL FACILITY DIMENSIONS
(All dimensions in feet)

Risk Case	Risk Level/Receptor	Length	Width	Height
1	10^{-6} / On-property resident farmer 10^{-6} / Off-property resident farmer	3810	2410	64
2	10^{-5} / On-property resident farmer 10^{-5} / Off-property resident farmer	2260	1600	40

The underdrain system for the disposal facility is anticipated to be operated during the period of active remediation for soil and sediment, with continued operation of the system, as needed, until dismantlement of the AWWT facility. Collected leachate from the underdrain system would be transferred to the AWWT for treatment before discharge to the Great Miami River.

Covered trucks, tarps, air-filtered staging areas, and water sprays would be employed to mitigate fugitive dust emissions during construction, excavation and demolition. The excavated contaminated soil would be loaded into 40-ton net capacity roll-off containers at the excavation site and delivered to the disposal facility construction site. This excavated soil would either be sent directly to the facility for immediate placement, placed in a nearby staging facility, or sent to a central storage facility. Interim or alternate storage would be provided by the installation of new tension-support structures (central storage facility) in the southwest portion of the site. Waste would be staged in these facilities while awaiting disposition.

On-site contaminated material would be transported using existing FEMP roads or newly constructed haul roads. These roads would be demolished as the disposal facility expands. The main entrance roads to the FEMP from the south (Willey Road) and north (Rt. 126) would be maintained throughout the remediation effort. Off-site contaminated material would be transported to the disposal facility in accordance with DOT regulations.

Off-Property Disposal

Contaminated soil not meeting the waste acceptance criteria for the on-property disposal facility would be shipped to an off-site disposal facility whose waste acceptance criteria are commensurate with the characteristics of the contaminated material. For alternatives requiring off-site disposal of greater than 50,000 cubic yards of contaminated soil it was assumed that the material would be transported by rail to the commercial disposal facility located in Clive, Utah. Where an alternative would require the off-site disposal of less than 50,000 cubic yards of contaminated soil (e.g., Alternative 2A, Cases 1 and 2), shipments by rail would no longer represent the most cost-effective means of transportation. In this instance, soil containing radioactive contaminants would be transported by truck to DOE's NTS waste disposal facility in Nevada. Where contaminated material contains hazardous or mixed wastes, the material would be transported by truck for disposal at the commercial disposal facility in Utah.

Great Miami Aquifer Restoration

Great Miami Aquifer restoration would be achieved as previously described for Alternative 1 (Section 5.4.2.1), with the exception that consideration would be given to dispositioning treatment residuals in the on-property disposal facility.

Sediment sludge, spent ion exchange resins, carbon filter media, regenerate sludge, and other miscellaneous waste streams generated by operation of the AWWT facility and the groundwater treatment facility would be dewatered, stabilized (if required) and dispositioned at an off-site disposal facility. For cost estimating purposes, cementation was employed as the stabilization technology. Consideration would be given to dispositioning sediment sludge and cement-stabilized sludge in the on-property disposal facility during the period of active remedial actions for soil/sediment, provided the facility waste acceptance criteria could be attained. Cement stabilization would be performed by a vendor-supplied sludge stabilization service or through installation of an annex to the treatment facility.

Storm Water Management

Storm water would be managed as previously described for Alternative 1 (Section 5.4.2.1), with the exception that consideration would be given to disposing of dewatered sediment sludge from the SWRB in the on-property disposal facility. If the dewatered sludge was to attain the waste acceptance criteria for the disposal facility, the sludge would be placed during the time that the facility is actively receiving contaminated materials. Following final closure of the facility or in the event the sludge does not attain the waste acceptance criteria, the dewatered sludge would be dispositioned off site. If required, the sludge would be cement-stabilized before dispositioning at either the on-property or off-property facility. For cost estimating purposes, it was assumed that these materials would not require stabilization.

Decontamination and Demolition

D&D of remedial action support facilities would be accomplished as previously described for Alternative 1 (Section 5.4.2.1).

Resultant Land Use Potential

Alternative 2A targeted the consolidation of contaminated materials to the smallest possible on-property area, releasing the maximum amount of FEMP land for alternate uses. The disposal facility area would be designed to be maintained as a restricted waste management area. Other portions of the FEMP property could be considered for alternate land uses without restriction.

Institutional and Administrative Control Requirements

To ensure the long-term performance of the remedial action, Alternative 2A requires the performance of long-term groundwater monitoring and maintenance, and the establishment of a series of institutional and administrative controls including the following:

- Establishing and maintaining a fence around the disposal area, including appropriate postings on the fence notifying individuals of the buried materials

- Establishing permanent markers (monuments) demarcating the footprint of the disposal area
- Placing deed restrictions noting the existence of the buried materials prohibiting intrusive activities into the area
- Establishing continued ownership of, at a minimum, the footprint of the disposal area
- Maintaining the fencing and the cover system of the disposal area
- Providing alternate water to affected users, assumed through the installation of a public water supply, during the period of active aquifer restoration (identical to Alternative 1)
- Operating a long-term groundwater monitoring network (see groundwater monitoring component description in Appendix L)
- Performing reviews (at least every five years following completion of remedial actions) to assess the continued effectiveness of the remedial action to protect human health and the environment.

5.4.3.2 Assessment

5.4.3.2.1 Overall Protection of Human Health and the Environment

Alternative 2A meets the remedial action objectives for Operable Unit 5 and would be protective of human health and the environment. Implementation of this alternative would prevent direct access to contaminated soil and sediment by removal of these media to PRL concentrations and consolidation in an on-property disposal facility or, if that waste acceptance criteria is exceeded, disposal at an off-site location. Implementation of Alternative 2A would mitigate the migration of contaminants in soil and sediment to the air and groundwater. Moreover, implementation of Alternative 2A would prevent the consumption or use of groundwater containing FEMP contaminants at above-PRL levels. Exposure to direct radiation above protective levels would also be prevented.

The primary actions that would be used to meet the remedial action objectives of Alternative 2A are: excavation of contaminated soil and sediment exceeding PRLs; dispositioning these materials in an on-property waste disposal facility or at an off-site waste disposal facility depending upon contaminant concentrations; backfilling excavated areas with clean borrow and topsoil; and extraction and treatment of contaminated groundwater from the Great Miami Aquifer.

The disposal facility and its associated waste acceptance criteria was designed to control contaminant migration to human and environmental receptors and to prevent direct radiation exposure from contained waste material. Excavation and containment in the on-property disposal facility of soil and sediment containing above-PRL concentrations of COCs, and the disposition at an off-site location of

soil contaminated above the waste acceptance criteria would ensure that risks to the hypothetical resident farmer outside the disposal facility would not exceed those considered health protective, as discussed in Section 5.4.3.2.3. Moreover, the disposal facility for containment of soil and sediment containing above-PRL concentrations of COCs is designed to be health protective for the expanded trespasser and would ensure that contaminant concentrations in the Great Miami Aquifer would not exceed PRLs within the 200- to 1000-year period considered under this FS. It is assumed that the design, siting and permitting of the off-site commercial disposal facility would preclude a corresponding increase in residual risk at that location.

Backfilling excavated areas with clean backfill and topsoil would prevent direct contact with residual contamination and would prevent the potential spread of contamination through the air pathway. The establishment of a vegetative cover would minimize future erosion. Extraction and treatment of Great Miami Aquifer groundwater combined with the remediation of soil, sediment and perched water would clean up existing contamination and ensure that PRLs would not be exceeded in the Great Miami Aquifer.

Following implementation of Alternative 2A, institutional controls would be maintained for the disposal facility to ensure continued protection of human health and the environment while remaining FEMP land could, at the discretion of the federal government, be made available for alternative land uses. Institutional controls maintained for the disposal area would include: continued federal ownership of that portion of the FEMP to preclude homesteading, intrusive actions or facility degradation; deed restrictions; and passive access controls (e.g., fencing) around the area to prevent unauthorized access or use of the land.

Loss of institutional controls in combination with failure of the disposal facility could, over the 200 to 1000-year period, result in contaminant migration or direct exposure to contaminated material by future human and environmental receptors. Exposures to potential receptors would be minimized due to the reduced surface area of the consolidated material and low concentration of contamination in the contained soil. Under the intruder scenario, however, a future farmer who might choose to establish a residence on top of the disposal facility and who achieved daily contact with materials contained within over a long period of time would be subject to incremental risks higher than those contemplated herein. Due to its design, however, the use of the disposal area as a residential area is considered highly unlikely. This scenario is further addressed under the Adequacy and Reliability of Controls portion of Section 5.4.3.2.3.

The most significant short-term risks associated with the implementation of Alternative 2A are the risks associated with the transport of contaminated media to an off-site waste disposal area.

Increased worker risks would be expected throughout implementation of this alternative. However, through the implementation of a worker health and safety plan in compliance with 29 CFR 1910.120, exposures would be kept to below regulatory limits and would comply with DOE orders. These risks are discussed further in Section 5.4.3.2.5.

To mitigate potential short-term risk to off-property personnel, the implementation of Alternative 2A would include providing alternative water supplies to affected properties pending completion of Great Miami Aquifer remedial actions. It is currently contemplated that the alternative water supplies will consist of public water supplied by Hamilton County.

5.4.3.2.2 Compliance with ARARs

Discussion of the principal ARARs and TBCs is presented in Section 2.4 and Appendix B. The complete list of ARARs/TBCs is presented in Appendix B.

Alternative 2A would comply with the chemical- and location-specific ARARs as described for Alternative 1 in Section 5.4.2.2.2. Alternative 2A, however, considers on-property disposal as an additional location- and action-specific option. A waiver from EPA would be required to carry out this alternative, as described below under location- specific ARARs. Other action- and chemical-specific requirements would be identical to those described in Section 5.4.2.2.2 for Alternative 1.

Chemical-Specific ARARs

Alternative 2A would comply with the chemical-specific ARARs/TBCs identified in Table B.1 of Appendix B. ARARs associated with penetrating radiation and potential releases of contaminants to air, surface water and groundwater would be met through the removal of contaminated material from the site. This material would be placed in an on-property disposal facility if the contaminants in this material meet the facility's waste acceptance criteria. Material exceeding the waste acceptance criteria would be disposed of off site.

The prescribed engineering controls for the on-property disposal facility were established for the protection of human health and would ensure that the groundwater PRLs, air emission standards, and radon protection standards (Table B.1 of Appendix B) would be met.

Water encountered during remediation would be treated at the AWWT facility to meet the Ohio Water Quality Standards in accordance with the ARARs listed in Table B.1 of Appendix B.

Location-Specific ARARs

Alternative 2A would meet the principal location-specific ARARs discussed in Table B.2 and Section B.2 of Appendix B with the exception that a CERCLA waiver would be required for two State of Ohio solid waste disposal siting restrictions. These restrictions prohibit the siting of disposal facilities over 1) sole-source aquifers designated under the Safe Drinking Water Act and 2) aquifers capable of providing 100 gpm or more of sustained yield for consumptive use. Section 5.6 provides the technical basis and rationale for the issuance of the CERCLA waiver.

The on-property disposal of soil would be performed under the CAMU regulations (40 CFR 64.552). The on-property disposal actions contemplated in the Operable Unit 5 alternatives would not constitute "placement" under the CAMU concept, and thus would not require treatment of the environmental media to the LDR treatment standards. The alternatives would, however, be expected to meet the protectiveness threshold envisioned by the CAMU provisions for materials that do not require treatment. Consequently, the LDRs (40 CFR 268.40 through 268.44) for hazardous constituents would not be triggered.

Compliance with location-specific ARARs for floodplains, wetlands, dredging, endangered species, and historical preservation would be met as described in Section 5.4.2.2.2.

Action-Specific ARARs

Alternative 2A would meet the principal action-specific ARARs discussed in Section 5.4.2.2.2, Section B.3, and in Tables B.3, B.4, and B.5.C of Appendix B. Because the FEMP contains low-level radioactive waste/residual radioactive material, solid waste, and hazardous waste, the on-property disposal facility would meet the more stringent requirements for disposal of low-level radioactive waste/residual radioactive material. EPA states in 40 CFR 192(a) for uranium mill tailings that the disposal facility must be designed to be effective for up to 1000 years, to the extent reasonably achievable, and in any case, for at least 200 years, and provide protection of groundwater. DOE Order 5820.2A sets performance objectives that a low-level radioactive waste disposal site must be protective of public health and safety, protective of the environment and protective of groundwater resources from releases of radioactivity. This disposal facility would also exceed the engineering design criteria for the less-stringent Ohio EPA (OEPA) and RCRA technical requirements for the disposal of solid waste.

5.4.3.2.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 2A would be slightly lower than that of Alternative 1. While Alternative 1 involves the excavation and off-property disposal of contaminated soil and sediment, soil and sediment excavated under Alternative 2A would be placed in an

on-property disposal facility. The use of an on-property disposal facility would cause no immediate increase in the residual risk associated with this alternative. Its continued presence, however, results in a reduction in the perceived permanence due to uncertainty associated with the ability of the federal government to maintain long-term (i.e., up to 1000 years) institutional controls and the long-term performance of the engineered components of the system.

Groundwater Residual Risk - All alternatives provide for the extraction and treatment of contaminated groundwater from the regional aquifer in the same manner. Residual risk associated with groundwater would be the same as that discussed under Alternative 1.

Soil Residual Risk - As presented in Section 2.0, footprints for soil excavation were based upon the use of total uranium as an indicator parameter. The excavation footprints were then expanded to capture other COCs whose concentration in soil exceeded their respective PRLs. Before initiation of soil excavation activities, verification sampling would be performed to confirm the excavation footprints. Radiological surveys performed using field instruments would help to direct excavation activities. Upon completion of excavation in a given area, certification sampling would be performed to confirm that soil PRLs were obtained. Effectiveness in meeting the target risk levels would be ensured through this confirmation that PRLs were attained. Long-term effectiveness and permanence would be assured through a combination of institutional controls and design considerations incorporated into the disposal facility, as discussed below.

Adequacy and Reliability of Controls

The on-property disposal facility called for in this alternative would use proven technologies and materials of construction. Similar systems are currently used for the disposal of low-level radioactive waste under DOE and Nuclear Regulatory Commission (NRC) programs at other sites. For purposes of the FS, the northeast corner of the disposal facility is assumed to be generally located 1200 feet north and 1000 feet east of the northeast corner of the FEMP production area. The disposal area would extend to the southwest, covering a portion of the production area. This area is located away from Paddys Run and the floodplain to minimize the potential for surface water induced erosion. The bottom of the facility liner would be, on average, 9 feet below existing grade, which is well above the Great Miami Aquifer water table at this location. Contaminated soil would be placed at or above existing grade, precluding the potential for the material to come into contact with the perched water system.

A drainage ditch would be constructed around the disposal facility area to divert storm water run-on. A leachate collection system would be installed to manage leachate generated during construction and placement of contaminated soil in the facility. The collected leachate would be transferred to the

AWWT facility for treatment before discharge to the Great Miami River. In accordance with OAC 3745-57-10, the leachate collection system would continue to operate until leachate is no longer detected.

The liner of the facility would be designed to be slightly more permeable than the cap to minimize the potential for the "bathtub" effect, whereby a disposal facility could collect excess infiltration through the cap. This design feature would ensure that infiltration would not build up within the facility over a long period of time and would minimize the time that infiltration remains in contact with contaminated soil contained within the facility.

Once all contaminated soil is excavated and placed in the disposal facility, Alternative 2A would require active maintenance and monitoring of the facility for a period of time sufficient to ensure long-term performance of the system. Groundwater monitoring and air monitoring would be conducted during the groundwater extraction and treatment period which is 27 years or 75 years, depending on the groundwater cleanup goals. During this period, sampling and analysis would be conducted annually. Wells would be installed in water-bearing zones at 150-foot intervals around the perimeter of the disposal area. Maintenance would include inspection and groundskeeping of the vegetative cover, clearing of engineered surface water drainage ways, and inspection of the cap and berm integrity. Inspections would be conducted at the time groundwater monitoring samples are collected. Postclosure groundwater monitoring associated with the disposal facility is planned for an additional 50 years beyond the groundwater extraction and treatment phase. During this period, it is envisioned that only monitoring specific to the on-property disposal facility would be required. It is anticipated that the same wells would be used beyond the initial monitoring period, with replacement wells installed as necessary. Sampling frequency and an analyte list for the extended monitoring program would be described in more detail in the Remedial Action Work Plan. Data from the extended monitoring would be assessed at the end of the extended monitoring period and would indicate whether additional remedial activities should be undertaken.

The potential loss of facility integrity following this active maintenance period was incorporated into the design and the waste acceptance criteria. The conceptual cap configuration adopted for the FS incorporates a 36-inch-thick biotic barrier consisting of cobbles. This barrier will prevent burrowing animals from penetrating the cap and will prevent rooting of trees. Modeling of the long-term facility performance, presented in Appendix F, shows that the system would be protective of the underlying aquifer (i.e., would maintain the concentration of uranium at below the 20 ppb proposed MCL) even after multiple, hypothetical failures in the facility's containment system. The analysis assumes that the geotextile fabric and the high density polyethylene (HDPE) membrane liner in the cap and the bottom leachate collection system fail immediately upon installation. Additional conditions include

failure of the bentonite geocomposite at 200 +/- 50 years and failure of the 24-inch compacted clay layer of the cap at 800 +/- 200 years. The analysis revealed that, even assuming this failure scenario, the probability that the proposed uranium MCLs would be exceeded in the Great Miami Aquifer remained less than 12 percent over a period of 1000 years.

The disposal facility boundaries would be delineated with fencing, signs, and markers. Deed restrictions would be implemented to restrict potential future use of the consolidation area. The long-term reliability of deed restrictions is uncertain. For this reason, the disposal facility incorporates design features which would mitigate the impacts of potential future intrusion by man. First, the berm and toe include a stone layer to prevent erosion. This layer would minimize the potential for intrusion through excavation. Any excavation would be localized and would not likely be used for the establishment of a residence. Moreover, the entire cap includes a 36-inch cobble biotic barrier followed by a 12-inch layer of pea gravel. These layers would discourage the potential installation of wells. The cover over the cobbles (6 inches of sand, 21 inches of common soil and 6 inches of topsoil) would support the growth of indigenous grasses but is insufficient to support farming for an extended period. Because the area is unattractive for excavation or residential/agricultural use, potential exposure to a hypothetical future intruder would result in a risk potential comparable to that already considered for an expanded trespasser.

Soil whose contaminant levels exceed the waste acceptance criteria for the on-property disposal facility would be excavated and transported to an off-site disposal facility. The off-site disposal facility would be responsible for long-term monitoring and maintenance activities for the waste material. The off-site facility would hold a current license for disposal of low-level radioactive waste; therefore, institutional controls and maintenance activities are likely to be adequate.

Extraction and treatment of contaminated perched groundwater and groundwater from the Great Miami Aquifer for this alternative would be the same as described in Alternative 1. The adequacy and reliability of controls associated with this component of Alternative 2A is the same as previously described for Alternative 1 (Section 5.4.2.2.3).

Long-Term Environmental Impacts

The following paragraphs discuss long-term impacts to the environment for Alternative 2A. For a compilation of the irreversible and irretrievable commitment of resources associated with this alternative, refer to Section 5.5. The long-term environmental impacts to the FEMP site from remedial activities associated with Alternative 2A are similar to those previously identified for Alternative 1 (Section 5.4.2.2.3) with the differences outlined below. For the purposes of evaluating ecological impacts, the NTS near Las Vegas, Nevada was considered. For a detailed description of the environmental setting associated with NTS, refer to Appendix I.

Soil and Geology - Construction of the on-property abovegrade disposal facility (including the probable maximum flood [PMF] channel) and placement of contaminated soil under Alternative 2A, Case 1, would result in the permanent commitment of 300 acres of land at the FEMP site; Case 2 would result in a commitment of 140 acres. The regional geology of the FEMP site and surrounding area would not be affected by implementation of this alternative.

Approximately 1 acre of soil at NTS would be permanently disturbed for the disposal of contaminated material resulting from Alternative 2A, Case 1; Case 2 would result in the permanent disturbance of 0.5 acres. Borrow material from NTS may be required for the shallow land disposal burial there. The geology of NTS has been determined to be suitable for disposal of low-level radioactive waste (DOE 1991). NTS characterization indicates that groundwater depths beneath NTS vary from about 515 to more than 2000 feet. Groundwater movement in the saturated and unsaturated zones is very slow and there is an extremely low potential for radioactivity transport to off-site areas. In addition, downward movement of the groundwater is exceedingly slow in the unsaturated zone. These parameters make the geology of NTS very suitable for long-term disposal activities.

Water Quality and Hydrology - A long-term water quality monitoring system would be implemented by incorporating design features into the disposal facility and installing a leachate collection/detection system and monitoring wells around the perimeter. A discussion of exposure and risks associated with long-term disposal is provided in Appendix H.

The disposal facility would be actively monitored and maintained. Periodic monitoring of nearby surface water and groundwater would continue. Periodic site inspections would be performed to identify potential damage to the facility from occurrences such as erosive forces from heavy winds and rain, biointrusion, or natural phenomena (e.g., earthquake or tornado). Maintenance would be performed as necessary.

Long-term impacts to water quality and hydrology would be similar to those described in Alternative 1. Additional impacts would result from the construction of the PMF channel around the on-property disposal facility, which would increase flow into Paddys Run and the SSOD. Increased sediment loading could result from the construction of the PMF channel. However, sediment controls installed throughout the PMF channel would reduce this impact.

Air Quality - The disposal facility would be designed and constructed to minimize the likelihood of releases to the atmosphere; thus, minimizing the potential for releases of inhalable particulates.

Biotic Resources - Long-term impacts to biotic resources are expected to be minimal as a result of implementing mitigative measures, as discussed in Alternative 1 (Section 5.4.2.2.3)

Long-term impacts to biotic resources as a result of soil and sediment excavation would be similar to the excavation impacts described for Alternative 1. Under Alternative 2A, Case 1 these impacts include the loss of 100 acres of early to mid-successional woodlands, 100 acres of riparian habitat, and 70 acres of pine plantation. Additional long-term impacts would result from the construction of support facilities. The construction of a disposal facility and associated PMF channel would cause the loss of 18 acres of early to mid-successional woodlands and 39 acres of pine plantation habitat. Similarly, for Alternative 1, Case 2, 10 acres of early to mid-successional woodlands, 42 acres of riparian habitat, 47 acres of pine plantation, and 17 acres of wetlands would be impacted by excavation activities.

Most of the NTS is vegetated by various desert shrubs. There are 711 types of vascular plants within or near the boundaries of NTS (DOE 1991). Several mammal species on NTS (e.g., feral horses, burros, mountain lions, kit foxes) have been placed on the protected classification list by the State of Nevada. The desert tortoise (*Gopherus agassizii*) is federally listed as a threatened species and is present in some areas of NTS. Disposal activities at NTS related to the Operable Unit 5 remedial activities are not expected to impact the habitat of the desert tortoise or displace any other species at NTS.

Wetlands and Floodplains - Impacts to wetlands and floodplains are the same as those identified for Alternative 1, (Section 5.4.2.2.3), where 36 acres of wetlands would be impacted under Case 1 and 17 acres of wetlands would be impacted under Case 2.

Socioeconomics and Land Use - Impacts resulting from the implementation of Alternative 2A would be identical to those of Alternative 1. Displacement of workers would occur after remedial activities have concluded; however, impacts resulting from decreased work activities at the FEMP would be offset through a variety of training and job placement programs.

Land Use Objective 2 provides for the establishment of an on-property, disposal facility for contaminated soil, with unrestricted use of all remaining areas of the property. This land use objective considers the potential for establishing a hypothetical family farm, following cleanup, on any portion of the FEMP property outside the area where the contaminated materials are disposed.

As previously discussed, NTS would be used as a disposal facility when the overall remedial actions result in lower volumes of contaminated media (i.e., less than 100,000 cubic yards) requiring off-property disposal. The DOE NTS facility encompasses 1350 square miles, an area larger than the State of Rhode Island. It has been used primarily for nuclear weapons testing and disposal of low-level radioactive waste from DOE-affiliated generators since 1951. Material disposal activities associated with this alternative would not impact socioeconomics or land use at NTS.

Cultural Resources - Identified cultural resources at the FEMP site would be managed consistent with the measures outlined in Alternative 1 (Section 5.4.2.2.3).

Cultural resources at NTS would be managed consistently with the requirements of NHPA, AIRFA, and NAGPRA.

5.4.3.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative provides no reduction of toxicity, mobility, or volume of radioactively contaminated soil or sediment through treatment. The majority of excavated soil would remain on property in an engineered disposal facility (see Table 5-9). However, those materials that do not meet the waste acceptance criteria for the facility, and are thus deemed principal threat materials, would be shipped off site for disposal.

As previously described for Alternative 1 (Section 5.4.2.2.4), an estimated 28,000 cubic yards of soil and sediment containing RCRA hazardous, petroleum, and PCB waste would be treated using mobile thermal desorption or soil stabilizing units, as appropriate.

Treatment of the perched groundwater and Great Miami Aquifer groundwater for this alternative would be the same as described in Alternative 1 (Section 5.4.2.2.4).

5.4.3.2.5 Short-Term Effectiveness

Protection of the Community During Remedial Actions

Through implementation of a combination of engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls), the short-term risks associated with Alternative 2A to members of the community would be minimized. A remedial action risk assessment was conducted to assess the potential short-term risks associated with the implementation of remedial actions.

Using historical transportation statistics, it is projected that implementation of Alternative 2A, Case 1 would result in less than one fatality and two injuries for members of the public due to mechanical

hazards associated with accidents during transportation. Similar statistics for Alternative 2A, Case 2 project less than one fatality or injury for members of the public. These fatalities and injuries are associated with off-site disposal operations of excavated soil and sediment during the 22 years of remedial activities.

The estimated ILCR to hypothetical receptors, representing members of the public near the FEMP, due to external radiation and inhalation associated with releases during remedial actions are estimated at 6.8×10^{-7} for Case 1 and 4.3×10^{-7} for Case 2 for Alternative 2A. ILCRs to members of the public located along the transportation route are 2.8×10^{-8} for Case 1 and 1.4×10^{-8} for Case 2.

Protection of Workers During Remedial Actions

A detailed analysis of the potential short-term risks to workers engaged in remedial activities and on-site workers not engaged in remedial activities is presented in Appendix G. The ILCR for remediation workers for Case 1 is estimated at 2.3×10^{-3} for excavation activities, 4.6×10^{-3} for off-site disposal activities, and 2.2×10^{-3} for on-site disposal facility activities. For Case 2, the ILCR for excavation activities is 1.3×10^{-3}, 2.9×10^{-3} for off-site disposal activities, and 1.5×10^{-3} for on-site disposal activities. For both cases, the dominant risk is from the inhalation of radioactive contaminants. These risk levels are less than those extrapolated from the maximum allowable exposure limits for workers. These risks do not exceed worker standards (10 CFR 835 and 29 CFR 1910).

Short-Term Environmental Impacts

The following paragraphs discuss short-term impacts for Alternative 2A, Case 1 which are similar to those previously identified for Alternative 1, Case 1 (Section 5.4.2.2.5) with the differences outlined below.

Soil and Geology - Under Alternative 2A, Case 1, 7400 acres of on- and off-property soil would be disturbed due to excavation to remove contamination above PRLs; under Case 2, 980 acres would be disturbed. Soil disturbances would also result from the construction of the on-property disposal facility and associated PMF channel, construction of roads, construction and operation of support facilities and operation of heavy equipment. These construction activities would disturb approximately 343 acres of land within the site boundary under Alternative 2A, Case 1 and Case 2. Once remedial activities have ended, support facilities would be completely dismantled consistent with the ROD for Operable Unit 3.

Short-term impacts to soil at NTS are the same as long-term impacts identified for this alternative.

Water Quality and Hydrology - Impacts to water quality and hydrology are the same as those identified in Alternative 1 (Section 5.4.2.2.5).

Air Quality - Impacts to air quality are the same as those identified in Alternative 1 (Section 5.4.2.2.5) with the exception that impacts associated with off-site transportation would be reduced.

Biotic Resources - Short-term impacts due to the excavation of soil and sediment would be similar to the excavation impacts described for Alternative 1 (Section 5.4.2.2.5). Additional short-term impacts would result from the construction of the disposal facility. Approximately 117 acres of introduced grassland habitat would be lost due to the placement of the disposal facility for both Case 1 and Case 2. This is a short-term impact, however, because the placement of a vegetative cap over the disposal facility area would replace much of the introduced grassland habitat.

Wetlands and Floodplains - Impacts to wetlands and floodplains are the same as those identified for Alternative 1, Case 1 (Section 5.4.2.2.5).

Socioeconomics and Land Use - Impacts occurring during remedial activities would be minor with the implementation of Alternative 2A, Case 1. An annual 22 percent increase in the CMSA would occur for 22 years followed by a 2.5 percent increase for the remaining 53 years during treatment of the Great Miami Aquifer. Alternative 2A would increase the wealth of the CMSA by 7 percent annually for 22 years, slowing to a 1.7 percent increase for the remaining 8 years.

Noise impacts would be identical to Alternative 1. Traffic volumes are expected to remain constant on local roads with the implementation of Alternative 2A. Land use impacts are the same as Alternative 1 (Section 5.4.2.2.5).

Disposal activities would not impact socioeconomics or land use at NTS.

Cultural Resources - Identified cultural resources at the FEMP site would be managed consistent with Alternative 1 (Section 5.4.2.2.5).

In compliance with NHPA, DOE/Nevada contracted preactivity surveys and other studies to assess any impacts NTS operations may have on historical and archeological sites found on the NTS site. Sites identified were added to the cultural resources inventory files, site records, and all artifacts were collected for storage. All cultural resources at NTS would be either avoided or managed appropriately.

Time Period to Achieve Remedial Action Objectives

Physical, substantial and continuous on-site activities for soil remediation would be initiated within 15 months following issuance of the ROD. The estimated time to excavate and disposition contaminated soil to achieve remedial action objectives under Alternative 2A is 22 years. This time frame includes construction of an on-property disposal facility and the transport of soil which does not meet the waste acceptance criteria of the on-property facility to an off-site disposal facility.

The 22-year schedule assumes that soil excavation, construction of the disposal facility, and off-site transport would be performed on a five day per week, one shift per day basis. Following completion of soil emplacement in the disposal facility, capping activities would require an additional 12 months.

Operation of the Great Miami Aquifer groundwater recovery system is projected to continue for up to 75 years for Alternative 2A, Case 1 or 27 years for Alternative 2A, Case 2, as previously described for Alternative 1 (Section 5.4.2.2.5).

5.4.3.2.6 Implementability

Technical Feasibility: As in Alternative 1, the technical feasibility and operation of the excavation component of this alternative would be reliable. Excavation and placement of contaminated soil in the on-property disposal area would use standard construction equipment. A variety of equipment such as front-end loaders, backhoes, and hydraulic excavators may be used and are readily available. It is expected that contaminated materials would be placed in roll-off containers and transported by truck to the disposal area. Trained equipment operators, drivers, and maintenance personnel would be required.

Installation and operation of the disposal components of this alternative would be reliable. The design for the disposal facility and cap has been used at other sites. The design incorporates features from both RCRA and the Uranium Mill Tailings Remediation Act (UMTRA) to produce a facility capable of accommodating the FEMP wastes. Personnel familiar with the quality assurance requirements for cover installation are necessary to certify that the final cover meets the design criteria and specifications.

No specific site conditions (i.e., utilities, buildings) would prohibit implementation of this alternative. Remedial activities of Operable Unit 5 would be coordinated with the remediation schedules of other FEMP operable units. It is anticipated that buildings and utilities would be removed from the production area in coordination with Operable Unit 5's need for this area to construct the disposal facility. The footprint of the disposal facility for the 10^{-6} target risk level is estimated to be 211 acres and would cover a significant portion of the current production area (see Figure 5-6). Thus, any

scheduling delays of Operable Unit 3 would impact excavation and disposal activities for Operable Unit 5. To minimize impacts, the facility would be constructed in modules, commencing in the northeastern corner of the property where few structures exist and contaminated soil excavation would be minimal. The progression of D&D, excavation, and facility construction would trend generally northeast to southeast. The footprint of the disposal facility for the 10^{-5} target risk level is estimated to be 83 acres and impacts a smaller portion of the current production area (see Figure 5-7).

Materials exceeding the waste acceptance criteria for the on-property disposal facility would be transported to an off-site disposal facility by truck. The technical feasibility of implementing the disposal component of Alternative 2A depends on the implementability of transportation of the treated material to the disposal facility and on compliance with the waste acceptance criteria of this disposal site. Based on evaluation of the Operable Unit 5 waste material and the relatively small volume (50,000 and 25,000 cubic yards for Cases 1 and 2, respectively) of materials requiring off-site disposal over a 22-year period, it is expected that the waste would be accepted at the projected disposal facility (see Appendix E). The technical feasibility of the construction of waste shipment handling facilities for off-site transportation by truck would be straightforward and reliable.

Implementability implications for extraction and treatment of contaminated groundwater for this alternative are the same as in Alternative 1 (Section 5.4.2.2.6).

Administrative Feasibility

The implementability of this alternative would depend on the ability of DOE to site a solid waste facility over a sole-source aquifer. The waiver request would be based on the ability of the proposed cell design to attain a standard of performance that is equivalent to that required by the ARARs. Additional information on the waiver is provided in Section 5.6 and Appendix B. Implementability of the off-site disposal component would be the same as previously described for Alternative 1 (Section 5.4.2.2.6).

Clean backfill would be required to fill in excavated areas. A process of certification would be necessary to ensure that the backfill and borrow material meet PRLs for the site.

Administrative feasibility associated with extraction and treatment of contaminated groundwater would be the same as previously described for Alternative 1 (Section 5.4.2.2.6). Additionally, discharge of the treated groundwater to the Great Miami River would require a modification to the existing NPDES permit. Continued monitoring of the outfall line will be required under both the NPDES and CERCLA programs for as long as groundwater remediation is conducted.

Finally, close coordination with regulatory agencies and the local community before and during remedial actions are necessary for successful implementation.

Availability of Services and Materials

The area required for placement of the on-property disposal facility would be available once the excavation of building foundations, underground tanks, and utilities have been removed by Operable Unit 3 (as proposed in the Operable Unit 3 Remedial Design/Remedial Action Work Plan). Materials for the cap and liner include gravel, cobbles, sand, clay, vegetative soil, and HDPE, all of which are readily available. Clean backfill material would be available from on-property borrow areas and off-property sources.

Qualified personnel needed to successfully implement the excavation component of this alternative include field personnel to conduct contamination surveys, heavy equipment operators, laborers, and administrative personnel, all of whom are available locally. Design and construction of the disposal facility would require engineers, heavy equipment operators, and specialized equipment and personnel to install the membranes and liners, all of which are available.

As described for Alternative 1 (Section 5.4.2.2.6), the relatively small volume of RCRA hazardous soil would be treated with a mobile thermal desorption and/or soil stabilization system. These technologies are currently available from several vendors. Mobile systems generally have minimal field installation requirements. Trained personnel with experience in handling, sampling, and analyzing radioactive and hazardous materials are also readily available.

For Alternative 2A, the availability of services and materials associated with groundwater extraction and treatment would be the same as previously described for Alternative 1 (Section 5.4.2.2.6).

5.4.3.2.7 Cost

The cost to implement Alternative 2A includes the cost to construct remediation facilities, the cost to operate and maintain remedial actions and postremediation costs, which include D&D of remediation facilities. Table 5-11 summarizes the costs (in 1995 dollars) of Alternative 2A for Cases 1 and 2. It also contains the corresponding present worth and escalated costs. The present worth cost is calculated using a discount rate of 2.8 percent. The total cost (escalated) is calculated using an average escalation rate of 3.7 percent. Total cost (escalated) presents the total project cost in real dollars (including inflation).

The construction cost of Alternative 2A includes: verification surveys to establish the boundaries of excavation areas; the acquisition of earth moving equipment; excavation operations; storm water

controls; construction of haul roads, wheel washing and radiological screening stations, the off-site disposal staging facility, the cap material staging area and facility, the Great Miami Aquifer groundwater extraction system, and the groundwater treatment facility; and backfill operations.

The O&M costs for Alternative 2A include: the labor, materials, fuel, utilities, chemicals, and parts required to operate and maintain remediation actions; sampling and analysis; and transportation and disposal of contaminated material.

TABLE 5-11

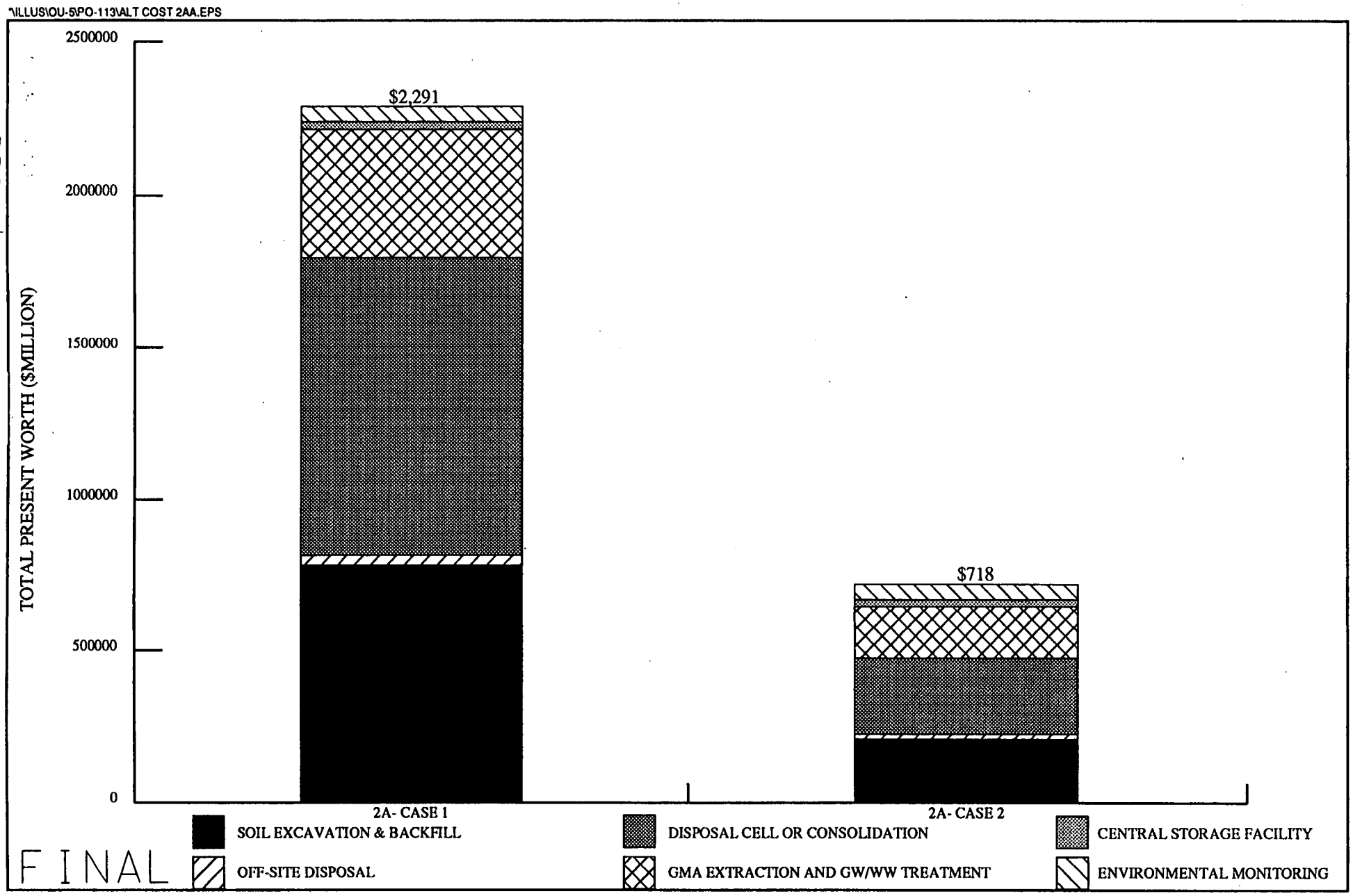
ALTERNATIVE 2A COSTS

	$ (million)	
	Risk Case 1	Risk Case 2
Costs	10^{-6} Risk/On-Property Resident Farmer 10^{-6} Risk/Off-Property Resident Farmer	10^{-5} Risk/On-Property Resident Farmer 10^{-5} Risk/Off-Property Resident Farmer
Construction	1990	550
Operations and maintenance	1470	420
Postremediation	260	80
Total cost (1995 dollars)	3710	1060
Present worth cost	2290	720
Total cost (escalated)	12,050	2580

Postremediation costs for Alternative 2A include: the D&D of remediation facilities; decontamination and free-release of equipment; and long-term monitoring.

Figure 5-8 shows the present worth cost of Alternative 2A, for each of the cases segmented into its remedial action components. As shown in the figure, the predominant costs for Case 1 are associated with the on-site disposal facility. This cost contributes 42 percent of the present worth costs. For Case 2, groundwater extraction and groundwater and wastewater treatment dominates the costs, contributing 34 percent.

Appendix K provides the cost basis and estimates for the remedial action components which comprise Alternative 2A.



FINAL

FIGURE 5-8. ALTERNATIVE 2A COSTS BY COMPONENT

5.4.4 Alternative 2C - Off-Site Shipment

Alternative 2C involves the complete excavation of contaminated soil and sediment exceeding PRLs. Contaminated soil would be excavated and consolidated to maximize the land area that can be made available for unrestricted use. Depending upon the level of contamination, soil would be consolidated beneath an earthen cover or shipped off site for disposal. Contaminated groundwater from the Great Miami Aquifer would be extracted until PRLs for all COCs are attained.

Alternative 2C differs from Alternative 2A in one aspect. Under Alternative 2A, soil with contamination levels exceeding PRLs would be placed in an engineered disposal facility or be dispositioned to an off-site, commercial disposal facility. Under Alternative 2C, the soil with contamination levels exceeding PRLs would be dispositioned to an off-site, commercial disposal facility or, if concentration levels allow, placed in an on-site consolidation area and covered with a 1-foot thick earthen cover and revegetated.

5.4.4.1 Detailed Description

The following remedial activities comprise Alternative 2C:

- Excavating contaminated soil, production-area gravel, and sediment exceeding PRLs; excavating contaminated perched zones presenting an unacceptable ingestion risk or unacceptable cross-media risks to the Great Miami Aquifer
- Backfilling excavated areas and regrading the site to achieve desired drainage patterns and controls
- Pretreating soil containing concentrations of RCRA-regulated constituents above the waste acceptance criteria established for these constituents
- Dispositioning contaminated soil in the following manner:
  - Soil containing appropriate levels of contamination would be consolidated and covered with one foot of clean soil and establishing a vegetative cover on the clean soil cover
  - Soil containing contaminant concentrations that exceed the waste acceptance criteria of the earthen covered consolidation area would be dispositioned to an off-site, commercial disposal facility
- Extracting contaminated groundwater from the Great Miami Aquifer until target concentrations of COCs are attained
- Treating all collected storm water, wastewater and groundwater as required
- Discharging storm water, wastewater, and recovered groundwater to the Great Miami River following any required treatment

- Decontaminating and demolishing required support facilities following completion of remedial actions with off-property disposal of all contaminated debris
- Maintaining federal ownership of the consolidation area, at a minimum. At the discretion of the federal government, release areas of the FEMP property outside the consolidation area for alternate uses including industrial development or recreational use
- Performing 5-year reviews (by EPA, in consultation with the State of Ohio and the DOE) to assess the continued performance of the completed remedial action.

To ensure that a full range of residual risk conditions are evaluated, Alternative 2C was evaluated for two different risk scenarios, referred to as Case 1 and Case 2 (see Table 2-18). Case 1 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property and off-property target receptors (i.e., an expanded trespasser in the consolidation area and the RME resident farmer in all other areas). Case 2 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to an expanded trespasser within the consolidation area and an ILCR of 10^{-5} to the RME resident farmer in all other areas. Table 5-12 provides a concise summary of the target receptors and associated risk levels considered under each case.

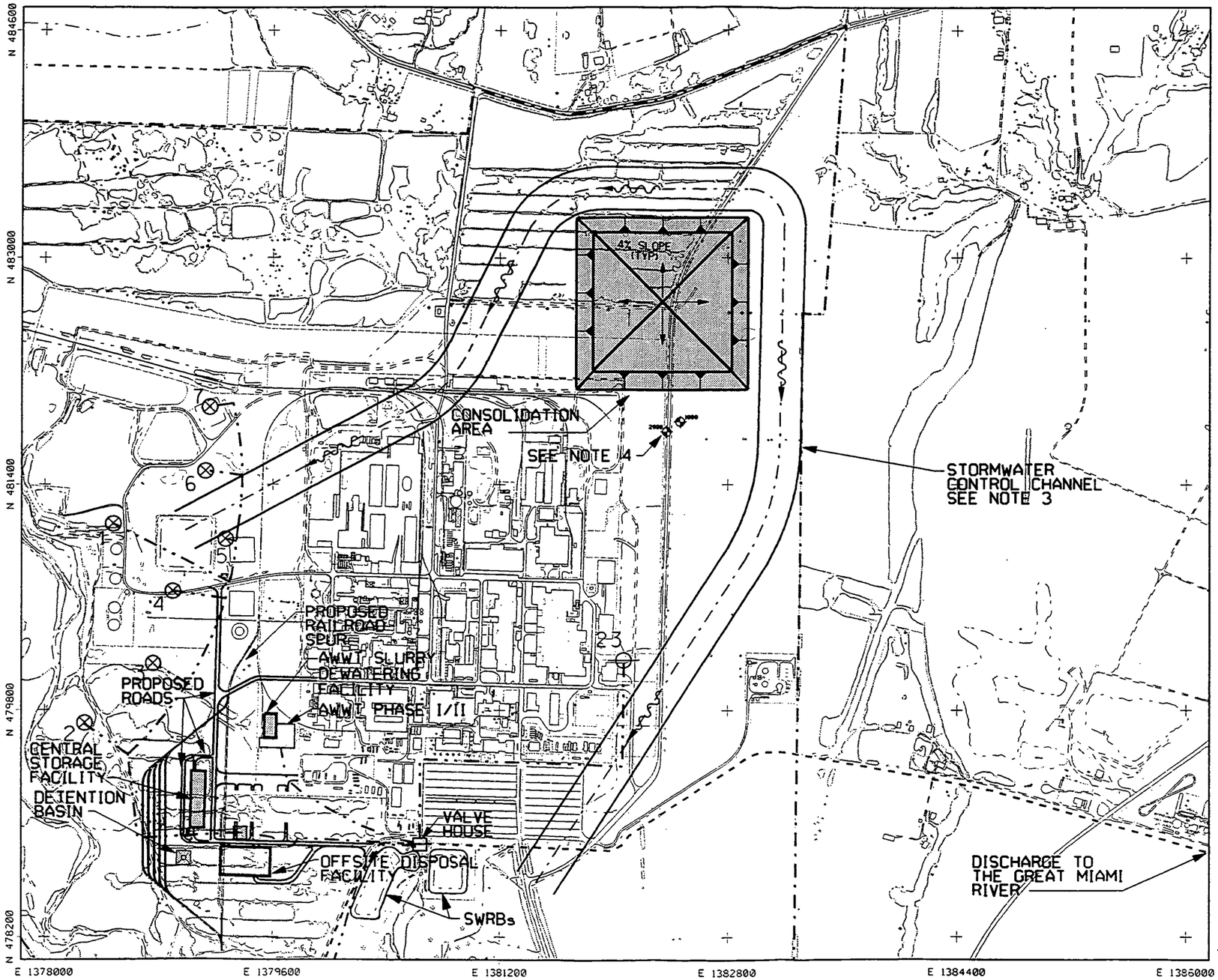
TABLE 5-12

TARGET RECEPTORS AND ASSOCIATED RISK LEVELS FOR ALTERNATIVE 2C

Risk Case	On-Property Soil and Sediment		Off-Property Soil		Groundwater	
	Receptor	Risk Level	Receptor	Risk Level	Receptor	Risk Level
1	Resident farmer*	10^{-6}	Resident farmer	10^{-6}	Resident farmer	10^{-6}
2	Resident farmer*	10^{-5}	Resident farmer	10^{-5}	ARARs**	Proposed MCLs

* This case assumes a residual risk level of 10^{-6} to the expanded trespasser inside the consolidation area.
** At a residual risk level of 10^{-5} to the resident farmer, the MCLs and proposed MCLs are more restrictive and are therefore used in lieu of the risk-based limits.

Figure 5-9 presents a conceptual site plan depicting the necessary support structures and disposal facilities for Alternative 2C, Case 2. The figure represents the configuration of remedial facilities necessary to address the anticipated volumes of material required to be excavated to achieve a residual



LEGEND

EXISTING		PROPOSED
	BUILDING/TRAILER	
	PAVED ROADWAY	
	UNPAVED ROADWAY	
—x—x—x—	FENCE	
	RAILROAD	
	TREE	
	TREE LINE	
	DITCH FLOW	
	EXTRACTION PIPELINE	
	SOUTHPLUME RECOVERY PIPELINE	
	SYSTEM 3 EXTRACTION WELL	
	WASTE PIT AREA EXTRACTION WELL	
	MONITORING WELLS	

NOTES:

1. SURFACE FEATURES BASED ON 1992 FLYOVER.
2. THIS FIGURE PROVIDES THE CONSOLIDATION AREA CONFIGURATION FOR 1.2 MILLION CUBIC YARDS CAPACITY.
3. THE STORMWATER CONTROL DITCH SHALL BE INSTALLED FOR THE CONSOLIDATION AREA SEDIMENT CONTROL MEASURES SHALL BE INSTALLED THROUGHOUT DITCH.
4. 32 PAIRS OF PROPOSED 1000 AND 2000 SERIES MONITORING WELLS AROUND CONSOLIDATION AREA PERIMETER.
5. BORROW AREA WILL BE LOCATED IN THE SOUTHEASTERN PORTION OF THE FEMP PROPERTY.

400 0 400 800 1200

SCALE IN FEET

STATE PLANAR COORDINATE SYSTEM 1927

P0113/B/sk-g03355.dgn/OU5

FINAL

FIGURE 5-9. SITE PLAN ALTERNATIVES 2C-2 AND 3C-3

risk level of 10^{-6} to the expanded trespasser in the consolidation area and a residual risk of 10^{-5} to the RME resident farmer for all other areas. Remediation facilities depicted in the site plan include a soil consolidation area, a central storage facility for contaminated material, a staging facility and rail spur for off-site shipment of bulk soil and stabilized treatment waste, the AWWT treatment facility and slurry dewatering facility, groundwater extraction systems, and a groundwater treatment system facility and associated piping.

Under Alternative 2C, Case 1, all soil excavated to achieve PRLs is shipped off site. In this instance, the excavation of contaminated soil is driven by a risk-based PRL of 5 ppm of uranium while the waste acceptance criteria for the consolidation area is 4 ppm of uranium. Because the waste acceptance criteria for the consolidation area is lower than the contaminant concentration which would cause soil to be excavated, none of the excavated material can be placed in the consolidation area. For this reason, Alternative 2C, Case 1, does not have a consolidation area component. As a result, the conceptual site plan for Alternative 2C, Case 1, is the same as Alternative 1, Case 1 (Figure 5-6). Thus, Alternative 2C, Case 1 is eliminated from further discussion. The following text applies to Case 2 only.

For Alternative 2C, the PRLs for areas outside the consolidation area would be those listed in Tables 2-12, 2-13, 2-14, and 2-15 for unrestricted land use. For areas outside the consolidation area, the PRLs are based upon the presumption that a resident farmer may be permitted to establish residence on the land in the future. For the consolidation area, the PRLs would be those listed in the same tables for continued federal ownership. The PRLs for the consolidation area are based upon the presumption that the area is under the continued ownership of the government and access would be restricted by a properly maintained fence with signs.

Figure 4-9 presents a conceptual block flow diagram of the remedial activities associated with Alternative 2C. Detailed discussions for each of the components comprising the alternatives are presented in Appendix L. The following sections present a brief description of the unique aspects of the remedial action components as they pertain to Alternative 2C.

Excavation and Backfill

Contaminated soil, sediment, and production area gravel not meeting PRLs would be excavated using conventional construction equipment. The areas to be excavated include the contaminated rubble along the Great Miami River near the outfall line, contaminated soil under pipelines, and affected soil in the area of the FEMP's former underground storage tanks. The Operable Unit 5 excavation footprints and soil volumes also include the incremental soil excavation necessary to complete remedial activities within the boundaries of the other operable units. Excavated materials determined

through pre-excavation characterization to meet the waste acceptance criteria for consolidation with an earthen and vegetative cover would be loaded into trucks or roll-off containers, transported to the consolidation area, and staged at that location in bulk before placement in the consolidation area.

Soil and sediment determined through pre-excavation characterization to be above the waste acceptance criteria of the consolidation area would be loaded into roll-off containers and transported to the off-site disposal staging facility. Contaminated soil would be loaded into 100-ton rail cars for shipment to the off-site facility.

Excavated soil and sediment determined (through HWMU history, process knowledge, excavation control surveys and verification sampling) to contain RCRA-listed or characteristic wastes would be pretreated as discussed in Section 4.0 under the strategy for managing RCRA-regulated constituents. These materials would be pretreated to meet the site-specific waste acceptance criteria developed for the RCRA-based COCs and would subsequently be placed in the on-site consolidation area. Materials that do not meet the specific waste acceptance criteria for the consolidation area would be sent off site for disposal.

Footprints of the projected excavations required to attain the PRLs for Alternative 2C, Cases 1 and 2 are presented in Figures 2-10 and 2-11, respectively. Table 5-13 provides the estimated in situ soil volume which would be excavated, both on and off property, under Alternative 2C for the two risk cases considered. The table also presents the quantity of this soil which meets the waste acceptance criteria for the consolidation area and that portion which would be shipped to an off-site commercial disposal facility. The on-property backfill represents the volume of soil that does not exceed PRLs, but must be excavated in order to reach more contaminated soil located beneath it. Because this soil does not exceed PRLs, it can be used as backfill.

Soil volume estimates presented in Table 5-13 are based upon engineering evaluations of available data which were completed for the detailed analysis of alternatives. Final excavation footprints and soil volumes would be established through completion of a pre-excavation verification survey. This verification survey is discussed further in the description of the soil excavation component presented in Appendix L.

Excavated areas would be backfilled with clean borrow material and topsoil to reestablish original grade. A vegetative cover would be reestablished on the backfilled areas.

Consolidation and Earthen Cover

Soil and sediment determined through pre-excavation surveys to meet the waste acceptance criteria for consolidation with an earthen cover would be transported to the consolidation area. Contaminated soil would be placed in designated portions of the consolidation area in 1-foot lifts and compacted. As an area is filled to final grade, that area would be covered with 1 foot of clean soil. The surface of the soil cover would be vegetated using grasses indigenous to the area. Table 5-14 presents the dimensions of the consolidation area for each risk level. Design details for the consolidation area are provided in the component descriptions in Appendix L.

TABLE 5-13
REMEDIAL ACTION ALTERNATIVE 2C SOIL VOLUMES

	Risk Case	
	Case 1	Case 2
Risk Goal		
On-Property		
Receptor	Resident farmer	Resident farmer
Risk level	10^{-6}	10^{-5}
Off-Property		
Receptor	Resident farmer	Resident farmer
Risk level	10^{-6}	10^{-5}
Soil Volume Requiring Excavation (yd^3)		
On-property[a]	4,450,000	2,340,000
Off-property	5,200,000	400,000
Total	9,650,000	2,740,000
Remedial Action (in situ soil volume in yd^3)		
On-property backfill	300,000	340,000
Consolidate w/ earthen cover	0	1,240,000
Off-site disposal	9,350,000	1,160,000
Total	9,650,000	2,740,000
Transportation Capacity		
Rail cars	165,000	20,400
Trains per year	3300	408
Trains per month	13	2

[a] Includes 175,000 cubic yards of gravel from the production area

TABLE 5-14

ALTERNATIVE 2C CONSOLIDATION AREA DIMENSIONS
(All dimensions in feet)

Risk Case	Risk Level/Receptor	Length	Width	Height
1	10^{-6} / On-property resident farmer 10^{-6} / Off-property resident farmer	*	*	*
2	10^{-5} / On-property resident farmer 10^{-5} / Off-property resident farmer	1200	1200	40

* No soil meets the waste acceptance criteria for the consolidation area for this risk level.

Off-Property Disposal

Soil and sediment containing contamination above that which can be consolidated under an earthen cover would be shipped off site for disposal. For purposes of this FS, a representative commercial disposal facility was selected for developing and evaluating the viability of off-property disposal. Contaminated soil will be loaded into 100-ton rail cars for shipment to the off-site facility. Assuming a bulk density of 1.76 tons per cubic yard for in situ soil, the number of rail cars presented in Table 5-13 would be required to support off-site disposal.

Great Miami Aquifer Restoration

Under Alternative 2C, contaminated groundwater from the Great Miami Aquifer would be remediated as described under Alternative 1.

Decontamination and Demolition

D&D of remedial action support facilities would be accomplished as previously described for Alternative 1.

Resultant Land Use Potential

The resultant land use potential for Alternative 2C, Case 1 would be the same as Alternative 1, because none of the excavated material would meet the waste acceptance criteria for consolidation with an earthen cover. The resultant land use potential under Alternative 2C, Case 2 would be the same as for Alternative 2A, Case 2.

Institutional and Administrative Control Requirements

To ensure the long-term performance of the remedial action, Alternative 2C requires the performance of long-term groundwater monitoring and maintenance, and the establishment of a series of institutional and administrative controls. The controls would be the same as previously described for Alternative 2A.

5.4.4.1 Assessment

5.4.4.1.1 Overall Protection of Human Health and the Environment

Alternative 2C meets the remedial action objectives for Operable Unit 5 and would be protective of human health and the environment. Implementation of this alternative would prevent direct access to contaminated soil and sediment by removal of these media to health-based levels and placement in an on-site consolidation area or disposal at an off-site location. Implementation of Alternative 2C would mitigate the migration of contaminants in soil and sediment to the air and groundwater. Moreover, implementation of Alternative 2C would prevent the consumption or use of groundwater containing FEMP contaminants at above MCL or proposed MCL levels. Exposure to direct radiation above protective levels would also be prevented.

The primary actions that would be used to meet the remedial action objectives of Alternative 2C are: excavation of contaminated soil and sediment exceeding PRLs; dispositioning these materials at an on-site consolidation area with earthen cover or at an off-site waste disposal facility depending upon contaminant concentrations; backfilling excavated areas with clean borrow and topsoil; and extraction and treatment of contaminated groundwater from the Great Miami Aquifer.

The consolidation area and its associated waste acceptance criteria were designed to control contaminant migration to human and environmental receptors and to prevent direct radiation exposure from contained waste material. Excavation and containment of contaminated soil and sediment in the on-site consolidation area and the off-site disposition of soil contamination above the waste acceptance criteria of the consolidation area would ensure that risks to the hypothetical resident farmer outside the consolidation area would not exceed those considered health protective. Moreover, the consolidation area with earthen cover for containment of soil contaminants at concentrations above the PRLs is designed to be health protective for the expanded trespasser and would ensure that contaminant concentrations in the Great Miami Aquifer would not exceed PRLs within the 200 year to 1000 year period considered under this FS. It is assumed that the design, siting and permitting of the off-site commercial disposal facility will preclude a corresponding increase in residual risk at that location.

Backfilling excavated areas with clean backfill and topsoil would prevent direct contact with residual contamination and would prevent the potential spread of contamination through the air pathway. The establishment of a vegetative cover would minimize future erosion. Extraction and treatment of Great Miami Aquifer groundwater would clean up existing contamination such that PRL concentrations would not be exceeded.

Following implementation of Alternative 2C, institutional controls would be established for the consolidation area to ensure continued protection of human health and the environment. Remaining FEMP land outside the consolidation area could, at the discretion of the federal government, be made available for alternative land uses. Institutional controls maintained for the consolidation area would include continued federal ownership of that portion of the FEMP to preclude homesteading, intrusive actions or facility degradation; deed restrictions; and passive access controls (e.g., fencing) around the consolidation area to prevent unauthorized access or use of the land.

Loss of institutional controls in combination with failure of the earthen cover over the consolidated waste could, over the 200 to 1000 year period, result in contaminant migration or direct exposure to contaminated material by human and environmental receptors. Exposures to potential receptors would be minimized due to the reduced surface area of the consolidated material and low concentration of contamination in the contained soil. Under the intrusive farmer scenario, however, a future farmer who might choose to establish a residence on top of the consolidation area and who achieved daily contact with materials contained within the consolidation area over a long period of time would be subject to an incremental risk higher than those contemplated herein. Due to its design, however, the use of the consolidation area as a residential area is considered unlikely.

The most significant short-term risks associated with the implementation of Alternative 2C are the risks associated with the transport of contaminated media to an off-site waste disposal area. In addition, increased worker risks would be expected throughout implementation of this alternative. However, through the implementation of a worker health and safety plan in compliance with 29 CFR 1910.120, exposures would be kept to below regulatory limits and would comply with DOE orders. These risks are discussed further in Section 5.4.4.2.5.

To mitigate potential short-term risk to off-property personnel, the implementation of Alternative 2C would include providing alternative water supplies to affected properties pending completion of Great Miami Aquifer remedial actions. It is currently contemplated that the alternative will consist of public water supplied by Hamilton County.

5.4.4.1.2 Compliance with ARARs

Alternative 2C would attain all chemical-, location-, and action-specific ARARs (see Appendix B) except for certain State of Ohio solid waste disposal facility siting requirements (e.g., location above a sole-source aquifer). An ARAR waiver (granted by EPA) to the State of Ohio's solid waste disposal prohibitions would be required. The State of Ohio has expressed an opinion that the basis for the waiver cannot be met without incorporation of an engineered disposal facility for excavated soil that remains on site.

5.4.4.1.3 Long Term Effectiveness and Permanence

Alternative 2C would dispose of more material with greater contaminant concentrations off site, leading to higher long-term effectiveness and permanence than Alternative 2A (where a larger volume of contaminated material would remain on property in the proposed disposal facility). The contaminated material placed in the on-property consolidation area with earthen cover under Alternative 2C would have lower contaminant concentrations than the material placed in the engineered disposal facility under Alternative 2A; this material would present lower overall risks to potential intruders if the planned institutional controls were ever to fail. However, the use of the consolidation area would result in a reduction in long-term effectiveness and permanence due to uncertainty about the maintenance of federal controls for 1000 years and the potential degradation of the earthen cover over the same period.

Groundwater Residual Risk - All alternatives provide for the extraction and treatment of contaminated groundwater from the regional aquifer in the same manner. Residual risk associated with groundwater would be the same as that discussed under Alternative 1.

Soil Residual Risk - As presented in Section 2.0, footprints for soil excavation were based upon the use of total uranium as an indicator parameter. The excavation footprints were then expanded to capture other COCs whose concentrations in soil exceeded their respective PRLs. Before initiation of soil excavation activities, verification sampling would be performed to confirm the excavation footprints. Radiological surveys performed using field instruments would help to direct excavation activities. Upon completion of excavation in a given area, certification sampling would be performed to confirm that soil PRLs were obtained. Effectiveness in meeting the target risk levels would be ensured through this confirmation. Long-term effectiveness and permanence would be ensured through a combination of institutional controls, design considerations incorporated into the consolidation area, and the establishment of the waste acceptance criteria for the consolidation area.

Adequacy and Reliability of Controls

Under Alternative 2C, soil and sediment containing higher levels of contamination would be excavated and shipped to an off-property disposal facility. As in Alternative 1, the off-property facility would be responsible for long-term management of these materials. Off-property disposal offers enhanced reliability because the facility would be licensed for low-level radioactive and mixed wastes. The institutional controls and maintenance activities have been previously approved by a regulatory agency as adequate and reliable.

Soil with lower levels of contamination that meet established waste acceptance criteria would be excavated and placed in an on-property consolidation area. The contaminated soil would be covered with one-foot of compacted soil and six-inches of topsoil which would be revegetated to minimize erosion. The cover would reduce the migration of contaminants to air and surface water. Infiltration through the soil cover would be six inches per year, the same as native soil. This design feature would limit the volume of soil meeting the waste acceptance criteria for the consolidation area.

For purposes of the FS, the northeast corner of the consolidation area is assumed to be located 1200 feet north and 1000 feet east of the northeast corner of the FEMP production area. The consolidation area would extend to the southwest, covering only a small portion of the northeast corner of the production area. This area is located away from Paddys Run and the floodplain to minimize the potential for surface water-induced erosion. The bottom of the contaminated soil would be at or above existing grade, precluding the potential for the material to come into contact with the perched water system. A drainage ditch would be constructed around the consolidation area to divert storm water run-on.

Once all contaminated soil are excavated and either transported off site or placed in the consolidation area, Alternative 2C would require active maintenance and monitoring of the consolidation area for a period of time sufficient to ensure long-term performance of the system. For purposes of the FS, this period was assumed to be 50 years beyond the active groundwater extraction period. It was assumed that the need for continued maintenance and monitoring would be assessed at the end of that time. In any event, five-year reviews would be conducted by EPA in consultation with the State of Ohio and the DOE for as long as the material remains on site. Maintenance and repair would include inspection and repair of potential erosion as well as seasonal upkeep such as grass cutting. Monitoring wells are assumed to be installed in water-bearing zones at 150-foot intervals around the perimeter of the consolidation area. Sampling frequency and an analyte list for the extended monitoring program would be described in the remedial action work plan. Risks associated with maintenance and monitoring activities would be limited to on-property workers and would be maintained as low as reasonably achievable (ALARA) through the use of formal work procedures.

The consolidation area would be delineated with fencing, signs, and markers. Deed restrictions would be implemented to restrict potential future use. The long-term reliability of deed restriction is uncertain. This and the potential loss of integrity of the soil cover on the consolidation area following the active maintenance period was incorporated into the waste acceptance criteria. The waste acceptance criteria for the consolidation area, required to ensure that the uranium concentration in the Great Miami Aquifer would not exceed the proposed MCL for uranium, was established at 45 ppm uranium. This waste acceptance criteria and those for other COCs are comparable to or lower than the PRLs established for hypothetical receptors with the exception of a resident farmer or industrial user. Even if institutional controls should fail, use of the property for a residence or as an industrial park is considered highly unlikely. Thus, even in the event of a hypothetical, catastrophic failure of the earthen cover on the consolidation area (e.g., a flood or tornado), combined with a total loss of institutional controls, potential receptors would be reasonably well protected.

Extraction and treatment of contaminated groundwater from the Great Miami Aquifer is the same as described under Alternative 1. Thus, the adequacy and reliability of controls for this component of Alternative 2C are the same as previously described for Alternative 1 (Section 5.4.2.2.3).

Long-Term Environmental Impacts

The long-term environmental impacts to the FEMP site associated with Alternative 2C, Case 1 are similar to those previously identified for Alternative 1, Case 1 (Section 5.4.2.2.3).

Long-Term Impacts from 10^{-5} Clean-Up Level For Case 2

Long-term environmental impacts from Alternative 2C, Case 2 are similar to Alternative 2A, Case 2 (Section 5.4.2.2.3) except that consolidation of contaminated soil (including the PMF channel) would result in the permanent commitment of 107.2 acres of land at the FEMP site, including 28.9 acres of pine plantation habitat. Permanent disruption of 21 acres of soil and the vegetative community at the representative commercial disposal facility would occur.

5.4.4.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative provides no reduction of toxicity, mobility, or volume of radiologically contaminated soil through treatment. Materials with the highest levels of contamination would be shipped off site for disposal, thus reducing the toxicity, mobility, and volume of contaminated soil on site.

As previously described for Alternative 1 (Section 5.4.2.2.4), approximately 28,000 cubic yards of soil and sediment containing RCRA hazardous, petroleum, and PCB waste would be treated with mobile thermal desorption or cement stabilization, as appropriate, to levels below which the soil would no longer be considered mixed waste.

Treatment of the perched groundwater and Great Miami Aquifer groundwater for this alternative would be the same as described in Alternative 1 (Section 5.4.2.2.4).

5.4.4.1.5 Short-Term Effectiveness

Protection of the Community During Remedial Actions

Through the implementation of a combination of engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls), the short-term risks to members of the community associated with Alternative 2C would be minimized.

Using historical transportation statistics, an estimated 3 fatalities and 11 injuries can be expected to members of the public for Alternative 2C, Case 2 due to mechanical hazards associated with accidents during transportation. These fatalities and injuries are associated with off-site disposal operations of excavated soil and sediment during the 22 years of remedial activities. As mentioned previously, Alternative 2C, Case 1 is the same as Alternative 1, Case 1.

The estimated ILCR to hypothetical receptors, representing members of the public near the FEMP, due to external radiation and inhalation associated with releases during remedial actions are estimated at 4.9×10^{-7} for Case 2 for Alternative 2C. ILCRs to members of the public located along the transportation route are 8.6×10^{-8} for Case 2.

Protection of Workers During Remedial Actions

A detailed analysis of the potential short-term risks to workers engaged in remedial activities and on-site workers not engaged in remedial activities is presented in Appendix G. The ILCR for remediation workers for Case 2 is estimated at 1.3×10^{-3} for excavation activities, 2.9×10^{-3} for off-site disposal activities, and 1.3×10^{-3} for on-site consolidation. The dominant risk is from external exposure to radioactive contaminants. These risk levels are less than those extrapolated from the maximum allowable exposure limits for workers and do not exceed worker standards (10 CFR 835 and 29 CFR 1910).

Short-Term Environmental Impacts

The short-term environmental impacts associated with Alternative 2C, Case 1, are similar to those previously identified for Alternative 1, Case 1 (Section 5.4.2.2.5). The short-term environmental impacts to the FEMP site from remedial activities for Alternative 2C, Case 2 are similar to those impacts identified for Alternative 1, Case 2 except that soil disturbances would result from construction of the consolidated area and associated PMF channel, construction of roads, construction and operation of support facilities and operation of equipment. These activities would disturb 128 acres of land within the site boundary. Approximately 46 acres of introduced grassland habitat would be impacted by the construction of a consolidated area and associated PMF channel.

The wealth of the CMSA would increase by 13 percent annually for 22 years and slow to a 1.7 percent annual increase for the remaining eight years. Traffic volumes on local roads are expected to remain constant.

Short-term impacts to soil and the vegetative community at the representative commercial disposal facility for all PRLs are the same as long-term impacts identified for this alternative.

Time Period to Achieve Remedial Action Objectives

Physical, substantial and continuous on-site activities for soil remediation would be initiated within 15 months following issuance of the ROD. The estimated time to excavate and disposition contaminated soil to achieve remedial action objectives under Alternative 2C is 22 years. This time frame includes construction of an on-property consolidation area and the transport of soil which does not meet the waste acceptance criteria of the on-property consolidation area to an off-site commercial disposal facility.

The 22-year schedule assumes that soil excavation, construction of the consolidation area, and off-site transport would be performed on a five day per week, one shift per day basis. Following completion of soil emplacement in the consolidation area, construction of an earthen and vegetative cover would require an additional 12 months.

Operation of the Great Miami Aquifer groundwater recovery system is projected to continue for up to 27 years for Case 2, as previously described for Alternative 1 (Section 5.4.2.2.5).

5.4.4.1.6 Implementability

Technical Feasibility

Technical feasibility issues for off-site disposal of the materials with the highest levels of contamination would be the same as for Alternative 1 (Section 5.4.2.2.6).

Readily available resources and standard procedures would be used for construction of the consolidation area and earthen cover. The technical feasibility of locating the consolidation area would be performed by using reliable conventional methods. The footprint of the consolidation area for a risk goal of 10^{-5} is estimated to be 33 acres. Sufficient area would be available on property to site the consolidation area.

Implementability implications for extraction and treatment of contaminated groundwater would be the same as in Alternative 1 (Section 5.4.2.2.6).

Administrative Feasibility

As discussed in greater detail in Alternative 1 (Section 5.4.2.2.6), the implementability of this alternative depends on the ability of DOE to negotiate a contract with a commercial disposal facility to accept material from the FEMP. Continued availability for disposal capacity over a 22-year remediation period is essential.

Under this scenario, clean fill material, available on property or from off-property commercial providers, would be required to backfill excavated areas. A process of certification would be necessary to ensure that borrow material would meet PRLs.

Discharge of the treated groundwater to the Great Miami River will require a modification to the existing NPDES permit. Continued monitoring of the outfall line will be required under both the NPDES and CERCLA programs.

Availability of Services and Materials

Personnel and equipment needed to excavate, segregate, and dispose of contaminated soil and sediment according to their contamination levels would be available locally, as discussed under Alternative 2A (Section 5.4.3.2.6). Materials required for the cover and backfill for excavated areas would be available on property. The availability of services and materials associated with off-site disposal and the groundwater treatment component of this alternative is the same as previously described for Alternative 1 (Section 5.4.2.2.6).

5.4.4.1.7 Cost

The cost to implement Alternative 2C includes the cost to construct remediation facilities, to operate and maintain remedial actions, and postremediation costs, which include D&D of remediation facilities. Table 5-15 summarizes the costs (in 1995 dollars) of Alternative 2C for Case 2. It also contains the corresponding present worth and escalated costs.

The construction cost of Alternative 2C includes: verification surveys to establish the boundaries of excavation areas; the acquisition of earth-moving equipment; excavation operations; storm water controls; construction of haul roads, wheel washing and radiological screening stations, the off-site disposal staging facility, the Great Miami Aquifer groundwater extraction system, and the groundwater treatment facility; and backfill operations.

TABLE 5-15

ALTERNATIVE 2C COSTS

Costs	$ (million) Risk Case 2 10^{-5} Risk/On-Property Resident Farmer 10^{-5} Risk/Off-Property Resident Farmer
Construction	320
Operations and maintenance	930
Postremediation	70
Total cost (1995 dollars)	1320
Present worth cost	910
Total cost (escalated)	2780

The O&M costs for Alternative 2C include: labor, materials, fuel, utilities, chemicals, and parts required to operate and maintain remediation actions; sampling and analysis; and transportation and disposal of contaminated material.

Postremediation costs for Alternative 2C include: D&D of remediation facilities; decontamination and free-release of equipment; and long-term monitoring.

Figure 5-10 shows the present worth cost of Alternative 2C, Case 2 divided into its remedial action components. As shown in the figure, off-site disposal is the predominant contributor to the present worth cost for Case 2. Off-site disposal accounts for 42 percent of total present worth costs for Alternative 2C while treatment of contaminated groundwater contributes 26 percent. As mentioned previously, costs for Case 1 for Alternative 2C are the same as Alternative 1, Case 1.

Appendix K provides the cost basis and estimates for the remedial action components which comprise Alternative 2C.

000184

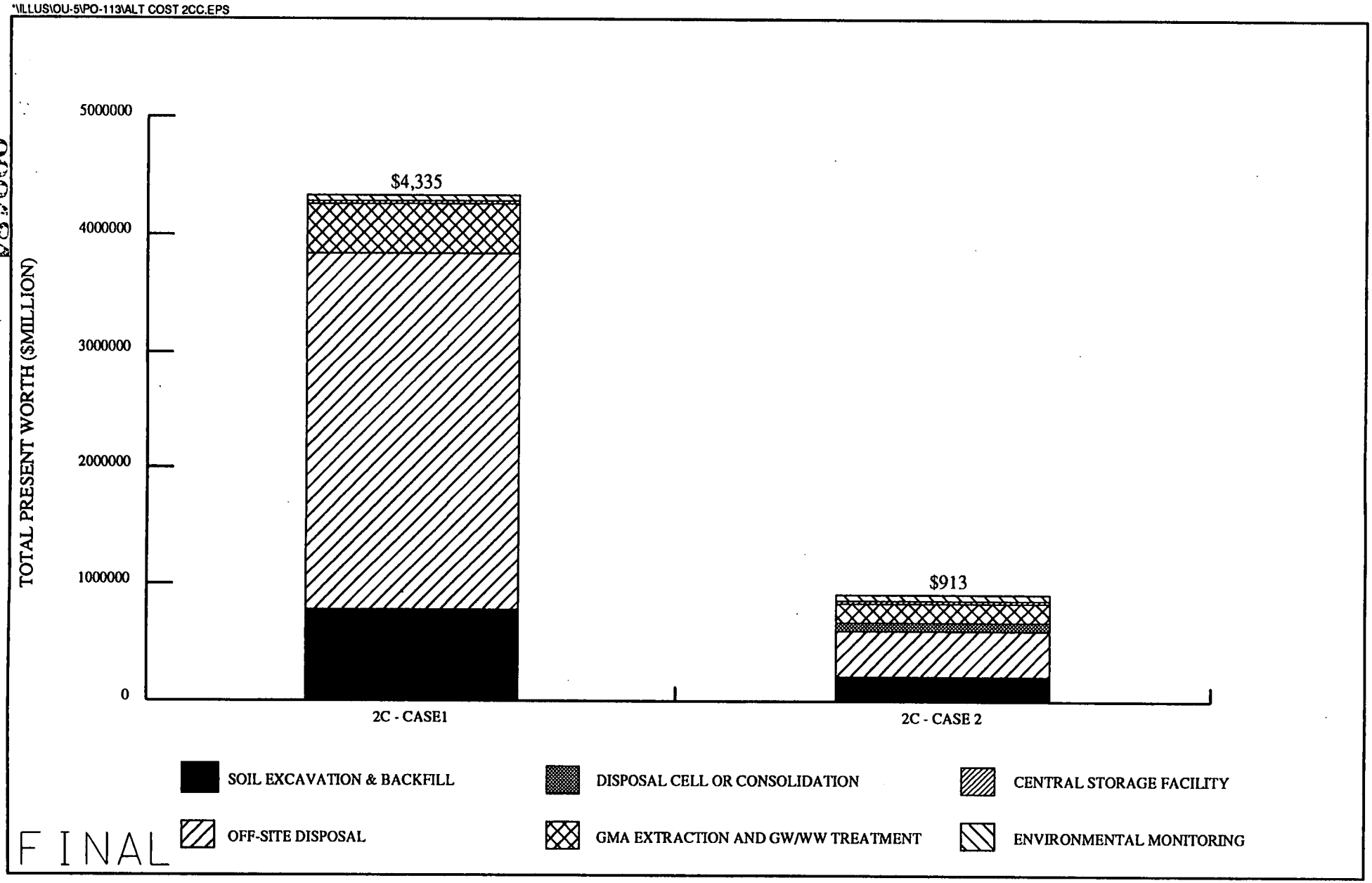


FIGURE 5-10. ALTERNATIVE 2C COSTS BY COMPONENT

5.4.5 Alternative 3A - Engineered Disposal Facility

The objective of Alternative 3A is to consolidate contaminated soil at a central FEMP location in an effort to maximize the on-property land area made available for alternative uses. Alternative 3A involves the excavation of contaminated soil and sediment exceeding PRLs. This contaminated soil and sediment would be moved to a central location on FEMP property and placed within an engineered disposal facility. Contaminated soil determined to exceed the waste acceptance criteria of the on-property disposal facility would be transported to an off-site waste disposal facility. Contaminated groundwater from the Great Miami Aquifer would be extracted until PRLs are attained.

The remedial actions which would be taken under Alternative 3A are the same as those which would be taken under Alternative 2A. The difference between these two alternatives lies in the target receptors and the associated cleanup levels. Alternative 2A contemplates the potential release of a portion of the FEMP for unrestricted land use, and the calculation of the PRLs and the associated volumes of media requiring remediation considered an on-site resident farmer as the representative receptor. In contrast, Alternative 3A contemplates the potential release of portions of the FEMP for restricted land use including industrial and recreational use (developed park and undeveloped park). Thus, the calculation of PRLs and the associated volumes of media requiring remediation under Alternative 3A considered an on-site industrial user and an on-site recreational user (for both a developed and an undeveloped park). Because industrial users or recreational users would spend less time at the FEMP site than would a resident, the corresponding PRLs are higher and the associated volumes of media requiring remediation are lower under Alternative 3A than under Alternative 2A. Other aspects of Alternative 3A are consistent with Alternative 2A.

5.4.5.1 Detailed Description

The following remedial activities comprise Alternative 3A:

- Excavating contaminated soil, production-area gravel, and sediment exceeding PRLs and excavating perched groundwater zones identified as presenting unacceptable cross-media risks to the Great Miami Aquifer
- Backfilling excavated areas and regrading the site to achieve desired drainage patterns and controls
- Consolidating excavated material in an on-property engineered disposal facility
- Dispositioning contaminated material exceeding the waste acceptance criteria for the on-property disposal facility to an off-property disposal facility
- Pretreating soil with concentrations of RCRA-regulated constituents above the waste acceptance criteria established for these constituents

- Extracting contaminated groundwater from the Great Miami Aquifer until target concentrations for COCs are attained
- Treating all collected storm water, wastewater, and groundwater as required
- Discharging storm water, wastewater and recovered groundwater to the Great Miami River following any required treatment
- Decontaminating and dismantling required support facilities, following completion of remedial actions, with off-property disposal of the contaminated debris at a commercial disposal facility
- Operating a groundwater monitoring network to assess the continued performance of the disposal facility
- Maintaining federal ownership of the entire FEMP to maintain imposed land use restrictions. At the discretion of the federal government, release of areas of the FEMP property outside the disposal area for alternative uses including industrial development or recreational use
- Performing five-year reviews (by EPA, in consultation with the State of Ohio and the DOE) to assess the continued performance of the completed remedial action

To ensure that a full range of residual risk conditions are evaluated, Alternative 3A was evaluated for five different risk scenarios referred to as Cases 3 through 7 (see Table 2-18). Case 3 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in the disposal area and an industrial user for on-property areas outside the disposal area) and an ILCR of 10^{-5} to off-property target receptors (i.e., the RME resident farmer).

Case 7 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in the disposal area and a recreational user of an undeveloped park for on-property areas outside the disposal area) and an ILCR in the range of 10^{-5} to off-property target receptors (i.e., the RME resident farmer). Moreover, Case 7 assumes that additional actions would be taken for on-property areas outside the disposal area which would result in an ILCR below 10^{-6} to the recreational user of an undeveloped park. In this regard, a residual concentration of uranium in soil of 80 ppm corresponds to an ILCR of 10^{-6} to the on-property recreational user. Because hand-held detectors are capable of detecting uranium in soil down to a level of 50 ppm uranium, the FEMP would apply the principle of ALARA by establishing an administrative target of 50 ppm for the residual concentration of uranium in on-property soil. Table 5-16 provides a concise summary of the target receptors and associated risk levels considered under each case.

TABLE 5-16

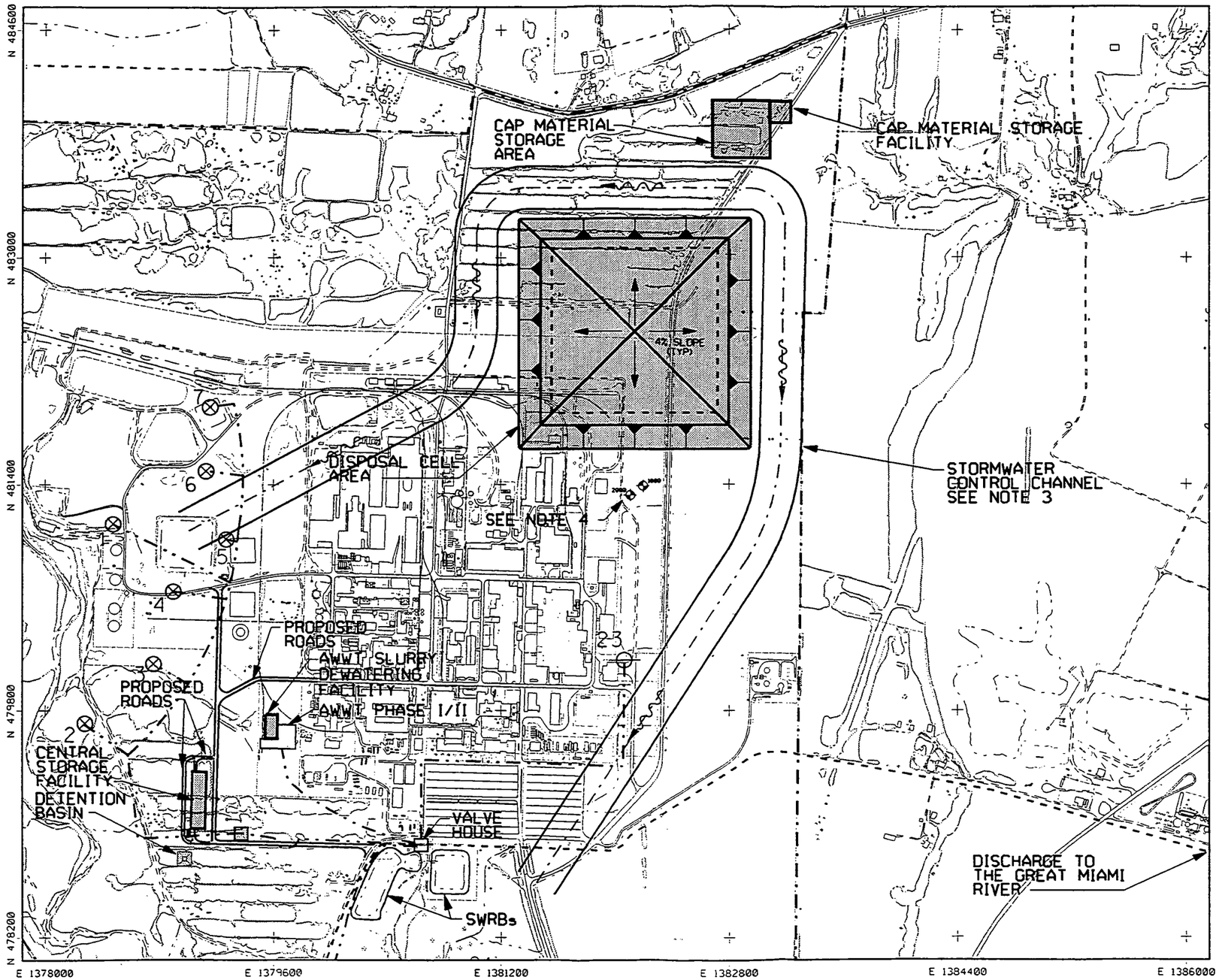
TARGET RECEPTORS AND ASSOCIATED RISK LEVELS FOR ALTERNATIVE 3A

	On-Property Soil and Sediment		Off-Property Soil		Groundwater	
Risk Case	Receptor[a]	Risk Level	Receptor	Risk[a] Level	Receptor[b]	Risk Level
3	Industrial user	10^{-6}	Resident farmer	10^{-5}	ARARs	Proposed MCLs
4	Recreational-developed park	10^{-6}	Resident farmer	10^{-5}	ARARs	Proposed MCLs
5	Recreational-undeveloped park	10^{-6}	Resident farmer	10^{-5}	ARARs	Proposed MCLs
6	Recreational-undeveloped park	10^{-6}	Resident farmer	10^{-5} [c]	ARARs	Proposed MCLs
7	Recreational-undeveloped park	10^{-6} ALARA[d]	Resident farmer	10^{-5} [d]	ARARs	Proposed MCLs

[a] Each case assumes a residual risk level of 10^{-6} to the expanded trespasser inside the area containing the disposal facility.
[b] At a residual risk level of 10^{-5} to the resident farmer, the MCLs and proposed MCLs are more restrictive and are therefore used in lieu of the risk-based limits.
[c] For Cases 6 and 7, the ILCR due to a residual uranium concentration of 50 ppm would be 3.5×10^{-5} and the HI would be 1.
[d] The PRL for uranium at an ILCR of 10^{-6} is 80 ppm. The target cleanup level for this case was set at the limits of survey instruments (50 ppm U) in the interest of ALARA.

The conceptual site plan depicting disposal facility size and the necessary support structures for Alternative 3A, Case 3 is the same as Alternative 2A, Case 2 (see Figure 5-7). A conceptual site plan depicting the necessary support structures and disposal facilities for Alternative 3A, Cases 4 - 7, is presented in Figure 5-11. The conceptual site plans represent the configuration of remedial facilities necessary to address the anticipated volumes of materials required to be excavated to achieve the residual risks associated with each case. Remedial support facilities depicted in the site plans include a central storage facility for contaminated material, an engineered disposal facility, a cap material storage area, and the wastewater treatment facilities required to address collected wastewater, storm water, perched groundwater and recovered Great Miami Aquifer groundwater.

The PRLs were previously presented in Section 2.0. For Alternative 3A, the PRLs for areas outside the disposal area would be those listed in Tables 2-12, 2-13, 2-14, and 2-15 for restricted land use.



N

LEGEND

EXISTING		PROPOSED
	BUILDING/TRAILER	
	PAVED ROADWAY	
	UNPAVED ROADWAY	
—x—x—x—	FENCE	
	RAILROAD	
	TREE	
	TREE LINE	
	DITCH FLOW	
	EXTRACTION PIPELINE	
	SOUTHPLUME RECOVERY PIPELINE	
	SYSTEM 3 EXTRACTION WELL	
	WASTE PIT AREA EXTRACTION WELL	
	MONITORING WELLS	

NOTES:

1. SURFACE FEATURES BASED ON 1992 FLYOVER.
2. THIS FIGURE PROVIDES THE DISPOSAL CELL CONFIGURATION FOR 1.75 MILLION CUBIC YARDS CAPACITY.
3. THE STORMWATER CONTROL DITCH SHALL BE INSTALLED FOR THE DISPOSAL CELL. SEDIMENT CONTROL MEASURES SHALL BE INSTALLED THROUGHOUT DITCH.
4. 43 PAIRS OF PROPOSED 1000 AND 2000 SERIES MONITORING WELLS AROUND DISPOSAL CELL AREA PERIMETER.
5. BORROW AREA WILL BE LOCATED IN THE SOUTHEASTERN PORTION OF THE FEMP PROPERTY.

400 0 400 800 1200

SCALE IN FEET

STATE PLANAR COORDINATE SYSTEM 1927

P0113/8/skg03358.dgn/OU5

FINAL

FIGURE 5-11. SITE PLAN ALTERNATIVES 3A-4, 3A-5, 3A-6, 3A-7, 4A-8, AND 4A-9 5-98

For the disposal area, PRLs would be those listed in these sample tables for continued federal ownership. The PRLs for the disposal area are based upon the presumption that the area is under the continued ownership of the government and would have access restricted by a properly maintained fence with signs.

Figure 4-7 presented a conceptual block flow diagram of the remedial activities associated with Alternative 3A. Detailed discussions on each of the components comprising the alternatives are presented in Appendix L. The following sections present a brief description of the unique aspects of the remedial action components as they pertain to Alternative 3A.

Excavation and Backfill

Contaminated soil, sediment, and production-area gravel not meeting PRLs would be excavated by conventional construction equipment. The areas to be excavated include the contaminated rubble along the Great Miami River near the outfall line, contaminated soil under pipelines, and affected soil in the area of the FEMP's former underground storage tanks. The Operable Unit 5 excavation footprints and soil volumes also include the incremental soil excavation necessary to complete remedial activities within the boundaries of the other operable units. Soil and sediment determined through pre-excavation characterization to meet the waste acceptance criteria for consolidation and confinement in an engineered disposal facility would be loaded into trucks or roll-off containers and transported to the disposal facility. Materials destined for disposal in the engineered facility would be staged, as necessary, in an interim soil storage facility.

Excavated soil and sediment determined (through HWMU history, process knowledge, excavation control surveys and verification sampling) to contain RCRA-listed or characteristic wastes would be pretreated as discussed in Section 4.0 under the strategy for managing RCRA-regulated constituents. These materials would be pretreated to meet the site-specific waste acceptance criteria developed for the RCRA-based COCs and would subsequently be placed in the on-property disposal facility. Materials that do not meet the specific waste acceptance criteria would be sent off site for disposal.

Footprints of the projected excavations required to attain the PRLs for Alternative 3A, Cases 3 through 7, are presented in Figures 2-12, through 2-15. Table 5-17 provides the estimated soil volumes which would be excavated under Alternative 3A, both on and off property, for the five risk level cases. The on-property backfill represents that volume of soil that does not exceed PRLs, but must be excavated in order to reach more contaminated soil located beneath it. Because this soil does not exceed PRLs, it can be used as backfill. Final footprints of excavation and volumes would be established through completion of a preexcavation verification survey. This verification survey is discussed further in the description of the soil excavation component presented in Appendix L.

TABLE 5-17

REMEDIAL ACTION ALTERNATIVE 3A SOIL VOLUMES

	Risk Case				
	3	4	5	6	7
Risk Goal					
On-Property					
Receptor	Industrial	Dev. park	Undev. park	Undev.	Undev.
Risk level	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-6}*
Off-Property					
Receptor	Resident farmer	Resident farmer	Resident farmer	Resident farmer	Resident farmer
Risk Level	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
Soil Volume Requiring Excavation (yd^3)					
On-property	1,990,000	1,800,000	1,790,000	1,789,000	1,799,000
Off-property	400,000	400,000	400,000	1,000	1,000
Total	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Remedial Action (in situ soil volume in yd^3)					
On-property backfill	25,000	425,000	415,000	15,000	25,000
On-site disposal facility	2,340,000	1,750,000	1,750,000	1,750,000	1,750,000
Off-site disposal	25,000	25,000	25,000	25,000	25,000
Total	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000

* Uses ALARA as presented in Table 2-16.

Excavated areas would be backfilled, as necessary, with clean borrow material and topsoil to reestablish original grade. A vegetative cover would be reestablished on the backfilled areas.

On-Property Disposal

Contaminated soil and sediment would be placed in an engineered disposal facility. Details on the conceptual design configuration for the disposal facility are found in the component descriptions in Appendix L. Table 5-18 presents the expected dimensions of the disposal facility for the excavated materials meeting the waste acceptance criteria for this facility. The underdrain system for the disposal facility is anticipated to be operated during the period of active remediation for soil and sediment, with continued operation of the system, as needed, until dismantlement of the wastewater treatment facility. Collected leachate from the underdrain system would be transferred from the location of the disposal facility to the wastewater treatment facility before discharge to the Great Miami River.

TABLE 5-18

ALTERNATIVE 3A DISPOSAL FACILITY DIMENSIONS
(All dimensions in feet)

Risk Case	Risk Level/Land Use/Receptor	Length	Width	Height
3	10^{-6} / On-property industrial 10^{-5} / Off-property resident farmer	2260	1600	40
4	10^{-6} / On-property dev. park 10^{-5} / Off-property resident farmer	1610	1610	37
5	10^{-6} / On-property undev. park 10^{-5} / Off-property resident farmer	1610	1610	37
6	10^{-6} / On-property undev. park 3.5×10^{-5} / Off-property resident farmer	1610	1610	37
7	10^{-6} / On-property undev. park* 3.5×10^{-5} / Off-property resident farmer	1610	1610	37

* Uses ALARA as presented in Table 2-16.

Off-Property Disposal

Contaminated soil not meeting the waste acceptance criteria for the on-property disposal facility would be shipped off-site for disposal. For purposes of this FS, the off-site disposal facility's waste acceptance criteria must be commensurate with the characteristics of the waste material. For Alternative 3A, soil exceeding the disposal facility waste acceptance criteria is estimated to be 25,000 cubic yards for all cases evaluated. Contaminated soil would be loaded into trucks for shipment to the off-site facility.

Great Miami Aquifer Restoration

Under Alternative 3A, contaminated groundwater from the Great Miami Aquifer would be remediated as described under Alternative 1, Case 2.

Storm Water Management

Storm water would be managed as previously described for Alternative 2A.

Decontamination and Demolition

D&D of remedial action support facilities would be accomplished as previously described for Alternative 1.

Resultant Land Use Potential

The remedial action alternatives were developed to achieve a range of target land use objectives and ensure the protection of the underlying Great Miami Aquifer. Alternative 3A targeted consolidation of contaminated material to the smallest possible area, freeing up maximum land for alternative land uses including industrial development or recreational use as a developed or undeveloped park. The disposal area is designated to be maintained as a restricted waste management area.

Institutional and Administrative Control Requirements

To ensure the long-term performance of the remedial action, Alternative 3A requires the performance of long-term groundwater monitoring and maintenance, and the establishment of a series of institutional and administrative controls. The controls would be the same as previously described for Alternative 2A (Section 5.4.3.1), with the addition that restrictions to control on-property land uses to nonfarming use would be necessary.

5.4.5.2 Assessment

5.4.5.2.1 Overall Protection of Human Health and the Environment

Alternative 3A meets the remedial action objectives for Operable Unit 5 and would be protective of human health and the environment. This alternative would prevent direct access to contaminated soil and sediment by removal of these media to health-based levels and consolidation in an on-site disposal facility. Implementation of Alternative 3A would mitigate the migration of contaminants in soil and sediment to the air and groundwater. Moreover, implementation of Alternative 3A would prevent the consumption or use of groundwater containing FEMP contaminants above MCLs or proposed MCLs. Exposure to direct radiation above protective levels would also be prevented.

The primary actions that would be used to meet the remedial action objectives of Alternative 3A are: excavation of contaminated soil and sediment exceeding PRLs; dispositioning these materials in an on-property disposal facility or shipment to an off-site disposal facility depending upon contaminant concentrations; backfilling excavated areas with clean borrow and topsoil; and extraction and treatment of contaminated groundwater from the Great Miami Aquifer.

The disposal facility and its associated waste acceptance criteria would be designed to control contaminant migration to human and environmental receptors and to prevent direct radiation exposure from contained material. Excavation and containment of contaminated soil and sediment in the

disposal facility would ensure that risks to the hypothetical resident farmer outside the disposal area would not exceed those considered health protective. Moreover, the disposal facility is designed to be health protective for the expanded trespasser and would ensure that contaminant concentrations in the Great Miami Aquifer would not exceed MCLs or proposed MCLs within the 200- to 1000-year period considered under this FS.

Backfilling excavated areas with clean backfill and topsoil would prevent direct contact with residual contamination and would prevent the potential spread of contamination through the air pathway. The establishment of a vegetative cover would minimize future erosion. Extraction and treatment of Great Miami Aquifer groundwater would clean up existing contamination such that MCLs and proposed MCLs would not be exceeded.

Following implementation of Alternative 3A, institutional controls would be maintained for the disposal facility to ensure continued protection of human health and the environment. Remaining FEMP land outside the disposal area could, at the discretion of the federal government, be made available for alternative land uses. Institutional controls maintained for the disposal facility would include continued federal ownership of that portion of the FEMP to preclude homesteading, intrusive actions or facility degradation; deed restrictions; and passive access controls (e.g., fencing) around the disposal facility to prevent unauthorized access to or use of the land.

Loss of institutional controls in combination with failure of the disposal facility could, over the 200- to 1000-year period, result in contaminant migration or direct exposure to contaminated material by future human and environmental receptors. Exposures to potential receptors would be minimized due to the reduced surface area of the consolidated material. Under the intrusive farmer scenario, however, a future farmer who might choose to establish a residence on top of the disposal facility and who achieved daily contact with materials contained within the disposal facility over a long period of time would be subject to incremental risks greater than those contemplated herein. Due to its design, however, the use of the disposal facility as a residential area is considered highly unlikely.

The most significant short-term risks associated with the implementation of Alternative 3A are the risks associated with the off-site transportation of soil and the excavation, movement and processing of soil on site. Implementation of a worker health and safety plan in compliance with 29 CFR 1910.120, would be expected to keep exposures below regulatory limits and comply with DOE orders. These risks are discussed further in Section 5.4.5.2.5.

5.4.5.2.2 Compliance with ARARs

The remedial action components of Alternative 3A are identical to Alternative 2A, and compliance with ARARs for this alternative would be identical to those described for Alternative 2A. Alternative 3A considers using less stringent, risk-based PRLs which would cause smaller areas of the site to be remediated. All ARAR-based PRLs would be incorporated.

5.4.5.2.3 Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 3A would be slightly lower than that of Alternative 1. While Alternative 1 involves the excavation and off-property disposal of contaminated soil and sediment, soil and sediment excavated under Alternative 3A would be placed in an on-property disposal facility. The use of an on-property disposal facility would cause no immediate increase in the residual risk associated with this alternative. Its continued presence, however, results in a reduction in the perceived permanence due to uncertainty associated with the ability of the federal government to maintain long-term (i.e., up to 1000 years) institutional controls and the long-term performance of the engineered components of the system.

Groundwater Residual Risk - All alternatives provide for the extraction and treatment of contaminated groundwater from the regional aquifer in the same manner. Residual risk associated with groundwater would be the same as that discussed under Alternative 1, Case 2.

Soil Residual Risk - As presented in Section 2.0, footprints for soil excavation were based upon the use of total uranium as an indicator parameter. The excavation footprints were then expanded to capture other COCs whose concentration in soil exceeded their respective PRLs. Before initiation of soil excavation activities, verification sampling would be performed to confirm the excavation footprints. Radiological surveys performed using field instruments would help to direct excavation activities. Upon completion of excavation in a given area, certification sampling would be performed to confirm that soil PRLs were obtained. Effectiveness in meeting the target risk levels would be assured through this confirmation that PRLs were attained. Long-term effectiveness and permanence would be ensured through a combination of institutional controls and design considerations incorporated into the disposal facility.

Adequacy and Reliability of Controls

For Alternative 3A, the adequacy and reliability of controls associated with the performance of the disposal facility and extraction and treatment of contaminated groundwater from the Great Miami Aquifer would be the same as previously described for Alternative 2A (Section 5.4.3.2.3) and Alternative 1 (Section 5.4.2.2.3), respectively.

Long-Term Environmental Impacts

Long-term impacts to the environment from Alternative 3A, Cases 3 and 7 are as follows. For a more detailed discussion of specific resources and their associated mitigative measures, refer to Alternative 1 (Section 5.4.2.2.3). For the purposes of evaluating NEPA values, NTS, a DOE-owned low-level radioactive waste facility near Las Vegas, Nevada was considered.

Alternative 3A, Cases 3-7 would require construction of the on-site above-grade disposal facility (including the PMF channel) resulting in the permanent commitment of 137.6 acres of land.

Alternative 3A, Case 3 would impact 10 acres of early to mid-successional woodlands, 42 acres of riparian habitat and 47 acres of pine plantation. For Cases 4-7 approximately 16.5 acres of riparian habitat and 1375 feet of Paddys Run would be impacted. These impacts would result from excavation activities. All cases for Alternative 3A would impact habitat and species for the state-threatened Sloan's crayfish (*Orconectes sloanii*) as well as habitat for the federally endangered Indiana bat (*Myotis sodalis*) and the state-threatened cave salamander (*Eurycea lucifuga*). As described in Alternative 1, mitigative measures would reduce these impacts.

Cases 3 through 7 would permanently disrupt approximately 0.5 acres of soil at NTS from the disposal of materials.

Alternative 3A, Case 3 would impact approximately 17 acres of freshwater wetlands by soil and sediment removal. Mitigation for wetland impacts would be determined using the 404(b)(1) guidelines of the Clean Water Act, as described in Alternative 1 (Section 5.4.2.2.3). Alternative 3A, Cases 4 through 7 would impact approximately 9 acres of freshwater wetlands as a result of soil and sediment removal; mitigation would be determined as above.

Land Use Objective 3 provides for the consolidation of contaminated soil in a central area, but restricts the potential uses of the remaining area of the property through the application of institutional controls. This objective considers the potential for establishing recreational, commercial/industrial, or undeveloped open space (i.e., green space) on any portion of the FEMP property outside the area where the contaminated materials are consolidated.

Impacts to cultural resources will be minimized as described in Alternative 1 (Section 5.4.2.2.3). For Alternative 3A, Cases 3 through 5, off-property mitigation activities would potentially be greater than for Cases 6 and 7, because 496 acres of off-property land would be disturbed for Cases 3 through 5, as opposed to 1.2 acres for Cases 6 and 7.

5.4.5.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative provides no reduction of toxicity, mobility, or volume of radioactively contaminated soil or sediment through treatment for the majority of excavated soil. As in Alternative 2A, the materials designated as principal threat materials would be disposed at an off-site disposal facility.

As previously described for Alternative 1 (Section 5.4.2.2.4), an estimated 28,000 cubic yards of soil and sediment containing RCRA hazardous, petroleum, and PCB wastes would be treated with mobile thermal desorption or cement stabilization, as indicated, to levels below which the soil would no longer be considered mixed wastes.

Treatment of the perched groundwater and Great Miami Aquifer groundwater for this alternative would be the same as described in Alternative 1, Case 2.

5.4.5.2.5 Short-Term Effectiveness

Protection of the Community During Remedial Actions

Through the implementation of a combination of engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls), the short-term risks to members of the community associated with Alternative 3A would be minimized. A remedial action risk assessment was conducted to assess the potential short-term risks associated with the implementation of remedial actions.

Using historical transportation statistics, less than 1 fatality would be expected for Cases 3, 4, 5, 6, and 7; and less than 1 injury for Cases 3, 4, 5, 6, and 7 to members of the public for Alternative 3A due to mechanical hazards associated with accidents during transportation to an off-site disposal facility during the 22 years of remedial activities.

The estimated ILCR to hypothetical receptors representing members of the public near the FEMP due to external radiation and inhalation associated with releases during remedial actions are estimated at 3.4×10^{-7} for Cases 3, 6 and 7 and 3.2×10^{-7} for Cases 4 and 5 for Alternative 3A. The ILCRs for members of the public located along the transportation route are estimated at 1.4×10^{-8} for Cases 3, 4, 5, 6, and 7.

Protection of Workers During Remedial Actions

A detailed analysis of the potential short-term risks to workers engaged in remedial activities and on-site workers not engaged in remedial activities is presented in Appendix G. The ILCR for remediation workers for Cases 3, 6, and 7 is estimated at 1.2×10^{-3} for excavation activities, 2.3×10^{-3} for off-site disposal activities, and 1.4×10^{-3} for on-site disposal facility activities. For Cases 4 and 5, the ILCR for excavation activities is 1.1×10^{-3}, and 2.2×10^{-3} for off-site disposal activities,

and 1.2 x 10^{-3} for on-site disposal facility activities. For all cases, the dominant risk is from inhalation of radioactive contaminants. These risk levels are less than those extrapolated from the maximum allowable exposure limits for workers, so these risks do not exceed worker standards (10 CFR 835 and 29 CFR 1910).

Short-Term Environmental Impacts

Short-term impacts to the environment from Alternative 3A, Cases 3-7 are as follows. Detailed discussions of the specified resources can be found in Alternative 1 (Section 5.4.2.2.5).

Between approximately 352 acres and 485 acres of land within the 1050-acre site boundary would be disturbed from removing contaminated soil and sediment. Between approximately 1.2 acres and 496 acres of land outside the site boundary would be disturbed from removing contaminated soil. Alternative 3A, Cases 3-7 would result in the disturbance of approximately 163.2 acres of land from associated short-term remedial activities, such as construction of support facilities and the on-property disposal facility. Approximately 172 acres of on-property grassland would be impacted by Alternative 3A, Case 3. Cases 4-7 would impact 115 acres of on-property grassland.

Alternative 3A, Case 3 would increase the wealth of the CMSA by 4.7 percent annually for 22 years followed by a 6.7 percent annual increase for the remaining eight years. Alternatives 3 A, Cases 4-7 would increase the wealth of the CMSA by 6.4 percent annually for 22 years followed by a 6.7 percent annual increase for the remaining eight years. Traffic volumes on local roads are expected to remain constant throughout the duration of remedial activities.

Short-term impacts to soil at NTS for all PRLs are the same as long-term impacts identified for this alternative.

Time Period to Achieve Remedial Action Objectives

Physical, substantial and continuous on-site activities for soil remediation would be initiated within 15 months following issuance of the ROD. The estimated time to excavate and disposition contaminated soil to achieve remedial action objectives under Alternative 3A is 22 years. This time frame includes construction of an on-property disposal facility and the transport of soil that does not meet the waste acceptance criteria of the on-property disposal facility to an off-site disposal facility.

The 22-year schedule assumes that soil excavation, construction of the disposal facility, and off-site transport would be performed on a five day per week, one shift per day basis. Following completion of soil emplacement in the disposal facility, capping activities would require an additional 12 months.

Operation of the Great Miami Aquifer groundwater recovery system is projected to continue for up to 27 years, as previously described for Alternative 1, Case 2 (Section 5.4.2.2.5).

5.4.5.2.6 Implementability

Technical Feasibility

For Alternative 3A, the technical feasibility associated with excavation, installation of an on-property disposal facility, and off-site disposal would be the same as previously described for Alternative 2A (Section 5.4.3.2.6). This alternative calls for extraction and treatment of groundwater to a risk goal of MCLs. This corresponds to the 27-year pumping scenario described in Alternative 1. Thus, implementability implications for extraction and treatment of contaminated groundwater are the same as in Alternative 1 (Section 5.4.2.2.6).

Administrative Feasibility

Administrative factors for Alternative 3A would be the same as previously described for Alternative 2A (Section 5.4.3.2.6), with the key factor being the siting of the disposal facility over a sole-source aquifer.

Availability of Services and Materials

For Alternative 3A, the availability of services and materials associated with excavation and installation of an on-property disposal facility, and off-site disposal of material exceeding the waste acceptance criteria for the on-property disposal facility would be the same as previously described for Alternative 2A (Section 5.4.3.2.6).

The availability of services and materials associated with extraction and treatment of contaminated groundwater would be the same as previously described for Alternative 1 (Section 5.4.2.2.6).

5.4.5.2.7 Cost

The cost to implement Alternative 3A includes the cost to construct remediation facilities the cost to operate and maintain remedial actions and postremediation costs, which include D&D of remediation facilities. Table 5-19 summarizes the cost (in 1995 dollars) of Alternative 3A for Cases 3, 4, 5, 6 and 7. It also contains the corresponding present worth and escalated costs.

The construction costs of Alternative 3A includes verification surveys to establish the boundaries of excavation areas; the purchase of earth-moving equipment; excavation operations; storm water controls; construction of haul roads, wheel washing and radiological screening stations, the soil stabilization facility, the cap material staging area and facility, the Great Miami Aquifer groundwater extraction system, and the groundwater treatment facility; and backfill operations.

TABLE 5-19

ALTERNATIVE 3A COSTS

	Cost ($ million)				
Risk Case	3	4	5	6	7
On-Property Land Use	Industrial	Dev. Park	Undev. Park	Undev. Park	Undev. Park
On-Property Risk Level	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-6} [a]
Off-Property Receptor	Resident farmer	Resident farmer	Resident farmer	Resident farmer	Resident farmer
Off-Property Risk Level	10^{-5}	10^{-5}	10^{-5}	10^{-5} [(b)]	10^{-5} [b]
Costs					
Construction	520	450	450	430	430
Operations & maintenance	400	390	370	340	340
Postremediation	80	70	70	70	70
Total cost (1995 dollars)	1010	920	890	850	850
Present worth cost	690	630	610	580	580
Total cost (escalated)	2510	2220	2180	2110	2110

[a] The target cleanup level for this case was set at 50 ppm of uranium, the limit of survey instrumentation.
[b] Uses a residual uranium concentration of 50 ppm which corresponds to a ILCR of 3.5×10^{-5} and HI of 1.

The O&M costs for Alternative 3A include: the labor, materials, fuel, utilities, chemicals, and parts required to operate and maintain remediation actions; sampling and analysis; and transportation and disposal of contaminated material. Postremediation costs include: the D&D of remediation facilities; decontamination and free-release of equipment; and long-term monitoring.

Figure 5-12 shows the present worth cost of Alternative 3A, for each of the cases divided into its remedial action components. As shown in the figure, the predominant costs are associated with the on-site disposal facility, and groundwater extraction and groundwater and wastewater treatment. On site disposal roughly contributes 30 percent of the total present worth cost for each case evaluated. The contribution of groundwater extraction and groundwater and wastewater treatment present worth cost to the total alternative cost increases from 35 percent for Case 3 to 41 percent for Case 7.

Appendix K provides the cost basis and estimates for the remedial action components which comprise Alternative 3A.

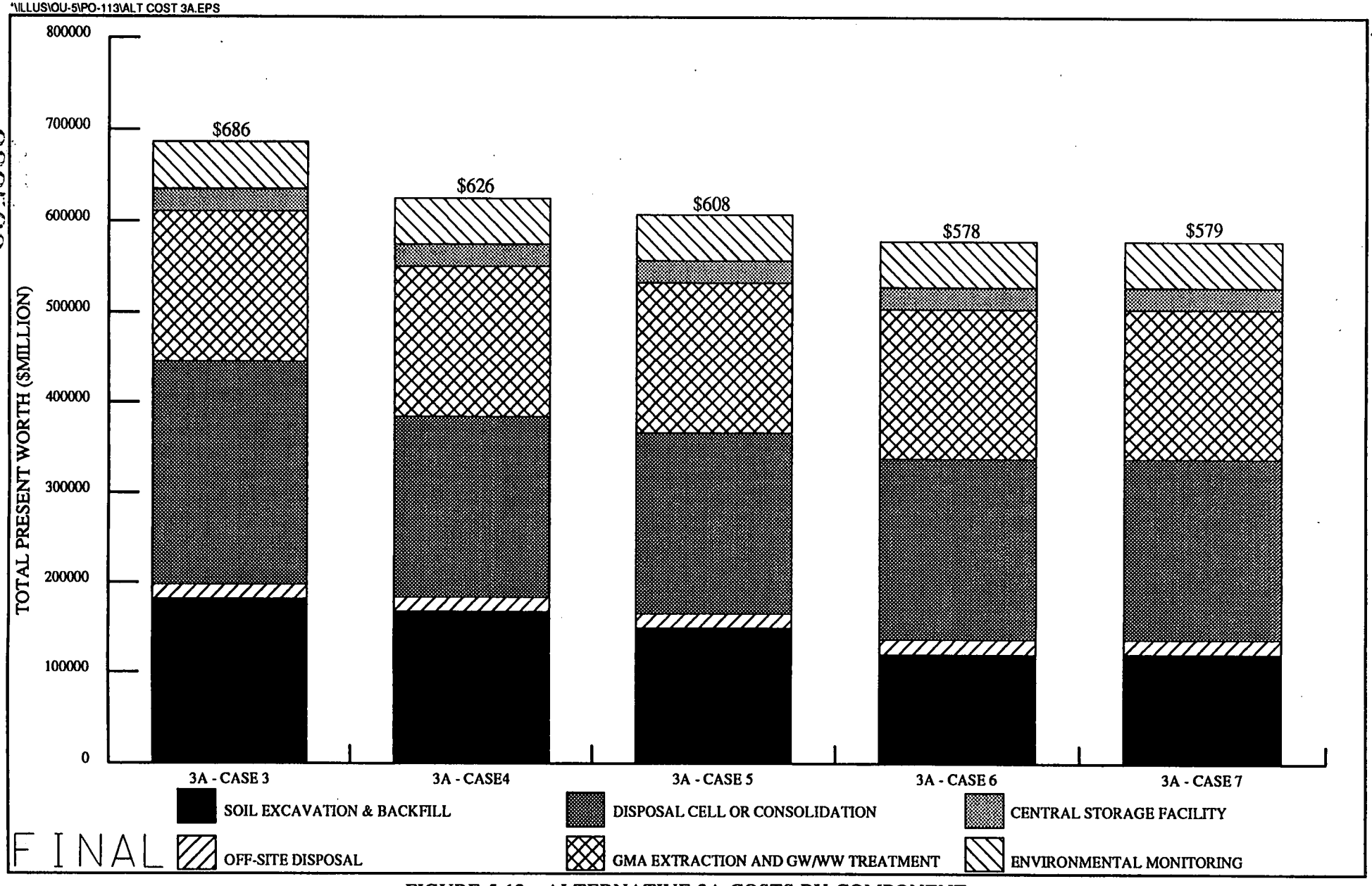


FIGURE 5-12. ALTERNATIVE 3A COSTS BY COMPONENT

000500

5.4.6 Alternative 3C - Off-Site Shipment

The objective of Alternative 3C is to consolidate contaminated soil at a central FEMP location in an effort to maximize the on-property land area made available for alternative uses. Alternative 3C involves the complete excavation of contaminated soil and sediment exceeding PRLs. Depending upon the level of contamination, soil would be consolidated beneath an earthen cover or shipped off-site for disposal. Contaminated groundwater from the Great Miami Aquifer would be extracted until PRLs for all COCs are attained.

Alternative 3C differs from Alternative 3A in one aspect. Under Alternative 3A, soil with contamination levels exceeding PRLs would be placed in an engineered disposal facility or be dispositioned to an off-site disposal facility. Under Alternative 3C, soil with contamination levels exceeding PRLs would be dispositioned to an off-site, commercial disposal facility or, if concentration levels allow, placed in an on-site consolidation area and covered with a 1-foot-thick earthen cover and revegetated.

5.4.6.1 Detailed Description

The following remedial activities comprise Alternative 3C:

- Excavating the contaminated soil, production-area gravel, and sediment exceeding PRLs; excavating contaminated perched zones presenting unacceptable cross-media risks to the Great Miami Aquifer

- Backfilling excavated areas and regrading the site to achieve desired drainage patterns and controls

- Pretreating soil with unacceptable concentrations of RCRA-regulated constituents above the waste acceptance criteria for these constituents

- Dispositioning contaminated soil in the following manner:
  - Soil containing appropriate levels of contamination would be consolidated and covered with 1 foot of clean soil.
  - Soil containing contaminant concentrations that exceed the waste acceptance criteria of the earthen covered consolidation area would be dispositioned to an off-site, commercial disposal facility

- Establishing a vegetative cover on consolidated contaminated materials

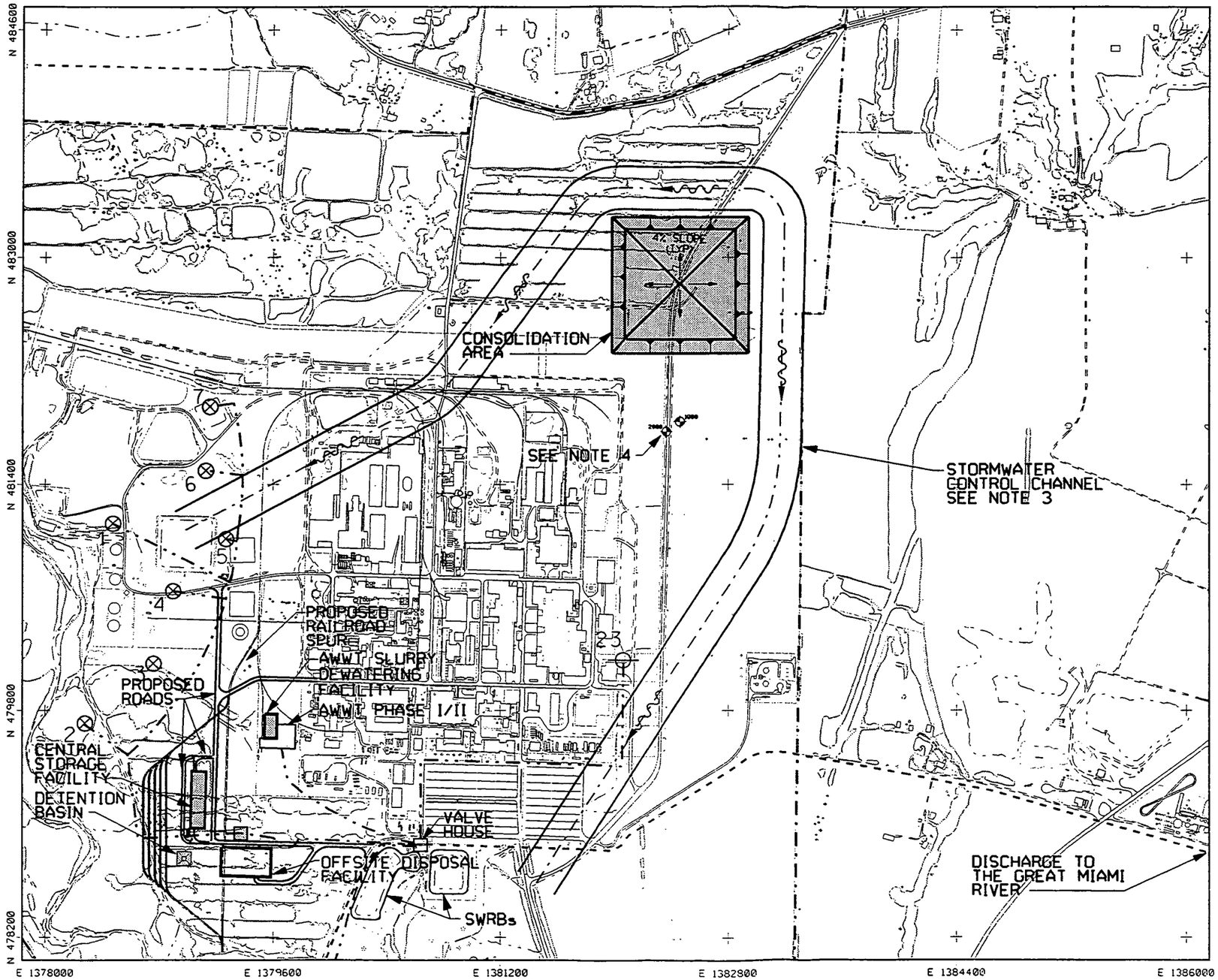
- Extracting contaminated groundwater from the Great Miami Aquifer until target concentrations of COCs are attained

- Treating all collected storm water, wastewater and groundwater as required
- Discharging storm water, wastewater and recovered groundwater to the Great Miami River following any required treatment.
- Decontaminating and dismantling required support facilities following completion of remedial actions with off-property disposal of the contaminated debris at a representative commercial disposal facility
- Maintaining continued federal ownership of the consolidation area, at a minimum; at the discretion of the federal government, release land outside the consolidation area for restricted use, i.e., industrial or recreational use as a developed or undeveloped park
- Operating a groundwater monitoring network to assess the performance of the consolidation/disposal system
- Performing five-year reviews (by EPA in consultation with the State of Ohio and the DOE), to assess the continued performance of the completed remedial action

To ensure that a full range of residual risk conditions are evaluated, Alternative 3C was evaluated for five different risk scenarios referred to as Cases 3 through 7 (see Table 2-18). Case 3 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in the consolidation area and an industrial user for on-property areas outside the consolidation area) and an ILCR of 10^{-5} to off-property target receptors (i.e., the RME resident farmer).

Case 7 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in the consolidation area and a recreational user of an undeveloped park for on-property areas outside the consolidation area) and an ILCR in the range of 10^{-5} to off-property target receptors (i.e., the RME resident farmer). Moreover, Case 7 assumes that additional actions would be taken for on-property areas outside the consolidation area that would result in an ILCR below 10^{-6} to the recreational user of an undeveloped park. In this regard, a residual concentration of uranium in soil of 80 ppm corresponds to an ILCR of 10^{-6} to the on-property recreational user. Because hand-held detectors are capable of detecting uranium in soil down to a level of 50 ppm uranium, the FEMP will apply the principle of ALARA by establishing an administrative target of 50 ppm for the residual concentration of uranium in on-property soil. Table 5-20 provides a summary of the target receptors and risk levels considered under each case.

Figure 5-13 presents a conceptual site plan depicting the necessary support structures and disposal facilities for Alternative 3C, Cases 4 - 7. The figure represents a configuration necessary to address



LEGEND

EXISTING		PROPOSED
	BUILDING/TRAILER	
	PAVED ROADWAY	
	UNPAVED ROADWAY	
—x—x—x—	FENCE	
	RAILROAD	
	TREE	
	TREE LINE	
	DITCH FLOW	
	EXTRACTION PIPELINE	
	SOUTHPLUME RECOVERY PIPELINE	
	SYSTEM 3 EXTRACTION WELL	
	WASTE PIT AREA EXTRACTION WELL	
	MONITORING WELLS	

NOTES:

1. SURFACE FEATURES BASED ON 1992 FLYOVER.
2. THIS FIGURE PROVIDES THE CONSOLIDATION AREA CONFIGURATION FOR .65 MILLION CUBIC YARDS CAPACITY.
3. THE STORMWATER CONTROL DITCH SHALL BE INSTALLED FOR THE CONSOLIDATION AREA SEDIMENT CONTROL MEASURES SHALL BE INSTALLED THROUGHOUT DITCH.
4. 26 PAIRS OF PROPOSED 1000 AND 2000 SERIES MONITORING WELLS AROUND CONSOLIDATION AREA PERIMETER.
5. BORROW AREA WILL BE LOCATED IN THE SOUTHEASTERN PORTION OF THE FEMP PROPERTY.

400 0 400 800 1200

SCALE IN FEET

STATE PLANAR COORDINATE SYSTEM 1927

P0113/B/skg03359.dgn/OU5

FINAL

FIGURE 5-13. SITE PLAN ALTERNATIVES 3C-4, 3C-5, 3C-6, 3C-7, 4C-8, AND 4C-9

the anticipated volumes of material requiring excavation to achieve the residual risk levels associated with these cases. Remediation facilities depicted in the site plan include a soil consolidation area, a central storage facility for contaminated material, a staging facility and rail spur for off-site shipment of bulk soil and stabilized treatment waste, groundwater extraction systems, and a groundwater treatment system facility and associated piping.

The conceptual site plan for Alternative 3C, Case 1 is the same as for Alternative 2C, Case 2 (see Figure 5-9). The only difference in the site plans is the size of the consolidation area.

The PRLs were previously presented in Section 2.0. For Alternative 3C, the PRLs for areas outside the consolidation area would be those listed in Tables 2-12, 2-13, 2-14, and 2-15 for restricted land use including industrial development, developed park and undeveloped park. For the consolidation area, PRLs would be those listed in these same tables for continued federal ownership. PRLs for the consolidation area are based upon the presumption that the area is under the perpetual ownership of the government and access would be restricted by a properly maintained fence with signs.

Figure 4-9 presented a conceptual block flow diagram of the remedial activities associated with Alternative 3C. Detailed discussions for each of the components comprising the alternatives are presented in Appendix L. The following sections present a brief description of the unique aspects of the remedial action components as they pertain to Alternative 3C.

Excavation and Backfill

Excavation and backfill of contaminated material would be implemented as described for Alternative 3A. Material contaminated with RCRA-regulated constituents would be handled as described for Alternative 2C.

Footprints of the projected excavations required to attain the PRLs for Alternative 3C, Cases 3 through 7 are presented in Figures 2-12 through 2-15. Table 5-21 provides the estimated in situ soil volumes which would be excavated under Alternative 3C, both on and off property, for the five risk cases considered. The table also presents the estimated soil volumes that meets the waste acceptance criteria for the consolidation area and the portion that would be shipped to an off-site commercial disposal facility.

TABLE 5-20

TARGET RECEPTORS AND ASSOCIATED RISK LEVELS FOR ALTERNATIVE 3C

	On-Property Soil and Sediment		Off-Property Soil		Groundwater	
Risk Case	Receptor[a]	Risk Level	Receptor	Risk Level	Receptor[b]	Risk Level
3	Industrial user	10^{-6}	Resident farmer	10^{-5}	ARARs	Proposed MCLs
4	Recreational-developed park	10^{-6}	Resident farmer	10^{-5}	ARARs	Proposed MCLs
5	Recreational-undeveloped park	10^{-6}	Resident farmer	10^{-5}	ARARs	Proposed MCLs
6	Recreational-undeveloped park	10^{-6}	Resident farmer	10^{-5} [c]	ARARs	Proposed MCLs
7	Recreational-undeveloped park	10^{-6} ALARA[d]	Resident farmer	10^{-5} [c]	ARARs	Proposed MCLs

[a] Each case assumes a residual risk level of 10^{-6} to the expanded trespasser inside the consolidation area.
[b] At a residual risk level of 10^{-5} to the resident farmer, the MCLs and proposed MCLs are more restrictive and are therefore used in lieu of the risk-based limits.
[c] For Cases 6 and 7, the ILCR due to a residual uranium concentration of 50 ppm would be 3.5×10^{-5} and an HI of 1.
[d] The PRL for uranium at an ILCR of 10^{-6} is 80 ppm. The target cleanup level for this case was set at the limits of survey instruments (50 ppm U) in the interest of ALARA.

Soil volume estimates presented in Table 5-21 are based upon engineering evaluations of available data which were completed for the detailed analysis of alternatives. Final excavation footprints and soil volumes would be established through completion of a preexcavation verification survey. This verification survey is discussed further in the description of the soil excavation component presented in Appendix L.

Excavated areas would be backfilled, as necessary, with clean borrow material and topsoil to reestablish original grade. A vegetative cover would be reestablished on the backfilled areas.

TABLE 5-21

REMEDIAL ACTION ALTERNATIVE 3C SOIL VOLUMES

	Risk Cases				
	Case 3	Case 4	Case 5	Case 6	Case 7
Risk Goal					
On-Property					
Receptor	Industrial	Dev. park	Undev. park	Undev. park	Undev. park
Risk level	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-6} [a]
Off-Property					
Receptor	Resident farmer	Resident farmer	Resident farmer	Resident farmer[a]	Resident farmer[b]
Risk Level	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-5}
Soil Volume Requiring Excavation (yd^3)					
On-property[c]	1,990,000	1,800,000	1,790,000	1,789,000	1,799,000
Off-property	400,000	400,000	400,000	1,000	1,000
Total	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Remedial Action (in situ soil volume in yd^3)					
On-property backfill	20,000	418,000	418,000	18,000	28,000
Consolidate w/earthen cover	1,220,000	652,000	652,000	652,000	652,000
Off-site disposal	1,150,000	1,130,000	1,120,000	1,120,000	1,120,000
Total	2,390,000	2,200,000	2,190,000	1,790,000	1,800,000
Transportation Capacity					
Rail cars	20,200	19,900	19,700	19,700	19,700
Train loads	404	398	394	394	394
Trains per month	2	2	2	2	2

[a] Target cleanup level for this case was set at the limits of survey instruments (50 ppm of uranium).
[b] Assumes a residual uranium concentration of 50 ppm which corresponds to an ILCR of 3.5×10^{-5} and an HI of 1.
[c] Includes 175,000 cubic yards of gravel from the production area.

Consolidation and Earthen Cover

Soil and sediment determined through pre-excavation surveys to meet the waste acceptance criteria for consolidation with an earthen cover would be transported to the consolidation area. Contaminated soil would be placed in designated portions of the consolidation area in 1-foot lifts and compacted. As an area is filled to final grade, that area would be covered with 1 foot of clean soil. The surface of the soil cover would be vegetated using grasses indigenous to the area. Table 5-22 presents the dimensions of the consolidation area for each risk level. Design details for the consolidation area are provided in the component descriptions in Appendix L.

TABLE 5-22

ALTERNATIVE 3C CONSOLIDATION AREA DIMENSIONS
(All dimensions in feet)

Risk Case	Risk Level/Land Use/Receptor	Length	Width	Height
3	10^{-6} / On-property industrial 10^{-5} / Off-property resident farmer	1200	1200	40
4	10^{-6} / On-property dev. park 10^{-5} / Off-property resident farmer	950	950	35
5	10^{-6} / On-property undev. park 10^{-5} / Off-property resident farmer	950	950	35
6	10^{-6} / On-property undev. park 10^{-5} / Off-property resident farmer[a]	950	950	35
	10^{-6} / On-property undev. park[b] 10^{-5} / Off-property resident farmer[a]	950	950	35

[a] Assumes a residual uranium concentration of 50 ppm which corresponds to an ILCR of 3.5×10^{-5} and an HI of 1.0.
[b] Target cleanup level for this case was set at the limits of survey instruments (50 ppm of uranium).

Off-Property Disposal

Soil and sediment which contains contamination above that which can be consolidated under an earthen cover would be shipped off site for disposal. For purposes of this FS, a representative commercial disposal facility was selected for developing and evaluating the viability of off-property disposal. Contaminated soil will be loaded into 100-ton rail cars for shipment to the off-site facility. Assuming a bulk density of 1.76 tons per cubic yard of excavated materials, the number of rail cars presented in Table 5-21 would be required to support off-site disposal.

Great Miami Aquifer Restoration

Under Alternative 3C, contaminated groundwater from the Great Miami Aquifer would be remediated in the same manner as Alternative 3A.

Storm Water Management

Under Alternative 3C, storm water would continue to be remediated as described under Alternative 2C.

Decontamination and Demolition

D&D of remedial action support facilities would be accomplished as previously described for Alternative 2C.

Resultant Land Use Potential

The resultant land use potential would be the same as previously described for Alternative 3A.

Institutional and Administrative Control Requirements

To ensure the long-term performance of the remedial action, Alternative 3C requires the performance of long-term groundwater monitoring and maintenance and the establishment of a series of institutional and administrative controls. The controls would be the same as previously described for Alternative 2A (Section 5.4.3.1), with the addition that restrictions for on-property alternative land uses would be maintained.

5.4.6.2 Assessment

5.4.6.2.1 Overall Protection of Human Health and the Environment

Alternative 3C meets the remedial action objectives for Operable Unit 5 and would be protective of human health and the environment. Implementation of this alternative would prevent direct access to contaminated soil and sediment by removal of these media to health-based levels and consolidation in an on-site consolidation area or disposal at an off-site location. Implementation of Alternative 3C would mitigate the migration of contaminants in soil and sediment to the air and groundwater. Moreover, implementation of Alternative 3C would prevent the consumption or use of groundwater containing FEMP contaminants above MCLs or proposed MCLs. Exposure to direct radiation above protective levels would also be prevented.

The primary actions that would be used to meet the remedial action objectives of Alternative 3C are: excavation of contaminated soil and sediment exceeding PRLs; dispositioning these materials at an on-site consolidation area with earthen cover or at an off-site waste disposal facility depending upon contaminant concentrations; backfilling excavated areas with clean borrow and topsoil; and extraction and treatment of contaminated groundwater from the Great Miami Aquifer.

The consolidation area and its associated waste acceptance criteria would be designed to control contaminant migration to human and environmental receptors and to prevent direct radiation exposure from contained waste material. Excavation and containment of contaminated soil and sediment in the on-site consolidation area and the off-site disposition of soil contamination above the waste acceptance criteria of the consolidation area would ensure that risks to the hypothetical resident farmer outside the consolidation area would not exceed those considered health protective as defined in

Section 5.4.6.2.3, Magnitude of Residual Risk. Moreover, the consolidation area with earthen cover for containment of soil contaminants at concentrations above the PRLs is designed to be health protective for the expanded trespasser and would ensure that contaminant concentrations in the Great Miami Aquifer would not exceed MCLs or proposed MCLs within the 200 year to 1000 year period considered under this FS. It is assumed that the design, siting and permitting of the off-site commercial disposal facility will preclude a corresponding increase in residual risk at that location.

Backfilling excavated areas with clean backfill and topsoil would prevent direct contact with residual contamination and would prevent the potential spread of contamination through the air pathway. The establishment of a vegetative cover would minimize future erosion. Extraction and treatment of Great Miami Aquifer groundwater would clean up existing contamination such that MCLs and proposed MCLs would not be exceeded.

Following implementation of Alternative 3C, institutional controls would be maintained for the consolidation area to ensure continued protection of human health and the environment. Remaining FEMP land outside the consolidation area could, at the discretion of the Federal government, be made available for alternative land uses. Institutional controls maintained for the consolidation area would include continued federal ownership of that portion of the FEMP to preclude homesteading, intrusive actions or facility degradation; deed restrictions; and passive access controls (e.g., fencing) around the consolidation area to prevent unauthorized access or use of the land.

Loss of institutional controls in combination with failure of the earthen cover over the consolidated soil could, over the 200- to 1000-year period, result in contaminant migration or direct exposure to contaminated material by future human and environmental receptors. Exposures to potential receptors would be minimized due to the reduced surface area of the consolidated material and low concentration of contamination in the contained soil. Under the intrusive farmer scenario, however, a future farmer who might choose to establish a residence on top of the consolidation area and who achieved daily contact with materials contained within the consolidation area over a long period of time would be subject to incremental risks greater than those contemplated herein. Due to its design, however, the use of the consolidation area as a residential area is considered highly unlikely.

The most significant short-term risks associated with the implementation of Alternative 3C are the risks associated with the transport of contaminated media to an off-site waste disposal area. In addition, increased worker risks would be expected throughout implementation of this alternative. However, through the implementation of a worker health and safety plan in compliance with 29 CFR 1910.120, exposures would be kept to below regulatory limits and would comply with DOE orders. These risks are discussed further in Section 5.4.6.2.6.

5.4.6.2.2 Compliance with ARARs

The components of Alternative 3C are identical to those for Alternative 2C; thus, compliance with ARARs for Alternative 3C would be the same as previously described for Alternative 2C (Section 5.4.4.2.2).

5.4.6.2.3 Long-Term Effectiveness and Permanence

Alternative 3C would dispose of more material with greater contaminant concentrations off site, leading to higher long-term effectiveness and permanence than Alternative 3A (where a larger volume of contaminated material would remain on property in the proposed disposal facility). The contaminated material placed in the on-property consolidation area with earthen cover under Alternative 3C would have lower contaminant concentrations than the material placed in the engineered disposal facility under Alternative 3A; this material would present lower overall risks to potential intruders if the planned institutional controls were ever to fail. However, the use of the consolidation area would result in a reduction in long-term effectiveness and permanence due to uncertainty about the maintenance of federal controls for 1000 years and the potential degradation of the earthen cover over the same period.

Groundwater Residual Risk - All alternatives provide for the extraction and treatment of contaminated groundwater from the regional aquifer in the same manner. Residual risk associated with groundwater would be the same as that discussed under Alternative 1, Case 2.

Soil Residual Risk - As presented in Section 2.0, footprints for soil excavation were based upon the use of total uranium as an indicator parameter. The excavation footprints were then expanded to capture other COCs whose concentration in soil exceeded their respective PRLs. Before initiation of soil excavation activities, verification sampling would be performed to confirm the excavation footprints. Radiological surveys performed using field instruments would help to direct excavation activities. Upon completion of excavation in a given area, certification sampling would be performed to confirm that soil PRLs were obtained. Effectiveness in meeting the target risk levels would be ensured through this confirmation that PRLs were attained. Long-term effectiveness and permanence would be ensured through a combination of institutional controls, design considerations incorporated into the consolidation area, and the establishment of the waste acceptance criteria for the consolidation area.

Adequacy and Reliability of Controls

The components of Alternative 3C are identical to those for Alternative 2C, Case 2. Therefore, the considerations for adequacy and reliability of controls are the same as previously described for Alternative 2C (Section 5.4.4.2.3). The adequacy and reliability of controls for groundwater

extraction and treatment are the same as described for Alternative 1 for the 27-year pumping design (Section 5.4.2.2.3).

Long-Term Environmental Impacts

Long-term impacts to the environment from Alternative 3C, Cases 3-7 are similar to those previously identified in Alternative 3A, Cases 3-7 with the differences outlined below.

Alternative 3C, Case 3 would require placement of soil in a consolidated area (including the PMF channel) resulting in the permanent commitment of 107.2 acres of land at the FEMP site, while Cases 4-7 would permanently commit 94.8 acres. Impacts to biotic resources from Alternative 3C, Cases 3-7, are similar to 3A, Cases 3-7, except the on-property consolidation area would cause the commitment of 25 acres of pine plantation habitat.

Alternative 3C, Cases 3-7 would result in the permanent disruption of between 20 and 21 acres of soil and the vegetative community at the representative commercial disposal facility.

5.4.6.2.4 Reduction of Toxicity Mobility, or Volume Through Treatment

This alternative provides no reduction of toxicity, mobility, or volume of radiologically contaminated soil through treatment. However, materials with the highest levels of contamination would be shipped off site for disposal, thus reducing the toxicity, mobility, and volume of contaminated soil on site.

As discussed in Alternative 1 (Section 5.4.2.2.4), approximately 28,000 cubic yards of soil and sediment containing RCRA hazardous, petroleum, and PCB waste would be treated with mobile thermal desorption or cement stabilization, as indicated, to levels below which the soil would no longer be considered mixed wastes.

Treatment of the perched groundwater collected during excavation would be the same as described in Alternative 1 (Section 5.4.2.2.4). Extraction and treatment of contaminated Great Miami Aquifer groundwater would correspond to the 27-year pumping design described under Alternative 1.

5.4.6.2.5 Short-Term Effectiveness

Protection of the Community During Remedial Actions

Through the implementation of engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls), the short-term risks to members of the community associated with Alternative 3C would be minimized. A remedial action risk assessment was conducted to assess the potential short-term risks associated with the implementation of remedial actions.

Using historical transportation statistics, Alternative 3C, Cases 3, 4, 5, 6, and 7 would be expected to result in fewer than three fatalities. Alternative 3C, Case 3 would be expected to result in approximately 11 injuries to members of the public due to mechanical hazards associated with accidents during transportation. Alternative 3C, Cases 4, 5, 6, and 7 would be expected to result in approximately 10 injuries each to members of the public due to mechanical hazards associated with accidents during transportation of excavated soil and sediment for off-property disposal during the 22 years of remedial activities.

The estimated ILCR to hypothetical receptors, representing members of the public residing near the FEMP, due to external radiation and inhalation associated with releases during remedial actions are estimated at 3.9×10^{-7} for Case 3, 3.6×10^{-7} for Cases 4 and 5 for Alternative 3C, and 3.8×10^{-7} for Cases 6 and 7. Risks to members of the public located along the transportation route are estimated at 8.5×10^{-8} for Case 3, and 8.3×10^{-8} for Cases 4, 5, 6 and 7.

Protection of Workers During Remedial Actions

A detailed analysis of the potential short-term risks to workers engaged in remedial activities and on-site workers not engaged in remedial activities is presented in Appendix G. The ILCR for remediation workers for Case 3 is estimated at 1.2×10^{-3} for excavation activities, 2.3×10^{-3} for off-site disposal activities, and 1.2×10^{-3} for on-site disposal consolidation activities. For Cases 4 and 5, the ILCR for excavation activities is 1.1×10^{-3}, 2.2×10^{-3} for off-site disposal activities, and 9.5×10^{-4} for on-site disposal consolidation activities. For Cases 6 and 7, the ILCR for excavation activities is 1.2×10^{-3}, 2.3×10^{-3} for off-site disposal activities, and 1.2×10^{-3} for on-site disposal consolidation activities. For all cases, the dominant risk is from inhalation of radioactive contaminants for excavation and off-site disposal activities, and from external radiation for consolidation activities. These risk levels are less than those extrapolated from the maximum allowable exposure limits for workers, so these risks do not exceed worker standards (10 CFR 835 and 29 CFR 1910).

Short-Term Environmental Impacts

Short-term impacts to the environment for Alternative 3C, Cases 3-7 are similar to those previously identified in Alternative 3A, Cases 3-7 with the differences outlined below.

Alternative 3C, Cases 3-7 would result in the disturbance of between approximately 116.2 and 128.3 acres of land from associated short-term remedial activities such as construction of support facilities and placement of soil in the consolidated area. Alternative 3C, Cases 3-7 would commit 46 acres of introduced grassland habitat from construction of the consolidation area and associated PMF channel.

Alternative 3C, Cases 3-7 would increase the wealth of the CMSA by 6 percent annually for 22 years slowing to a 1.7 percent annual increase for the remaining eight years. Traffic volumes on local roads are expected to remain constant.

Short-term impacts to soil and the vegetative community at the representative commercial disposal facility for Alternative 3C, Cases 3-7 are the same as long-term impacts identified for this alternative.

Time Period to Achieve Remedial Action Objectives

Physical, substantial and continuous on-site activities for soil remediation would be initiated within 15 months following issuance of the ROD. The estimated time to excavate and disposition contaminated soil to achieve remedial action objectives under Alternative 3C is 22 years. This time frame includes construction of an on-property consolidation area and the transport of soil which does not meet the waste acceptance criteria of the on-property consolidation area to an off-site commercial disposal facility.

The 22-year schedule assumes that soil excavation, construction of the consolidation area, and off-site transport would be performed on a five day per week, one shift per day basis. Following completion of soil emplacement in the consolidation area, construction of an earthen and vegetative cover would require an additional nine months.

Operation of the Great Miami Aquifer groundwater recovery system is projected to continue for up to 27 years, as previously described for Alternative 1, Case 2 (Section 5.4.2.2.5).

5.4.6.2.6 Implementability

Technical Feasibility

Technical feasibility issues for off-site disposal of the materials with the highest levels of contamination would be the same as in Alternative 1 (Section 5.4.2.2.6).

Implementability implications for excavation and backfill and consolidation under an earthen cover would be the same as previously described for Alternative 2C, Case 2 (Section 5.4.4.2.6).

Readily available resources and standard procedures would be used for construction of the consolidation area and earthen cover. The technical feasibility of locating the consolidation area, would be performed by using reliable conventional methods. The footprint of the consolidation area is estimated to be 33 and 21 acres for Case 3 and Cases 4 through 7, respectively. Sufficient area would be available on property to site the consolidation area.

Implementability implications for extraction and treatment of contaminated groundwater for this alternative are the same as in Alternative 1 (Section 5.4.2.2.6).

Administrative Feasibility

For Alternative 3C, administrative factors associated with excavation, consolidation with earthen cover and backfill would be the same as previously described for Alternative 2C (Section 5.4.4.2.6). Those factors associated with shipment to an off-site commercial disposal facility via rail car would be the same as previously described in Alternative 1 (Section 5.4.2.2.6).

Availability of Services and Materials

For Alternative 3C, the availability of services and materials associated with excavation and consolidation with an earthen cover would be the same as previously described for Alternative 2C. The availability of services and materials associated with shipment to an off-site commercial disposal facility and extraction and treatment of contaminated groundwater would be the same as previously described in Alternative 1 (Section 5.4.2.2.6). However, the volume of soil requiring off-site disposal in Alternative 3C is significantly less than in Alternative 1 and the coordination efforts between DOE, EPA, and the states through which the waste travels would be less.

The extraction and treatment of contaminated groundwater would be the same as described in Alternative 1 for the 27-year pumping design.

5.4.6.2.7 Cost

The cost to implement Alternative 3C includes the cost to construct remediation facilities, the cost to operate and maintain remedial actions and postremediation costs, which include decontamination and decommissioning of remediation facilities. Table 5-23 summarizes the costs (in 1995 dollars) of Alternative 3C for Cases 3, 4, 5, 6 and 7. It also contains the corresponding present worth and escalated costs.

The capital cost, O&M costs, and postremediation costs for Alternative 3C are the same as for Alternative 2C, Case 2. All cases under Alternative 3C extract and treat contaminated groundwater until the concentration of uranium in the Great Miami Aquifer reaches 20 ppb. This corresponds to a 27-year pumping period.

The cost basis and estimates for the remedial action components which comprise Alternative 3C are provided in Appendix K.

TABLE 5-23

ALTERNATIVE 3C COSTS

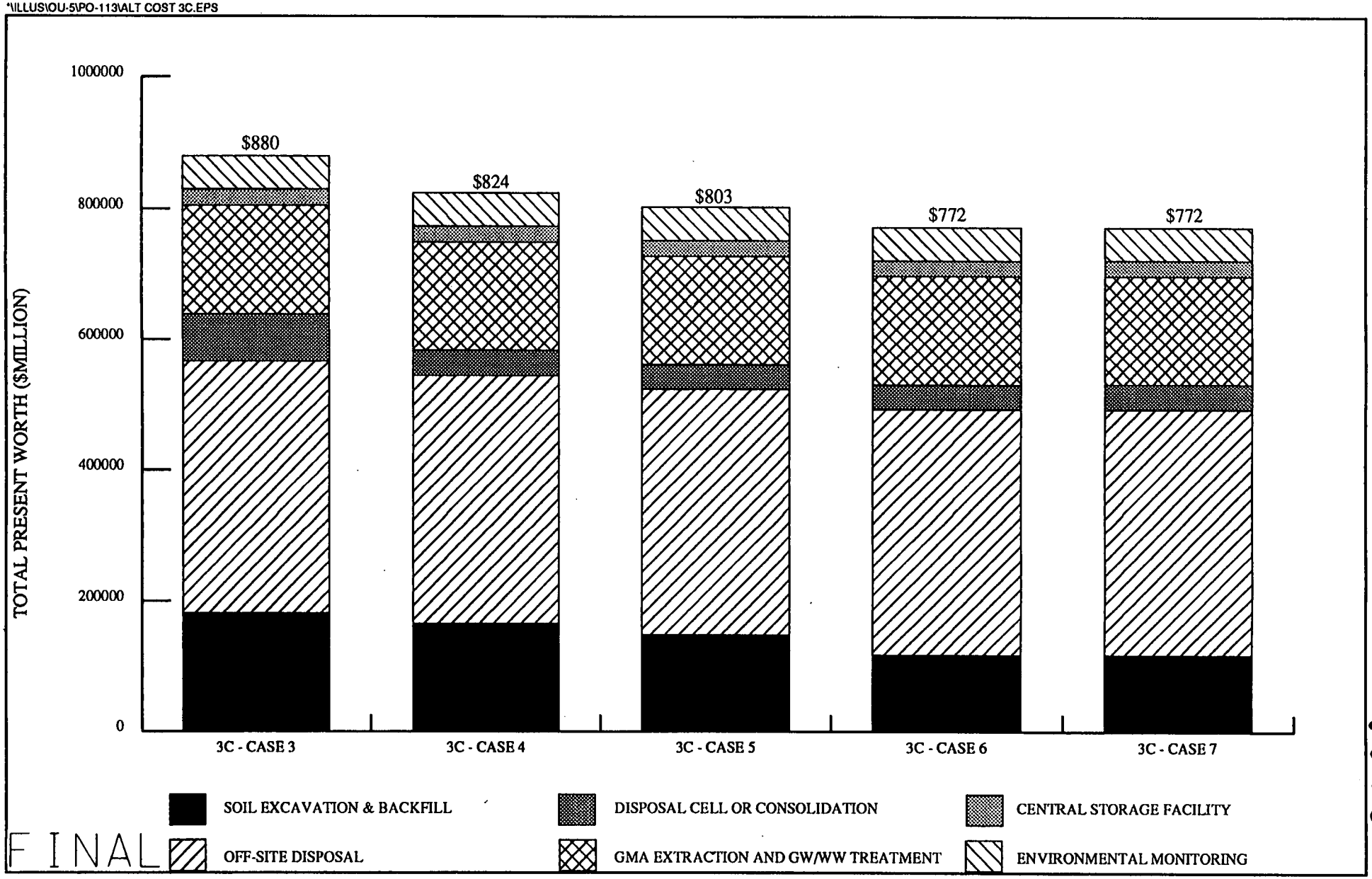
	Cost in $million				
Risk Case	3	4	5	6	7
On-property land use	Industrial	Dev. Park	Undev. Park	Undev. Park	Undev. Park
On-property risk level	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
Off-property receptor	Resident farmer	Resident farmer	Resident farmer	Resident farmer	Resident farmer
Off-property risk level	1×10^{-5}	1×10^{-5}	1×10^{-5}	3.5×10^{-5}	3.5×10^{-5}
Costs					
Construction	290	230	230	220	220
Operations & maintenance	920	900	870	840	840
Post-remediation	70	50	50	50	50
Total cost (1995 dollars)	1270	1180	1150	1110	1110
Present worth cost	880	820	800	770	770
Total cost (escalated)	2690	2290	2210	2170	2170

Figure 5-14 shows the present worth cost of Alternative 3C for each of the residual risk levels, divided into its remedial action components. As shown in the figure, the predominant costs are associated with off-site disposal. The contribution of this component to total present worth costs varies between the cases evaluated. The component contribution ranges from 43 percent for Case 3 to 8 percent for Case 7.

5.4.7 Alternative 4A - Engineered Disposal Facility

Alternative 4A involves the excavation of contaminated soil and sediment exceeding PRLs based upon the expanded trespasser for on-property areas and the RME resident farmer for off-site areas. Excavated contaminated soil would be placed in an on-property disposal facility or, if soil contaminant concentrations exceed the waste acceptance criteria for the disposal facility, shipped off site to a disposal facility. Contaminated groundwater from the Great Miami Aquifer would be extracted until PRLs are attained.

*\ILLUS\OU-5\PO-113\ALT COST 3C.EPS



FINAL

FIGURE 5-14. ALTERNATIVE 3C COSTS BY COMPONENT

000516

7069

Alternative 4A is like Alternatives 2A and 3A. The objective of Alternatives 2A and 3A, however, is to release a major portion of the FEMP site for unrestricted or restricted land use. Under Alternative 4A, the federal government would retain ownership of the FEMP. Remedial actions would not specifically consider the release of FEMP property for alternative land uses. Alternative land uses would be selectively considered for those areas which currently meet the PRLs for industrial or recreational use. Contaminated soil and sediment would be excavated to the extent necessary to ensure the protection of an inadvertent trespasser (i.e., expanded trespasser) and of the Great Miami Aquifer.

5.4.7.1 Detailed Description

The following remedial activities comprise Alternative 4A:

- Excavating contaminated soil, production-area gravel, and sediment exceeding PRLs; excavating contaminated perched zones presenting an unacceptable ingestion risk or unacceptable cross-media risks to the Great Miami Aquifer
- Backfilling excavated areas and regrading as necessary to achieve desired drainage patterns and controls
- Consolidating excavated materials in an on-property engineered disposal facility
- Dispositioning contaminated materials exceeding waste acceptance criteria for the on-property disposal facility at a licensed off-site disposal facility
- Pretreating soil with unacceptable concentrations of RCRA-regulated constituents above the waste acceptance criteria for these constituents
- Extracting contaminated groundwater from the Great Miami Aquifer until target concentrations of COCs are attained
- Treating all storm water, wastewater, and groundwater as necessary
- Discharging storm water, wastewater, and recovered groundwater to the Great Miami River following any required treatment
- Decontaminating and dismantling required support facilities, following completion of remedial actions, with off-property disposal of the contaminated debris at an off-site disposal facility
- Operating a groundwater monitoring network to assess the performance of the disposal system

- Maintaining federal ownership of the FEMP property, with consideration of alternative uses of select on-property areas at the discretion of the federal government on the basis of measured soil concentrations and the result of ongoing environmental monitoring

- Performing five-year reviews (by EPA in consultation with the State of Ohio and the DOE) to assess the continued performance of the completed remedial action.

To ensure that a full range of residual risk conditions are evaluated, Alternative 4A was evaluated for two different risk scenarios referred to as Cases 8 and 9 (see Table 2-18). Case 8 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in all on-site areas) and an ILCR of 10^{-5} to off-property target receptors (i.e., the RME resident farmer). Case 8 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in all on-site areas) and an ILCR in the range of 3.5×10^{-5} to off-property target receptors (i.e., the RME resident farmer). Table 5-24 provides a concise summary of the target receptors and associated risk levels considered under each case.

The conceptual site plan depicting the necessary support structures and disposal facilities for Alternative 4A is the same as for Alternative 3A, Cases 4 - 7 (see Figure 5-11). The conceptual site plan represents the configuration of remedial facilities necessary to address the anticipated volumes of materials required to be excavated to achieve the residual risk levels associated with both Cases 8 and 9. Remedial support facilities depicted in the site plan include a central storage facility for contaminated material, an engineered disposal facility, and the wastewater treatment facilities required to address collected wastewater, storm water, perched groundwater and recovered groundwater.

For Alternative 4A, the PRLs for on-property areas would be for the expanded trespasser receptor and are listed in Tables 2-12, 2-13, 2-14, and 2-15. The PRLs for on-property areas are based upon the presumption that the property is under the perpetual ownership of the government, with access to more heavily contaminated areas and the disposal facility area restricted by a fence with signs. Consideration would be given to alternate land uses for select portions of the FEMP based on measured soil/sediment concentrations and the application of an environmental monitoring system.

Figure 4-7 presented a conceptual block flow diagram of the remedial activities associated with Alternative 4A. Detailed discussions on each of the components comprising the alternatives are presented in Appendix L. The following sections present a brief description of the unique aspects of the remedial action components as they pertain to Alternative 4A.

TABLE 5-24

TARGET RECEPTORS AND ASSOCIATED RISK LEVELS FOR ALTERNATIVE 4A

Risk Case	On-Property Soil and Sediment		Off-Property Soil and Sediment		Groundwater	
	Receptor	Risk Level	Receptor	Risk Level	Receptor[a]	Risk Level
8	Expanded trespasser	10^{-6}	Resident farmer	10^{-5}	ARARs	Proposed MCLs
9	Expanded trespasser	10^{-6}	Resident farmer	10^{-5} [b]	ARARs	Proposed MCLs

[a] At a residual risk level of 10^{-5} to the resident farmer, the MCLs and proposed MCLs are more restrictive and are therefore used in lieu of the risk based limits.
[b] Case 9 assumes a residual uranium concentration of 50 ppm which corresponds to an ILCR of 3.5×10^{-5} and an HI of 1.

Excavation and Backfill

Excavation and backfill of contaminated materials, and handling of RCRA contaminated material, would be implemented as described for Alternatives 2A and 3A.

The footprint of the projected excavations required to attain the PRLs for Alternative 4A, Cases 8 and 9 are presented in Figure 2-16. Table 5-25 provides the estimated soil volumes that would be excavated, both on and off property, under Alternative 4A for the two risk cases considered. The table also presents the quantity of this excavated soil which meets the waste acceptance criteria for the disposal facility and the quantity of soil requiring off-site disposal. The on-property backfill represents that volume of soil which does not exceed PRLs, but which must be excavated to reach more contaminated soil beneath it. Because this soil does not exceed PRLs, it can be used as clean backfill in the area from which it was excavated. The volume projections presented in Table 5-25 are based upon an engineering evaluation of available data which was completed for purposes of developing and evaluating remedial alternatives. Final footprints of excavation and volumes would be established through completion of a pre-excavation verification survey.

Excavated areas would be backfilled, as necessary, with clean borrow material and topsoil to reestablish original grade. A vegetative cover would be reestablished on the backfilled areas.

TABLE 5-25

REMEDIAL ACTION ALTERNATIVE 4A SOIL VOLUMES

	Risk Case	
	8	9
Risk Goal		
On-Property		
Receptor	Trespasser	Trespasser
Risk level	10^{-6}	10^{-5}
Off-Property		
Receptor	Resident farmer	Resident farmer[a]
Risk level	10^{-5}	10^{-5}
Soil Volume Requiring Excavation (yd^3)		
On-property	1,790,000	1,789,000
Off-property	400,000	1,000
Total	2,190,000	1,790,000
Remedial Action (in situ soil volume in yd^3)		
On-property backfill	415,000	15,000
On-site disposal facility	1,750,000	1,750,000
Off-site disposal	25,000	25,000
Total	2,190,000	1,790,000

[a] Assumes a residual uranium concentration of 50 ppm which corresponds to an ILCR of 3.5×10^{-5} and an HI of 1.

On-property Disposal

Excavated contaminated soil and sediment would be placed in an engineered disposal facility. Details on the conceptual design configuration for the disposal facility are found in the component descriptions in Appendix L. Table 5-26 presents the expected sizes of the disposal facility to accommodate the anticipated excavated materials for Alternative 4A. The underdrain system for the disposal facility is anticipated to be operated during the period of active remediation for soil and sediment, with continuation of operation of the system, as needed, until dismantlement of the wastewater treatment facility. Collected leachate from the underdrain system would be transferred to the treatment facility for treatment before discharge to the Great Miami River.

TABLE 5-26

ALTERNATIVE 4A DISPOSAL FACILITY DIMENSIONS
(All dimensions in feet)

Risk Case	Risk Level/Receptor	Length	Width	Height
8	10^{-6} / On-property trespasser 10^{-5} / Off-property resident farmer[a]	1610	1610	37
9	10^{-6} / On-property trespasser 10^{-5} / Off-property resident farmer[a]	1610	1610	37

[a] Corresponds to an ILCR of 3.5×10^{-5} and an HI of 1.

Off-Property Disposal

Contaminated soil not attaining the waste acceptance criteria for the on-property disposal facility would be shipped off site for disposal. In this FS, the selection of an appropriate off-site disposal facility would be based on meeting the waste acceptance criteria for the off site facility. In Alternative 4A the estimated soil volume exceeding the waste acceptance criteria for the on-property disposal facility is 25,000 cubic yards. Thus, the contaminated soil would be loaded into trucks for shipment to the off- site disposal facility.

Great Miami Aquifer Restoration

Under Alternative 4A, contaminated groundwater from the Great Miami Aquifer would be remediated as described under Alternatives 2A and 3A.

Storm Water Management

Under Alternative 4A, storm water would be managed as previously described for Alternatives 2A and 3A.

Decontamination and Demolition

D&D of remedial action support facilities would be accomplished as previously described for Alternative 1 (Section 5.4.2.1).

Resultant Land Use Potential

As previously indicated, the remedial action alternatives were developed to achieve a range of target land use objectives and ensure the protection of the underlying Great Miami Aquifer. Under Alternative 4A, the disposal facility area would be maintained as a restricted waste management area and other on-property areas would be maintained under access control. Alternative land uses could be considered for select portions of the FEMP property based on an evaluation of actual contaminant concentrations, the nature of administrative controls, and the results of ongoing environmental monitoring.

Institutional and Administrative Control Requirements

To ensure the long-term performance of the remedial action, Alternative 4A requires the performance of long-term groundwater monitoring and maintenance and the establishment of a series of institutional and administrative controls. The controls would be the same as previously described for Alternative 2A (Section 5.4.3.1), with the exception that any FEMP land outside of the disposal facility area considered for alternate uses would continue to be owned by the federal government and restricted to selected surface uses only.

5.4.7.2 Assessment

5.4.7.2.1 Overall Protection of Human Health and the Environment

Alternative 4A meets the remedial action objectives for Operable Unit 5 and would be protective of human health and the environment. Implementation of this alternative would prevent direct access to contaminated soil and sediment by removal of these media to PRLs and placement in an on-site disposal facility or disposal at an off-site location. Implementation of Alternative 4A would mitigate the migration of contaminants in soil and sediment to the air and groundwater. Moreover, implementation of Alternative 4A would prevent the consumption or use of groundwater containing FEMP contaminants above MCLs or proposed MCLs. Exposure to direct radiation above protective levels would also be prevented.

The primary actions that would be used to meet the remedial action objectives of Alternative 4A are: excavation of contaminated soil and sediment (including perched groundwater zones) exceeding PRLs; dispositioning these materials at an on-property disposal facility or at an off-site waste disposal facility, depending upon contaminant concentrations; backfilling excavated areas with clean borrow and topsoil; and extraction and treatment of contaminated groundwater from the Great Miami Aquifer.

The disposal facility and its associated waste acceptance criteria would be designed to control contaminant migration to human and environmental receptors and to prevent direct radiation exposure

from contained waste material. Excavation and containment of contaminated soil and sediment in the on-property disposal facility, and the disposition of soil contaminated above the waste acceptance criteria at an off-site location, would ensure that risks to the hypothetical off-property resident farmer would not exceed those considered health protective as defined in Section 5.4.7.2.3, Magnitude of Residual Risk. Moreover, the on-property disposal facility for containment of soil contaminants at concentrations above the PRLs and all other areas of the FEMP property would be designed to be health protective for the expanded trespasser and would ensure that contaminant concentrations in the Great Miami Aquifer would not exceed MCLs or proposed MCLs within the 200- to 1000-year period considered under this FS. It is assumed that the design, siting and permitting of the off-site disposal facility would preclude a corresponding increase in residual risk at that location.

Backfilling excavated areas with clean backfill and topsoil would prevent direct contact with residual contamination and would prevent the potential spread of contamination through the air pathway. The establishment of a vegetative cover would minimize future erosion. Extraction and treatment of Great Miami Aquifer groundwater would clean up existing contamination such that MCLs and proposed MCLs would not be exceeded.

Following implementation of Alternative 4A, institutional controls would be maintained for the entire FEMP property to ensure continued protection of human health and the environment. Institutional controls would include continued federal ownership of the entire FEMP property to preclude homesteading, intrusive actions or facility degradation; deed restrictions; and passive access controls (e.g., fencing) around the property to prevent unauthorized access to or use of the land.

Loss of institutional controls in combination with failure of the disposal facility could, over the 200- to 1000-year period, result in contaminant migration or direct exposure to contaminated material by future human and environmental receptors. Exposures to potential receptors would be minimized due to the reduced surface area and low concentration of contamination in the contained soil. Under the intrusive farmer scenario, however, a future farmer who might choose to establish a residence on top of the disposal facility and who achieved daily contact with materials contained over a long period of time would be subject to incremental risks. Due to its design, however, the use of the disposal facility as a residential area is considered highly unlikely.

The most significant short-term risks associated with the implementation of Alternative 4A are the increased mechanical risks to remediation workers. However, through the implementation of a worker health and safety plan in compliance with 29 CFR 1910.120, exposures would be kept below regulatory limits and would comply with DOE orders. These risks are discussed further in Section 5.4.7.2.5.

5.4.7.2.2 Compliance with ARARs

The components of Alternative 4A are identical to those for Alternative 2A and 3A; thus compliance with ARARs is the same as previously described for Alternative 2A (Section 5.4.3.2.2).

5.4.7.2.3 Long Term-Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 4A would be slightly lower than that of Alternative 1. While Alternative 1 involves the excavation and off-property disposal of contaminated soil and sediment, soil and sediment excavated under Alternative 4A would be placed in an on-property disposal facility. The use of an on-property disposal facility would cause no immediate increase in the residual risk associated with this alternative. Its continued presence, however, results in a reduction in the perceived permanence due to uncertainty associated with the ability of the federal government to maintain long-term (i.e., up to 1000 years) institutional controls and the long-term performance of the engineered components of the system.

Groundwater Residual Risk - All alternatives provide for the extraction and treatment of contaminated groundwater from the regional aquifer in the same manner. Residual risk associated with groundwater would be the same as that discussed under Alternative 1, Case 2.

Soil Residual Risk - As presented in Section 2.0, footprints for soil excavation were based upon the use of total uranium as an indicator parameter. The excavation footprints were then expanded to capture other COCs whose concentration in soil exceeded their respective PRLs. Before initiation of soil excavation activities, verification sampling would be performed to confirm the excavation footprints. Radiological surveys performed using field instruments would help to direct excavation activities. Upon completion of excavation in a given area, certification sampling would be performed to confirm that soil PRLs were obtained. Effectiveness in meeting the target risk levels would be ensured through this confirmation that PRLs were attained. Long-term effectiveness and permanence would be ensured through a combination of institutional controls and design considerations incorporated into the disposal facility.

Adequacy and Reliability of Controls

For Alternative 4A, the adequacy and reliability of controls associated with the performance of the on-property disposal facility and off-site disposal would be the same as previously described for Alternative 2A (Section 5.4.3.2.3). The adequacy and reliability of controls associated with extraction and treatment of contaminated groundwater from the Great Miami Aquifer would be the same as previously described for the 27-year pumping design in Alternative 1 (Section 5.4.2.2.3).

Long-Term Environmental Impacts

Long-term environmental impacts associated with Alternative 4A for Cases 8 and 9 are similar to Alternative 3A, Case 5 with the differences outlined below. For a more detailed description of specific resources and associated mitigative measures, refer to Alternative 1 (Section 5.4.2.2.3). For purposes of evaluating NEPA values, NTS, a DOE-owned low-level radioactive waste facility near Las Vegas, Nevada was considered.

Construction of the on-site disposal facility (including the PMF channel) would result in the permanent commitment of 118.2 acres of land at the FEMP site.

Land Use Objective 4 provides for minimum consolidation of contaminated soil with access and future use of the FEMP property restricted. This land use objective contemplates the FEMP property being maintained as a waste management area.

5.4.7.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative provides no reduction of toxicity, mobility or volume of soil or sediment through treatment with the exception of an estimated 28,000 cubic yards of soil and sediment containing RCRA-regulated hazardous, petroleum, and PCB wastes. As previously described for Alternative 1 (Section 5.4.2.2.4), the mixed wastes would be excavated and treated with mobile thermal desorption or cement stabilization, as indicated, to attain the waste acceptance criteria.

Reduction of the volume of contaminated groundwater is the same as outlined in Alternative 1.

5.4.7.2.5 Short-Term Effectiveness

Protection of the Community During Remedial Actions

Through the implementation of engineering controls (e.g., dust suppression) and institutional controls (e.g., physical barriers, administrative controls), the short-term risks to members of the community associated with Alternative 4A would be minimized. A remedial action risk assessment was conducted to assess the potential short-term risks associated with the implementation of remedial actions.

Using historical transportation statistics, less than 1 fatality and less than 1 injury to members of the public for Alternative 4A for Cases 8 and 9 can be expected due to mechanical hazards associated with accidents during transportation. This fatality and injury estimate is associated with off-site disposal operations of excavated soil and sediment during the 22 years of remedial activities.

The estimated ILCR to hypothetical receptors, representing members of the public residing near the FEMP, due to external radiation and inhalation associated with releases during remedial actions are estimated at 3.2×10^{-7} for Case 8 and 3.4×10^{-7} for Case 9 for Alternative 4A. Risks to members of the public located along the transportation route are 8.3×10^{-8} for Cases 8 and 9.

Protection of Workers During Remedial Actions

A detailed analysis of the potential short-term risks to workers engaged in remedial activities and on-site workers not engaged in remedial activities is presented in Appendix G. The ILCR for remediation workers for Case 8 is estimated at 1.1×10^{-3} for excavation activities, 2.2×10^{-3} for off-site disposal activities, and 1.1×10^{-3} for on-site disposal facility activities. For Case 9, the ILCR for excavation activities is 1.2×10^{-3}, 2.3×10^{-3} for off-site disposal activities, and 1.2×10^{-3} for on-site disposal facility activities. For both cases, the dominant risk is from external exposure to radioactive contaminants. These risk levels are less than those extrapolated from the maximum allowable exposure limits for workers, so these risks do not exceed worker standards (10 CFR 835 and 29 CFR 1910).

Short-Term Environmental Impacts

The short-term environmental impacts to the FEMP site from remedial activities for Alternative 4A, Cases 8 and 9 are similar to those impacts identified for Alternative 3A, Cases 5 and 6 with the differences outlined below.

Disturbance of approximately 141.9 acres of land from associated short-term remedial activities such as construction of the disposal facility and associated PMF channel and support facilities would occur.

Time Period to Achieve Remedial Action Objectives

Physical, substantial and continuous on-site activities for soil remediation would be initiated within 15 months following issuance of the ROD. The estimated time to excavate and disposition contaminated soil to achieve remedial action objectives under Alternative 4A is 22 years. This time frame includes construction of an on-property disposal facility and the transport of soil which does not meet the waste acceptance criteria of the on-property disposal facility to an off-site commercial disposal facility.

The 22-year schedule assumes that soil excavation, construction of the disposal facility, and off-site transport would be performed on a five day per week, one shift per day basis. Following completion of soil emplacement in the disposal facility, cell capping activities would require an additional 12 months.

Operation of the Great Miami Aquifer groundwater recovery system is projected to continue for up to 27 years, as previously described for Alternative 1, Case 2 (Section 5.4.2.2.5).

5.4.7.2.6 Implementability

Technical Feasibility

The technical feasibility of the excavation, on-property disposal, transportation by truck and off-site disposal components of this alternative are the same as in Alternative 2A (Section 5.4.3.2.6). The estimate for the footprint of the disposal facility for both risk levels is 60 acres. Consequently, sufficient area would be available to site the disposal facility.

For Alternative 4A, the technical feasibility associated with extraction and treatment of contaminated groundwater are the same as for the 27-year pumping scenario under Alternative 1, Case 2 (Section 5.4.2.2.6).

Administrative Feasibility

Administrative factors for the on-property disposal facility and truck transportation and off-site disposal components of Alternative 4A would be the same as previously described for Alternative 2A (Section 5.4.3.2.6). Administrative factors for extraction and treatment of contaminated groundwater are the same as for Alternative 1 (Section 5.4.2.2.6).

Availability of Services and Materials

For Alternative 4A, the availability of services and materials associated with excavation, installation of an on-property disposal facility, and transportation and off-site disposal would be the same as previously described for Alternative 2A (Section 5.4.3.2.6). The availability of services and materials associated with extraction and treatment of contaminated groundwater would be the same as previously described for Alternative 1 (Section 5.4.2.2.6).

5.4.7.2.7 Cost

The cost to implement Alternative 4A includes the cost to construct remediation facilities, the cost to operate and maintain remedial actions and postremediation costs, which include D&D of remediation facilities. Table 5-27 summarizes the costs (in 1995 dollars) of Alternative 4A for Cases 8 and 9. It also contains the corresponding present worth and escalated costs.

TABLE 5-27
ALTERNATIVE 4A COSTS

	$ (million)	
	Risk Case 8	Risk Case 9
Costs	10^{-6} Risk/On-Property Trespasser 10^{-5} Risk/Off-Property Resident Farmer	10^{-6} Risk/On-Property Trespasser HI=1/Off-Property Resident Farmer
Construction	450	430
Operations and maintenance	370	340
Postremediation	70	70
Total cost (1995 dollars)	890	850
Present worth cost	610	580
Total cost (escalated)	2180	2110

The construction cost of Alternative 4A includes: verification surveys to establish the boundaries of excavation areas; the purchase of earth-moving equipment; excavation operations; storm water controls; construction of haul roads, wheel washing and radiological screening stations, the off-site disposal staging facility, the cap material staging area and facility, the Great Miami Aquifer groundwater extraction system, and the groundwater treatment facility; and backfill operations.

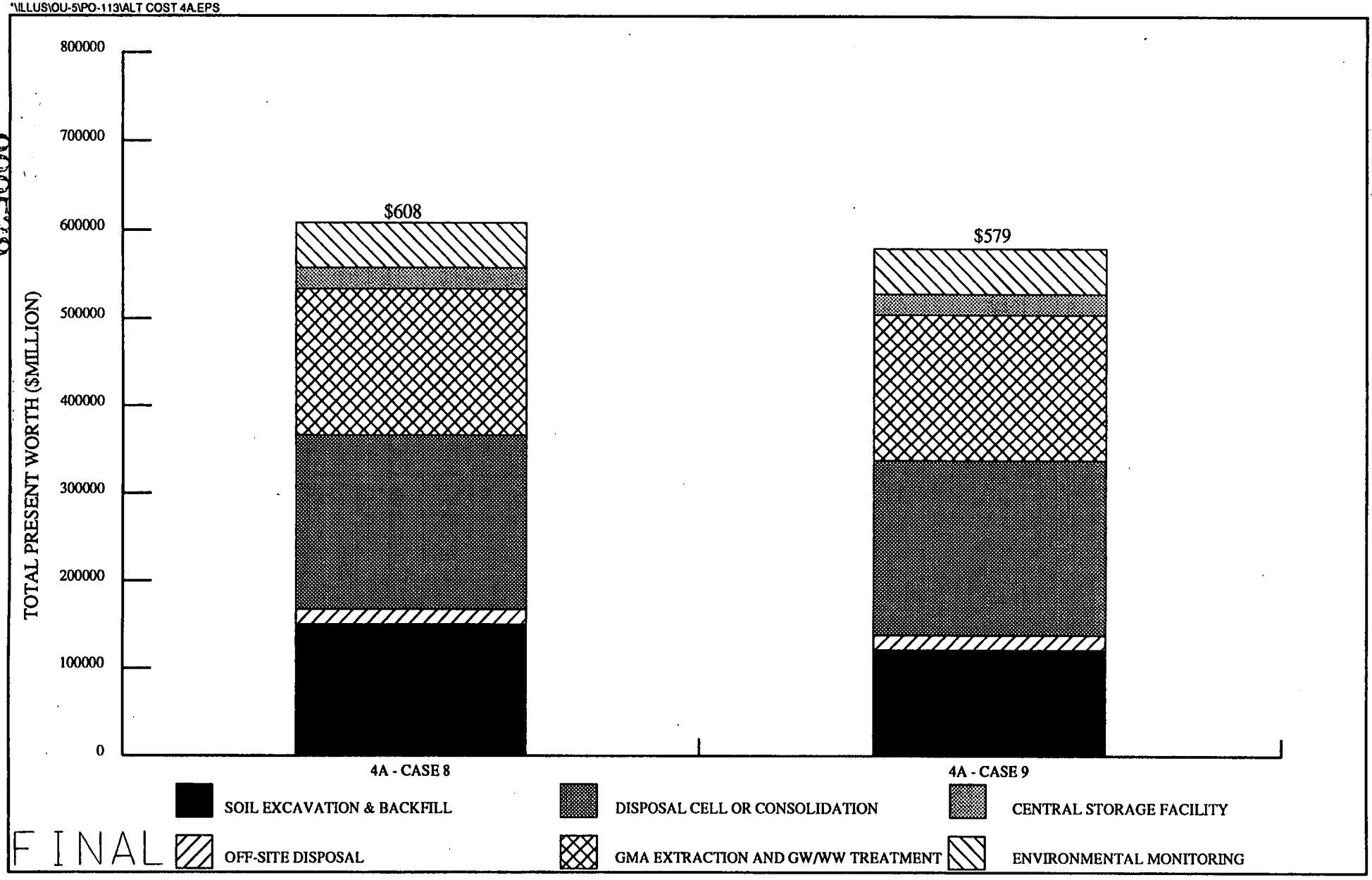
The O&M costs for Alternative 4A include: the labor, materials, fuel, utilities, chemicals, and parts required to operate and maintain remediation actions; sampling and analysis; and transportation and disposal of contaminated material.

Postremediation costs for Alternative 4A include: D&D of remediation facilities; decontamination and free-release of equipment; and long-term monitoring.

Figure 5-15 shows the present worth cost of Alternative 4A for each of the cases divided into its remedial action components. As shown in the figure, groundwater extraction and groundwater and waste water treatment are the predominant costs for both Cases 8 and 9. The present worth contribution of water treatment is 39 percent and 41 percent, respectively. The on-site disposal facility roughly contributes 30 percent for both cases evaluated under Alternative 4A.

Appendix K provides the cost basis and estimates for the remedial action components which comprise Alternative 4A.

*\ILLUS\OU-5\PO-113\ALT COST 4A.EPS



FINAL

FIGURE 5-15. ALTERNATIVE 4A COSTS BY COMPONENT

000529

5.4.8 Alternative 4C - Off-Site Shipment

Alternative 4C involves the excavation of contaminated soil and sediment exceeding PRLs based upon the expanded trespasser for on-property areas and the RME resident farmer for off-site areas. Depending upon contaminant concentration levels, excavated contaminated soil would be placed in an on-property consolidation area with an earthen and vegetative cover or shipped off site to a commercial disposal facility. Contaminated groundwater from the Great Miami Aquifer would be extracted until PRLs are attained.

Alternative 4C is like Alternatives 2C and 3C. The objective of Alternatives 2C and 3C, however, is to release a major portion of the FEMP site for unrestricted or restricted land use. Under Alternative 4C, the federal government would retain ownership of the FEMP. Remedial actions would not specifically consider the release of FEMP property for alternative land uses. Alternative land uses would be selectively considered for those areas which currently meet the PRLs for industrial or recreational use. Contaminated soil and sediment would be excavated to the extent necessary to ensure the protection of an inadvertent trespasser (i.e., expanded trespasser) and of the Great Miami Aquifer.

5.4.8.1 Detailed Description

The following remedial activities comprise Alternative 4C:

- Excavating the contaminated soil, production-area gravel, and sediment exceeding PRLs.; excavating contaminated perched zones presenting unacceptable cross-media risks to the Great Miami Aquifer

- Backfilling excavated areas and regrading as necessary to achieve desired drainage patterns and controls

- Pretreating soil with unacceptable concentrations of RCRA-regulated constituents above the waste acceptance criteria for these constituents

- Dispositioning contaminated soil in the following manner:
  - Soil containing appropriate levels of contamination would be consolidated and covered with 1 foot of clean soil
  - Soil containing contaminant concentrations which exceed the waste acceptance criteria of the earthen covered consolidation area would be dispositioned to an off-site, commercial disposal facility

- Establishing a vegetative cover on consolidated contaminated materials

- Extracting contaminated groundwater from the Great Miami Aquifer until target concentrations of COCs are attained

- Treating all collected storm water, wastewater and groundwater as necessary
- Discharging storm water, wastewater, and recovered groundwater to the Great Miami River following any required treatment
- Decontaminating and dismantling required support facilities following completion of remedial actions with off-property disposal of the contaminated debris at a representative commercial disposal facility
- Maintaining federal ownership of the FEMP with consideration of alternative uses of select on-property areas, at the discretion of the federal government, on the basis of measured soil concentrations and the results of on-going environmental monitoring
- Operating a groundwater monitoring network to assess the performance of the consolidation/disposal system
- Performing five-year reviews (by EPA in consultation with the State of Ohio and the DOE), to assess the continued performance of the completed remedial action.

To ensure that a full range of residual risk conditions are evaluated, Alternative 4C was evaluated for two different risk scenarios referred to as Cases 8 and 9 (see Table 2-18). Case 8 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in all on-site areas) and an ILCR of 10^{-5} to off-property target receptors (i.e., the RME resident farmer). Case 8 assumes that the FEMP is remediated to achieve an ILCR of 10^{-6} to on-property target receptors (i.e., an expanded trespasser in all on-site areas) and an ILCR in the range of 3.5×10^{-5} to off-property target receptors (i.e., the RME resident farmer). Table 5-28 provides a summary of the target receptors and associated risk levels considered under each case.

A conceptual site plan depicting the necessary support structures and disposal facilities for Alternative 4C is the same as for Alternative 3C, Cases 4 - 7 and is presented in Figure 5-13. The figure represents a configuration necessary to address the anticipated volumes of material requiring excavation to achieve the residual risk levels associated with both Cases 8 and 9. Remediation facilities depicted in the site plan include a consolidation area, a central storage facility for contaminated material, rail spur for off-site shipment of bulk soil and stabilized treatment waste, a groundwater extraction system and treatment systems for extracted groundwater, perched groundwater, storm water and process water.

TABLE 5-28

TARGET RECEPTORS AND ASSOCIATED RISK LEVELS FOR ALTERNATIVE 4C

Risk Case	On-Property Soil and Sediment		Off-Property Soil and Sediment		Groundwater	
	Receptor	Risk Level	Receptor	Risk Level	Receptor[a]	Risk Level
8	Expanded Trespasser	10^{-6}	Resident Farmer	10^{-5}	ARARs	Proposed MCLs
9	Expanded Trespasser	10^{-6}	Resident Farmer	10^{-5} [b]	ARARs	Proposed MCLs

[a] At a residual risk level of 10^{-5} to the resident farmer, the MCLs and proposed MCLs are more restrictive and are therefore used in lieu of the risk-based limits.
[b] Case 9 assumes an off-property residual uranium concentration of 50 ppm, corresponding to an ILCR of 3.5×10^{-5} and an HI of 1.

The PRLs are presented in Section 2.0. For Alternative 4C, the PRLs for all FEMP on-property areas would be those listed in Tables 2-12, 2-13, 2-14 and 2-15 for the expanded trespasser. The PRLs are based upon the presumption that the FEMP is under the continual ownership of the government, with access to more heavily contaminated areas restricted by a properly maintained fence with signs. Consideration would be given to alternative land uses for select portions of the FEMP.

Figure 4-9 presented a conceptual block flow diagram of the remedial activities associated with Alternative 4C. Detailed discussions for each of the components comprising the alternatives are presented in Appendix L. The following sections present a brief description of the unique aspects of the remedial action components as they pertain to Alternative 4C.

Excavation and Backfill

Excavation and backfill of contaminated soil and sediment would be implemented as described for Alternative 1 (Section 5.4.2.1). Management of excavated materials contaminated with RCRA-regulated constituents would be the same as discussed under Alternative 2C.

The footprint of the projected excavations required to attain the PRLs for Alternative 4C, Cases 8 and 9 are presented in Figure 2-16. Table 5-29 provides the estimated in situ soil volumes that would be excavated under Alternative 4C, both on and off property, for the two risk cases considered. The table also presents the quantity of this soil that meets the waste acceptance criteria for the consolidation area and those portions that would be shipped to an off-site commercial disposal facility and used as on-property backfill.

TABLE 5-29

REMEDIAL ACTION ALTERNATIVE 4C SOIL VOLUMES

	Risk Case	
	Case 8	Case 9
Risk Goal		
On-Property		
Receptor	Trespasser	Trespasser
Risk level	10^{-6}	10^{-5}
Off-Property		
Receptor	Resident farmer	Resident farmer[a]
Risk level	10^{-5}	10^{-5}
Soil Volume Requiring Excavation (yd^3)		
On-property	1,790,000	1,789,000
Off-property	400,000	1000
Total	2,190,000	1,790,000
Remedial Action (In situ soil volume in yd^3)		
On-property backfill	418,000	18,000
Consolidate w/earthen cover	652,000	652,000
Off-site disposal	1,120,000	1,120,000
Total	2,190,000	1,790,000
Transportation Capacity		
Rail cars	19,700	19,700
Train loads	394	394
Trains per month	2	2

[a] Uses a residual uranium concentration of 50 ppm which corresponds to an ILCR of 3.5×10^{-5} and an HI of 1.

Soil volume estimates presented in Table 5-29 are based upon engineering evaluations of available data which were completed for the detailed analysis of alternatives. Final excavation footprints and soil volumes would be established through completion of a preexcavation verification survey. This verification survey is discussed further in the description of the soil excavation component presented in Appendix L.

Excavated areas would be backfilled, as necessary, with clean borrow material and topsoil to reestablish original grade. A vegetative cover would be reestablished on the backfilled areas.

Consolidation and Earthen Cover

Soil and sediment determined through preexcavation surveys to meet the waste acceptance criteria for consolidation with an earthen cover would be transported to the consolidation area. Contaminated soil would be placed in designated portions of the consolidation area in 1-foot lifts and compacted. As an area is filled to final grade, that area would be covered with 1 foot of clean soil. The surface of the soil cover would be vegetated using grasses indigenous to the area. Table 5-30 presents the dimensions of the consolidation area for each risk level.

TABLE 5-30

ALTERNATIVE 4C CONSOLIDATION AREA DIMENSIONS
(All dimensions in feet)

Risk Case	Risk Level/Receptor	Length	Width	Height
8	10^{-6} / On-property trespasser 10^{-5} / Off-property resident farmer	950	950	35
9	10^{-6} / On-property trespasser 10^{-5} / Off-property resident farmer*	950	950	35

* Employs use of HI=1 level for total uranium of 50 ppm.

Design details for the consolidation area are provided in the component descriptions in Appendix L.

Off-Property Disposal

Soil and sediment which contain contamination above that which can be consolidated under an earthen cover would be shipped off site for disposal. For purposes of this FS a representative commercial disposal facility was selected for developing and evaluating the viability of off-property disposal. Contaminated soil will be loaded into 100-ton rail cars for shipment to the off-site facility. Assuming a bulk density of 1.76 tons per cubic yard of excavated materials, the number of rail cars presented in Table 5-29 would be required to support off-site disposal.

Great Miami Aquifer Restoration

Under Alternative 4C, contaminated groundwater from the Great Miami Aquifer would be remediated as described under Alternatives 2C and 3C.

Storm Water Management

Under Alternative 4C, storm water would continue to be remediated as described under Alternatives 2C and 3C.

Decontamination and Demolition

D&D of remedial action support facilities would be accomplished as previously described for Alternative 1 (Section 5.4.2.1).

Resultant Land Use Potential

The resultant land use potential would be the same as previously described for Alternative 4A (Section 5.4.7.1).

Institutional and Administrative Control Requirements

To ensure the long-term performance of the remedial action, Alternative 4C requires the performance of long-term groundwater monitoring and maintenance, and the establishment of a series of institutional and administrative controls. The controls would be the same as previously described for Alternative 2A (Section 5.4.3.1), with the exception that restrictions on on-property alternate land uses would be maintained.

5.4.8.2 Assessment

5.4.8.2.1 Overall Protection of Human Health and the Environment

Alternative 4C meets the remedial action objectives for Operable Unit 5 and would be protective of human health and the environment. Implementation of this alternative would prevent direct access to contaminated soil and sediment by removal of these media to PRLs and consolidation in an on-site consolidation area or disposal at an off-site location. Implementation of Alternative 4C would mitigate the migration of contaminants in soil and sediment to the air and groundwater. Moreover, implementation of Alternative 4C would prevent the consumption or use of groundwater containing FEMP contaminants above MCLs or proposed MCLs. Exposure to direct radiation above protective levels would also be prevented.

The primary actions that would be used to meet the remedial action objectives of Alternative 4C are: excavation of contaminated soil and sediment exceeding PRLs; dispositioning these materials at an on-site consolidation area with earthen cover or at an off-site waste disposal facility depending upon contaminant concentrations; backfilling excavated areas with clean borrow and topsoil; and extraction and treatment of contaminated groundwater from the Great Miami Aquifer.

The consolidation area and its associated waste acceptance criteria would be designed to control contaminant migration to human and environmental receptors and to prevent direct radiation exposure

from contained waste material. Excavation and containment of contaminated soil and sediment in the on-site consolidation area and the off-site disposition of soil contaminated above the waste acceptance criteria of the consolidation area would ensure that risks to the hypothetical resident farmer outside the consolidation area would not exceed those considered health protective as defined in Section 5.4.6.2.3, Magnitude of Residual Risk. Moreover, the consolidation area with earthen cover for containment of soil contaminants at concentrations above the PRLs is designed to be health protective for the expanded trespasser and would ensure that contaminant concentrations in the Great Miami Aquifer would not exceed MCLs or proposed MCLs within the 200- to 1000-year period considered under this FS. It is assumed that the design, siting and permitting of the off-site commercial disposal facility will preclude a corresponding increase in residual risk at that location.

Backfilling excavated areas with clean backfill and topsoil would prevent direct contact with residual contamination and would prevent the potential spread of contamination through the air pathway. The establishment of a vegetative cover would minimize future erosion. Extraction and treatment of Great Miami Aquifer groundwater would clean up existing contamination such that MCLs and proposed MCLs would not be exceeded.

Following implementation of Alternative 4C, institutional controls would be maintained for the entire FEMP property to ensure continued protection of human health and the environment. Institutional controls would include continued federal ownership of the FEMP property to preclude homesteading, intrusive actions or facility degradation; deed restrictions; and passive access controls (e.g., fencing) around the property to prevent unauthorized access to or use of the land.

Loss of institutional controls in combination with failure of the earthen cover over the consolidated waste could, over the 200- to 1000-year period, result in contaminant migration or direct exposure to contaminated material by future human and environmental receptors. Exposures to potential receptors would be minimized due to the reduced surface area of the consolidated material and low concentration of contamination in the contained soil. Under the intrusive farmer scenario, however, a future farmer who might choose to establish a residence on top of the consolidation area and who achieved daily contact with materials contained within the consolidation area over a long period of time would be subject to incremental risks greater than those contemplated herein. Due to its design, however, the use of the consolidation area as a residential area is considered highly unlikely.

The most significant short-term risks associated with the implementation of Alternative 4C are the risks associated with the transport of contaminated media to an off-site waste disposal area. In addition, increased worker risks would be expected throughout implementation of this alternative. However, through the implementation of a worker health and safety plan in compliance with

29 CFR 1910.120, exposures would be kept to below regulatory limits and would comply with DOE Orders. These risks are discussed further in Section 5.4.8.2.5.

5.4.8.2.2 Compliance with ARARs

The components of Alternative 4C are identical to those for Alternatives 2C and 3C. Compliance with ARARs would be the same as previously described in Alternative 2C (Section 5.4.4.2.2).

5.4.8.2.3 Long-Term Effectiveness and Permanence

Alternative 4C would dispose of more material with greater contaminant concentrations off site, leading to higher long-term effectiveness and permanence than Alternative 4A (where a larger volume of contaminated material would remain on property in the proposed disposal facility). The contaminated material placed in the on-property consolidation area with earthen cover under Alternative 4C would have lower contaminant concentrations than the material placed in the engineered disposal facility under Alternative 4A; this material would present lower overall risks to potential intruders if the planned institutional controls were ever to fail. However, the use of the consolidation area would result in a reduction in long-term effectiveness and permanence due to uncertainty about the maintenance of federal controls for 1000 years and the potential degradation of the earthen cover over the same period.

Groundwater Residual Risk - All alternatives provide for the extraction and treatment of contaminated groundwater from the regional aquifer in the same manner. Residual risk associated with groundwater would be the same as that discussed under Alternative 1, Case 2.

Soil Residual Risk - As presented in Section 2.0, footprints for soil excavation were based upon the use of total uranium as an indicator parameter. The excavation footprints were then expanded to capture other COCs whose concentrations in soil exceeded their respective PRLs. Before initiation of soil excavation activities, verification sampling would be performed to confirm the excavation footprints. Radiological surveys performed using field instruments would help to direct excavation activities. Upon completion of excavation in a given area, certification sampling would be performed to confirm that soil PRLs were obtained. Effectiveness in meeting the target risk levels would be ensured through this confirmation. Long-term effectiveness and permanence would be ensured through a combination of institutional controls, design considerations incorporated into the consolidation area, and the establishment of the waste acceptance criteria for the consolidation area.

Adequacy and Reliability of Controls

The adequacy and reliability of the on-site consolidation area would be the same as described in Alternative 2C. A significant portion of the excavated soil (over half) would be shipped off site for disposal. Therefore, as in Alternative 1 (Section 5.4.2.2.3), the off-site disposal facility would be responsible for long-term management of these wastes.

The adequacy of reliability and controls for the extraction and treatment of contaminated groundwater would be the same as the 27-year pumping scenario described in Alternative 1, Case 2 (Section 5.4.2.2.3).

Long-Term Environmental Impacts

Long-term environmental impacts associated with Alternative 4C, Cases 8 and 9 are similar to Alternative 4A, Cases 8 through 9 impacts, with the differences outlined below. For a detailed description of specific resources, refer to Alternative 1 (Section 5.4.2.2.3).

Consolidation of contaminated soil (including the PMF channel) would result in the permanent commitment of 92.3 acres of land at the FEMP site, including 6.3 acres of pine plantation habitat.

Permanent disruption of 20 acres of soil and the vegetative community at the representative commercial disposal facility would occur.

5.4.8.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This alternative provides for no reduction of toxicity, mobility or volume of soil contaminants through treatment. However, an estimated 1.12×10^6 cubic yards of contaminated material would be shipped off site for disposal under both risk goals evaluated under this alternative. Thus, the toxicity, mobility, and volume of contaminated materials that remain on site would be reduced.

As discussed in Alternative 1 (Section 5.4.2.2.4), an estimated 28,000 cubic yards of soil and sediment containing RCRA hazardous, petroleum, and PCB waste would be excavated and treated with mobile thermal desorption or cement stabilization, as indicated, to meet LDR requirements and shipped off site for disposal.

Treatment of the Great Miami Aquifer groundwater for this alternative would be the same as the 30 year pumping scenario described in Alternative 1, Case 2 (Section 5.4.2.2.4).

5.4.8.2.5 Short-Term Effectiveness

Protection of the Community During Remedial Actions

A remedial action risk assessment was conducted to assess the potential short-term risks associated with the implementation of remedial actions. Using historical transportation statistics, 3 fatalities and 10 injuries to members of the public for Alternative 4C for Case 8 and Case 9 can be expected due to mechanical hazards associated with accidents during transportation. These fatalities and injuries are associated with off-site disposal of excavated soil and sediment during the 22 years of remedial activities.

The estimated ILCR to hypothetical receptors, representing members of the public near the FEMP, due to external radiation and inhalation associated with releases during remedial actions are estimated at 3.6×10^{-7} and 3.8×10^{-7} for Cases 8 and 9, respectively for Alternative 4C. Risks to members of the public located along the transportation route are 8.3×10^{-8} for Cases 8 and 9.

Protection of Workers During Remedial Actions

A detailed analysis of the potential short-term risks to workers engaged in remedial activities and on-site workers not engaged in remedial activities is presented in Appendix G. The ILCR for remediation workers for Case 8 is estimated at 1.1×10^{-3} for excavation activities, 4.0×10^{-3} for off-site disposal activities, and 1.5×10^{-3} for on-site disposal consolidation. For Case 9, the ILCR is 1.2×10^{-4} for excavation activities, 2.3×10^{-3} for off-site disposal activities, and 1.1×10^{-3} for on-site disposal facility activities. For both cases, the dominant risk is from external exposure to radioactive contaminants. These risk levels are less than those extrapolated from the maximum allowable exposure limits for workers and do not exceed worker standards (10 CFR 835 and 29 CFR 1910).

Short-Term Environmental Impacts

The short-term environmental impacts to the FEMP site from remedial activities for Alternative 4C, Cases 8 through 9 are similar to those impacts identified for Alternative 4A, Cases 8 through 9 with the differences outlined below.

Soil disturbances from Alternative 4C, Cases 8 through 9 would result from the construction of the consolidated area and associated PMF channel, construction of roads, construction and operation of support facilities and operation of equipment. These activities would disturb 109 acres of land within the site boundary.

Short-term impacts to soil and vegetation at the representative commercial disposal facility for Alternative 4C, Cases 8 and 9 are the same as long-term impacts identified for this alternative.

Time Period to Achieve Remedial Action Objectives

Physical, substantial and continuous on-site activities for soil remediation would be initiated within 15 months following issuance of the ROD. The estimated time to excavate and disposition contaminated soil to achieve remedial action objectives under Alternative 3C is 22 years. This time frame includes construction of an on-property consolidation area and the transport of soil which does not meet the waste acceptance criteria of the on-property consolidation area to an off-site commercial disposal facility.

The 22-year schedule assumes that soil excavation, construction of the consolidation area, and off-site transport would be performed on a five day per week, one shift per day basis. Following completion

of soil emplacement in the consolidation area, construction of an earthen and vegetative cover would require an additional 12 months.

Operation of the Great Miami Aquifer groundwater recovery system is projected to continue for up to 27 years, as previously described for Alternative 1, Case 2 (Section 5.4.2.2.5).

5.4.8.2.6 Implementability

Technical Feasibility

Alternative 4C and Alternative 2C employ the same components. Therefore, the technical implementability factors would be the same as previously described for Alternative 2C (Section 5.4.2.2.6).

Administrative Feasibility

Administrative factors for Alternative 4C would be the same as previously described for Alternative 2C (Section 5.4.4.2.6).

Availability of Services and Materials

The availability of services and materials for Alternative 4C would be the same as previously described under Alternative 2C (Section 5.4.4.2.6).

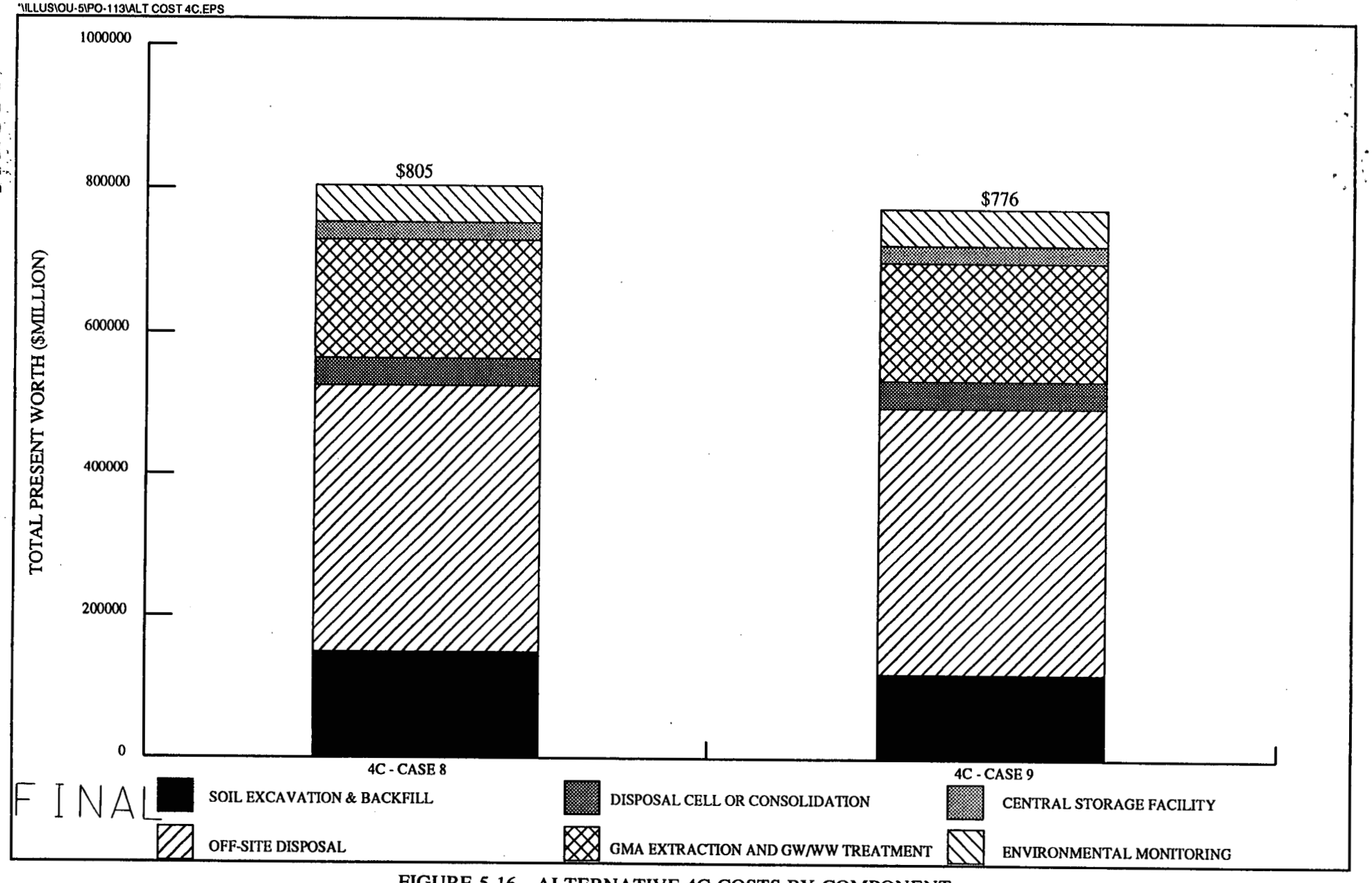
5.4.8.2.7 Cost

The cost to implement Alternative 4C includes the cost to construct remediation facilities the cost to operate and maintain remedial actions and postremediation costs, which include D&D of remediation facilities. Table 5-31 summarizes the costs (in 1995 dollars) of Alternative 4C for Cases 8 and 9. It also contains the corresponding present worth and escalated costs.

Appendix K provides cost basis and estimates for the remedial action components which comprise Alternative 4C.

Figure 5-16 shows the present worth cost of Alternative 4C for each of the residual risk levels, divided into its remedial action components. As shown in the figure, off-site disposal is the predominant cost for both Cases 8 and 9. Off-site disposal contributes 46 percent and 47 percent of the present worth cost for Cases 8 and 9, respectively.

000541



FINAL

FIGURE 5-16. ALTERNATIVE 4C COSTS BY COMPONENT

TABLE 5-31

ALTERNATIVE 4C COSTS

	$ (million)	
	Case 8	Case 9
Costs	10^{-6} Risk/On-Property Trespasser 10^{-5} Risk/Off-Property Resident Farmer	10^{-5} Risk/On-Property Resident 10^{-5} Risk/Off-Property Resident Farmer
Construction	230	220
Operations and maintenance	870	840
Post-remediation	50	50
Total cost (1995 dollars)	1150	1110
Present worth cost	800	780
Total cost (escalated)	2240	2170

5.5 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Natural resources and associated services would be permanently committed as a result of implementing the remedial alternatives. The commitments of natural resources and land corresponding to each alternative and case are addressed below. These commitments not only include the resources and land, but the services they provide as well.

Implementing all remedial action alternatives except Alternatives 1 (Cases 1 and 2), and 2C (Case 1) would result in permanent commitment of on-property land for material disposal at the FEMP site. In addition, the permanent commitment of land at the representative commercial disposal facility and NTS would occur. A summary of resource impacts and associated quantities from implementation of remedial action alternatives and associated cases is provided in Table 5-31. These resource impacts would occur at the FEMP unless otherwise indicated.

It is anticipated that all areas disturbed at the FEMP site would be regraded and revegetated. However, permanent disruption of terrestrial and aquatic habitats could occur, resulting in irreversible and retrievable commitment of resources. These areas include potential habitat for threatened and endangered species including the Indiana bat and cave salamander, and actual habitat of the Sloan's crayfish. Long-term impacts are expected to be minimal from the implementation of mitigative measures, discussed in the short-term effectiveness evaluation summaries for each alternative in Section 5.0. Terrestrial habitat at the representative commercial disposal facility is sparse, resulting

in minimal displacement of species. Habitat for the desert tortoise at UTS is not expected to be impacted.

Consumptive use of geological resources (e.g., quarried rock, sand, and gravel) and petroleum products (e.g., diesel fuel and gasoline) would be required for removal, construction, and disposal activities of all action alternatives. Supplies of these materials would be provided by the construction contractor. Additional fuel use would result from off-site transport of the materials. However, adequate supplies are available without affecting local requirements for these products.

Treatment processes for the action alternatives would require consumptive use of materials and energy. The vendor-operated solidification process would require additives such as cement and flyash. The AWWT and groundwater treatment facility processes would require carbon, ion exchange resin, caustic soda, and sulfuric acid. Additives for these two processes are readily available locally in the quantities required.

The committed land at the FEMP site would be actively monitored and maintained. Periodic monitoring of nearby surface water and groundwater from monitoring wells around the perimeter of the on-property disposal area would be performed, and periodic inspections would identify any damage to the disposal area. Maintenance activities would be performed as necessary. Therefore, no negative impacts to groundwater are expected to occur from Operable Unit 5 remedial activities.

5.6 ARAR COMPLIANCE ISSUES FOR ON-PROPERTY DISPOSAL

Remedial action alternatives which contemplate on-property disposal of contaminated soil and sediment need to balance future land use objectives with disposal configurations that are protective of human health and the environment. In order to locate an on-property disposal facility at the FEMP, a waiver would be required under CERCLA from portions of the State of Ohio solid waste facility siting requirements. The basis for the CERCLA waiver would be an equivalent standard of performance by which the geology beneath the on-property disposal facility, coupled with the protective engineering features of the design and the waste acceptance criteria for the facility contents would result in the same overall protection of the Great Miami Aquifer that would be afforded by acceptable, undisturbed geology as specified by State of Ohio requirements.

The standard for gauging the equivalent standard of performance for the disposal facility is derived from the need to protect the Great Miami Aquifer as a drinking water supply over the long term. Under the equivalent performance standard, groundwater quality in the aquifer would not be allowed to exceed established risk-based PRLs for all site-related constituents at any location in the aquifer for a performance period of up to 1000 years, as contemplated by other ARARs affecting on-site disposal. In addition to the risk-based PRLs, groundwater quality in the aquifer would not be allowed

to exceed promulgated or proposed standards for drinking water defined by the Safe Drinking Water Act, also over the 1000-year performance period. To establish the Operable Unit 5 PRLs through the FS process, two risk-based cases for the Great Miami Aquifer were used to provide decision makers with the appropriate range of risk-based options as required by the NCP:

- A risk-based case that corresponds to an ILCR of 10^{-6} and a HI of 0.2 for individual site-related contaminants capable of reaching the Great Miami Aquifer within the 1000-year performance period
- A risk-based case that corresponds to the proposed and promulgated MCLs under the Safe Drinking Water Act for individual contaminants capable of reaching the Great Miami Aquifer within the 1000-year performance period. For contaminants that do not have promulgated or proposed MCLs, an ILCR of 10^{-5} and an HI of 0.2 were used to represent the corresponding risk-based values.

Although the NCP provides an ILCR risk range of 10^{-4} to 10^{-6} for decision making, development of a higher-bound 10^{-4} case is not appropriate for the Great Miami Aquifer. The proposed MCL for uranium under the Safe Drinking Water Act is less than the corresponding 10^{-4} risk-based value. The MCL-based case therefore represents the health-protective upper bound for decision making.

The two risk-based cases were used as the foundation for developing protective site-specific waste acceptance criteria for the on-site disposal facility under consideration for the FS. As part of the selection of the preferred remedy for Operable Unit 5, EPA will select which of the two cases is preferred by virtue of the selection of the appropriate residual risk level for the site.

5.6.1 State of Ohio Siting Requirements

The State of Ohio has requirements that must be considered when siting a solid waste disposal facility within the state. Two of the requirements prohibit siting a solid waste disposal facility over aquifers similar in character to the Great Miami Aquifer. These prohibitions are documented in OAC Rule 3745-27-07(H)(2)(c), which prohibits siting a solid waste landfill above a sole source aquifer and OAC 3745-27-07(H)(2)(d), which prohibits siting a solid waste landfill above an unconsolidated aquifer capable of sustaining a yield of 100 gpm for a 24-hour period to a water supply well located within 1000 feet of the solid waste placement.

Both of these State of Ohio siting prohibitions apply to the FEMP because the Great Miami Aquifer meets the 100-gpm sustained yield specifications and is also designated as a sole source aquifer under the provisions of the Safe Drinking Water Act. While no public water supply wells are located within 1000 feet of any proposed on-property disposal facility, the requirement is interpreted from State of Ohio guidance GD 202.102 to apply to any hypothetical future locations of public water supply wells.

TABLE 5-32

QUANTITIES OF RESOURCES PERMANENTLY COMMITTED

Alternative	Risk Case	Land[a]	Biotic Resources[a]	Wetlands[a]
1	1	171 acres at representative commercial disposal facility	171 acres of plant community (shadscale-gray molly) at representative commercial disposal facility	36 acres of freshwater wetlands
1	2	44 acres at representative commercial disposal facility	44 acres of plant community (shadscale-gray molly) at representative commercial disposal facility	17 acres of freshwater wetlands
2A	1	301 acres .9 acres at Nevada Test Site (NTS)	18 acres of early to mid-successional woodlands 39 acres of pine plantation	36 acres of freshwater wetlands
2A	2	137.6 acres 0.5 acres at NTS	7.5 acres of early to mid-successional woodlands 50 acres of pine plantation	17 acres of freshwater wetlands
2C	1	171 acres at representative commercial disposal facility	171 acres of plant community (shadscale-gray molly) at representative commercial disposal facility	36 acres of freshwater wetlands
2C	2	107.2 acres 21 acres at representative commercial disposal facility	29 acres of pine plantation 21 acres of plant community (shadscale-gray molly) at representative commercial disposal facility	17 acres of freshwater wetlands
3A	3-7	137.6 acres 0.5 acres at NTS	7.5 acres of early to mid-successional woodlands 50 acres of pine plantation	17 acres of freshwater wetlands (Case 3) 9 acres of freshwater wetlands (Case 4-7)
3C	3	107.2 acres 21 acres at representative commercial disposal facility	29 acres of pine plantation 21 acres of plant community (shadscale-gray molly) at representative commercial disposal facility	17 acres of freshwater wetlands
3C	4-7	94.8 acres 21 acres at representative commercial disposal facility (Case 4) 20 acres at representative commercial facility (Cases 5-7)	25 acres of pine plantation 21 acres of plant community (shadscale-gray molly) at representative commercial disposal facility (Case 4) 20 acres of plant community (shadscale-gray molly) at representative commercial disposal facility (Cases 5-7)	9 acres of freshwater wetlands
4A	8-9	118.2 acres 0.5 acres at NTS	1.5 acres of early to mid-successional woodlands 12.2 acres of pine plantation	9 acres of freshwater wetlands
4C	8-9	92.3 acres 20 acres at the representative commercial disposal facility	6.3 acres of pine plantation 20 acres of plant community (shadscale-gray molly) at representative commercial disposal facility	9 acres of freshwater wetlands

[a] Resource impacts occur at the FEMP unless noted otherwise.

A State of Ohio document (OAC 3734.02(G)) provides mechanisms for obtaining exemptions to state permitting or licensing requirements for solid waste disposal facilities. Granting of an exemption must be based on a finding that the conditions of the exemption would not adversely affect public health, public safety, or the environment. Because of the location-specific constraints at the FEMP, in order to site a disposal facility on the FEMP property it would be necessary for the Director of the OEPA to grant exemptions from both the sole-source aquifer siting prohibition and the 100 gpm sustained-yield aquifer siting prohibition, or for EPA to provide an ARAR waiver under CERCLA for both OEPA siting restrictions, if the conditions and criteria for obtaining the OEPA exemptions cannot be met.

For the sole-source aquifer restriction, State of Ohio document GD 202.101 provides interpretative guidance on the application of the OAC Rule 3745-27-07(H)(2)(c) requirements. This document provides guidance as to the technical basis and considerations for granting an exemption to the State of Ohio siting restriction. The guidance document provides that an exemption may be granted by the Director of the OEPA if the Director determines that no adverse impact to human health or safety to the environment will occur due to granting the exemption and lists some of the factors considered. These must show that:

> "...there is a significant thickness of low permeability material between the disposal facility liner and the aquifer, and there is no significant interconnection between the aquifer and any significant zone of saturation that exists above the aquifer."

The guidance further indicates that the demonstrations requested to attain the exemption to this siting requirement must be based upon the geologic conditions present at the site without consideration of engineering controls or improvements. Information obtained during RI site investigations indicates that the geologic material at the FEMP cannot meet these exemption requirements without consideration of engineering controls or improvements such as lining systems.

OEPA guidance GD 202.102 presents the circumstances under which an exemption can be attained from the siting prohibition for a disposal facility over an unconsolidated aquifer capable of sustaining a yield of 100 gallons per minute in a 24-hour period. While no public water supply wells are located within 1000 feet of any proposed on-property disposal facility contemplated for the FEMP, the requirement is interpreted to apply to any hypothetical future locations of public water supply wells. For the 100-gpm or greater aquifer siting prohibition, an exemption can be granted by the Director of OEPA if it can be demonstrated that:

> "...the thickness and lack of permeability of sediment that exists between the bottom of the proposed facility liner and the top of the unconsolidated high yield aquifer provides protection to the unconsolidated high yield aquifer from the effects of a release of leachate from the disposal facility."

The guidance further indicates that the sediment should prevent leachate from migrating from the bottom of the liner of the facility to the high-yield aquifer in a time period equal to the active life of the facility including the postclosure care period. The period of active operation of the proposed disposal facility for all FEMP remedial alternatives is projected to be 22 years. State of Ohio postclosure care regulations for solid waste landfill facilities [OAC 3745-27-14(A)(1)(2)] provide for a minimum postclosure care period for landfills of 30 years. Thus, to meet this exemption criteria, it would have to be demonstrated that the travel time for water from the base of the liner of the proposed facility to the Great Miami Aquifer exceeds 52 years, and that the underlying aquifer is protected from releases.

The vertical seepage rates for water in the gray clay at the FEMP are discussed in Section 3.6 of the Operable Unit 5 RI Report (DOE 1995e). The most favorable on-site condition for the disposal facility would be in an area where the underlying gray clay is 30 feet thick. Even under this favorable condition, seepage through the gray clay layer is estimated in 41 years, which is less than the 52 years indicated by the State of Ohio exemption requirement. With the exemption criteria prohibiting consideration of contaminant retardation in the time-of-travel calculations, the FEMP cannot meet the exemption criteria.

The hydrogeologic conditions at the FEMP indicate that the exemption criteria for both the sole-source aquifer and the 100-gpm aquifer siting restrictions cannot be met on the basis of the protective properties of the native geologic materials alone. It would therefore be necessary to obtain a waiver to the two restrictions through the CERCLA process for remedies contemplating on-property disposal.

5.6.2 CERCLA Waiver Requirements

The NCP [40 CFR 300.430 (f)(1)(ii)(c)] provides guidance as to the circumstances under which a waiver may be granted for an ARAR. The basis for the required waivers would employ the following criteria from the referenced citation in the NCP:

> "...the alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach."

To grant the waivers, the engineering controls and improvements associated with the disposal facility would have to complement the existing geology so that an equivalent standard of performance, as contemplated by the exemption criteria for these siting requirements, would be attained. The equivalent standard of performance, as previously defined, is to ensure the long-term protection of groundwater in the Great Miami Aquifer such that the standards for drinking water quality are not

exceeded at any location in the aquifer. Equivalency would be obtained through adoption of a systems approach in which elements of the hydrogeology, disposal facility design, disposal facility construction, and operational disposal restrictions (i.e., waste acceptance criteria) are considered to ensure that adequate protection of the aquifer is provided. Equivalency can be attained by: 1) adopting a rigorous design for the facility, including use of multilayered capping and lining systems; 2) establishing waste acceptance criteria which ensure long-term performance of the disposal system; and 3) ensuring that the geologic material underlying the lining system of the facility provides the necessary incremental level of protection for the Great Miami Aquifer, with consideration for engineering controls provided through 1 and 2 above.

Available geologic information for the FEMP, assembled from borings and wells installed during RI activities, indicates that the northern and eastern portions of the on-property area exhibit the most favorable hydrogeologic conditions for the siting of a waste disposal facility. A predesign investigation has been initiated to establish the optimum location within this area. The objective is to identify that area where there is the greatest thickness of gray clay and the least amount of interbedded coarse-grained sediment within the gray clay. The predesign investigation will also obtain additional site-specific field data to help verify the accuracy of modeling parameters that have been used to develop the preliminary waste acceptance criteria for the Operable Unit 5 FS.

The preamble to the NCP (53 FR 51439) provides four technical criteria for demonstrating that an equivalent standard of performance can be achieved through application of the CERCLA waiver process. The four criteria are: 1) the degree of protection; 2) the level of performance; 3) the reliability into the future; and 4) the time required for results. These criteria were used as the framework for demonstrating that the on-site disposal options under consideration for the FEMP can provide a degree of protection equivalent to that contemplated by the State of Ohio in the establishment of their exemption criteria. The site-specific findings for each of the four criteria are provided below.

5.6.2.1 Degree of Protection

As discussed in the component description for the disposal facility in Appendix L, the conceptual design configuration adopted for purposes of this FS includes the application of a multilayered capping and lining system with the use of a leachate collection underdrain system. The conceptual design for the lining system satisfies the prescriptive requirements defined in the State of Ohio regulations for the construction of a solid waste landfill (OAC 3745-27-08). The lining system would also incorporate the supplemental design requirements imposed by the RCRA as defined at 40 CFR 265.301 for a hazardous waste landfill. The conceptual design for the multilayered capping system

would attain, as a minimum, the State of Ohio construction requirements for a solid waste landfill (OAC 3745-27-08). To ensure long-term performance, the conceptual design basis has been supplemented to incorporate the design features defined at 40 CFR 265.301 for hazardous waste landfills. Additionally, the conceptual design basis for the facility capping system incorporates design performance requirements provided by the Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192). The final design approach for the facility would accommodate each of these ARARs with final demonstration of attainment as part of the certification for construction remedial design packages.

These design features, coupled with the incremental protective benefits that are offered by the native geology, provide a degree of protection for the aquifer equivalent to that envisioned by the State of Ohio in their exemption criteria. The waste acceptance criteria for the disposal system, which consider the protective features of both the engineering controls and the natural geology, are developed specifically to provide protection for the Great Miami Aquifer for a 1000-year performance period.

5.6.2.2 Level of Performance

The waste acceptance criteria for the disposal facility were developed through computer modeling simulations that take credit for both the design features (e.g., the liners and cap) and the incremental protective properties provided by the native geology underlying the facility. The design features and the native geology function together as a system to provide the protection of the Great Miami Aquifer. The waste acceptance criteria that have been developed through the simulation efforts conducted as part of the Operable Unit 5 FS strike a technical balance between the protective features of the facility design and those offered by the native geology. If the protective properties of the native geology were such that they could be relied upon on their own merit to meet the exemption criteria envisioned by the State of Ohio, then this would permit the establishment of a higher waste acceptance criteria that could take additional credit for the additional protection that is offered by the more reliable geology. Conversely, as the geology becomes less reliable, the waste acceptance criteria must decrease accordingly, and a greater volume of affected materials will require shipment and disposal off site. Therefore, the waste acceptance criteria value itself establishes the equivalent level of performance that can be expected for any combination of engineering controls and native hydrogeology.

EPA, in consultation with OEPA, will have approval authority for all of the waste acceptance criteria developed for the on-property facility to ensure that the FEMP has identified the proper balance between the protective credits available from the native geology and the facility's design features.

The waste acceptance criteria have been developed to ensure that the adopted concentration-based PRLs for the Great Miami Aquifer are not exceeded at any location in the aquifer for a period up to 1000 years. The preliminary waste acceptance criteria for the on-property disposal facility are presented in Section F.5 of Appendix F. The criteria are based upon a conservative modeling approach that takes into account the concentration, available mass, and mobility of the contaminants to ensure the long-term protection of human health and the environment. Supplemental operational constraints would also be imposed to prevent the disposal of any other materials that could compromise the long-term structural integrity of the disposal facility.

5.6.2.3 Reliability into the Future

The design basis for the disposal facility is focused on meeting the 1000-year upper bound time frame of the 200- to 1000-year performance period mandated by 40 CFR 192 requirements. As part of the conceptual design process used to establish 1000-year design requirements, hypothetical failure modes were examined to identify critical design components affecting the long-term performance and reliability of the facility. This failure analysis was conducted to provide a relative measure for assessing compliance of the design with 40 CFR 192 performance requirements. For the analysis, effectiveness was defined as ensuring that protective standards for drinking water were not exceeded in the Great Miami Aquifer at any point beneath the facility's footprint. The performance analysis focused on the long-term infiltration rate through the cell considering the reliability and anticipated performance lifetimes of various components of the multilayer cap and the leachate collection system in the disposal facility. Conducted using Monte Carlo probablistic failure simulations, the performance analysis provided perspective as to whether the conceptual design could be relied upon for 1000 years.

Even under the hypothetical failure modes evaluated through the Monte Carlo simulations, the disposal facility was found to be reliable over the full 200- to 1000-year performance period envisioned by 40 CFR 192. As a means to enhance long-term performance, the waste acceptance criteria development process took into consideration the most probable hypothetical failure mechanism (failure of synthetic cap and liner materials over time) as if it occurred from day one of the facility's performance period. Thus, no protective credits were taken for the synthetic elements of the design in establishing the concentration-based waste acceptance criteria. This action provides an additional margin of safety to account for the inherent uncertainties that exist in predicting the long-term performance of synthetic engineering materials, and is customary practice for designs based on 40 CFR 192.

The performance assessment provides a reasonable level of assurance that the on-property disposal facility will cause negligible impacts to the Great Miami Aquifer within the first 200 years. This time frame is much longer than the 52-year performance lifetime envisioned by the State of Ohio siting

restriction exemption provisions. The quantitative details of the performance assessment including procedures, assumptions, and results are presented in Appendix F.

5.6.2.4 Time Required for Results

This criterion focuses on EPA's expectation that by granting a waiver of an ARAR, the time to achieve remedial objectives through the alternative approach or technology should not be significantly more than that required under the waived ARAR. From this criterion, EPA can also weigh the benefits of an alternative approach against the time constraints required for implementation, recognizing that duration needs to be balanced against other beneficial factors as necessary.

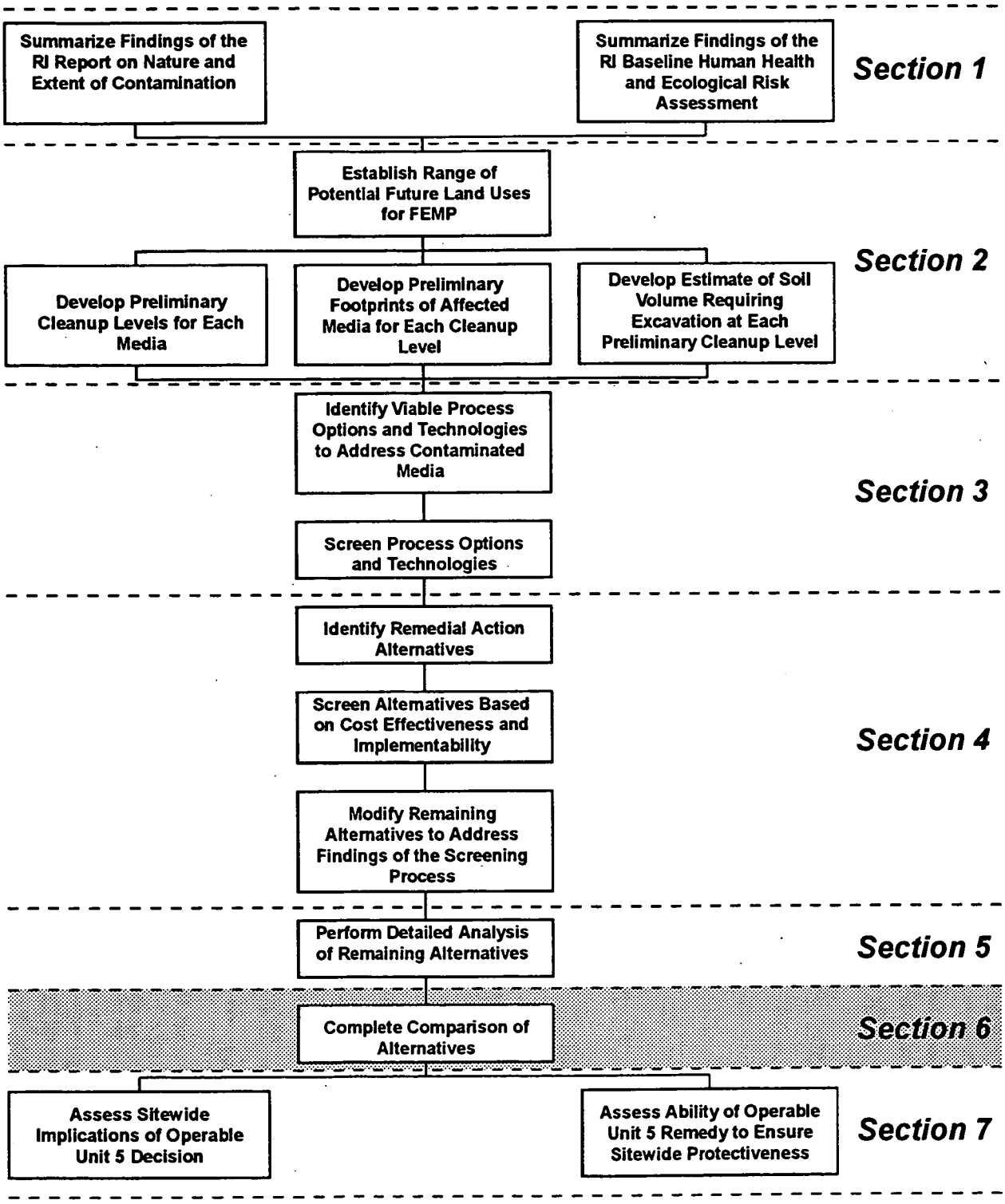
Failure to secure the waiver to the two State of Ohio siting restrictions could significantly extend the time required for the FEMP to achieve target remedial action objectives. If the waiver is not granted, all of the material from all operable units would require off-site disposal. A significant delay in the FEMP's remediation effort could be encountered while off-site disposal capacity is secured for up to 10 million cubic yards (depending on the final cleanup levels selected by EPA) of affected material. Licensed off-site disposal capacity would need to be available on a continuous basis for at least 20 years to meet these needs. Through the use of established waste acceptance criteria thresholds, the on-site disposal option for the FEMP presents a more balanced management approach by designating those materials that can remain on-site and safely meet all site-specific protective requirements, and those materials that require off-site disposal by virtue of their contaminant concentrations or characteristics.

Construction of the design facility will be governed by strict adherence to field implementation of quality assurance and quality control requirements to ensure longevity of the engineering controls. Best management practices will be used during construction and would include such activities as agency review of construction plans and oversight of the actual construction of the facility.

5.6.3 Conclusion

On the basis of the foregoing considerations, it is concluded that the engineered features of the disposal facility coupled with the incremental protective features that are provided by the native geology below the facility and strict application of waste acceptance criteria for materials placed in the facility would provide an equivalent level of protection for the Great Miami Aquifer to that envisioned by the State of Ohio in their exemption criteria established for the two aquifer-based siting prohibitions. These elements taken together provide a sound basis for granting the required CERCLA waiver to the siting-restriction ARARs.

Section 6.0


Summarize Findings of the RI Report on Nature and Extent of Contamination
Summarize Findings of the RI Baseline Human Health and Ecological Risk Assessment
Section 1
Establish Range of Potential Future Land Uses for FEMP
Develop Preliminary Cleanup Levels for Each Media
Develop Preliminary Footprints of Affected Media for Each Cleanup Level
Develop Estimate of Soil Volume Requiring Excavation at Each Preliminary Cleanup Level
Section 2
Identify Viable Process Options and Technologies to Address Contaminated Media
Screen Process Options and Technologies
Section 3
Identify Remedial Action Alternatives
Screen Alternatives Based on Cost Effectiveness and Implementability
Modify Remaining Alternatives to Address Findings of the Screening Process
Section 4
Perform Detailed Analysis of Remaining Alternatives
Section 5
Complete Comparison of Alternatives
Section 6
Assess Sitewide Implications of Operable Unit 5 Decision
Assess Ability of Operable Unit 5 Remedy to Ensure Sitewide Protectiveness
Section 7

6.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section provides a comparative analysis of the remedial alternatives that were evaluated in Section 5.0. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another, so that key tradeoffs to be considered by project stakeholders and regulatory decision makers can be identified. Highlights of the individual alternative evaluations are provided to assist decision makers in identifying which alternative best qualifies as the preferred remedy for Operable Unit 5.

Similar to the detailed analyses conducted in Section 5.0, the comparative analysis is conducted using seven of the nine National Contingency Plan (NCP) evaluation criteria as the framework for identifying technical and administrative differences among the alternatives. The remaining two criteria, state and community acceptance, are not included because these criteria cannot be assessed until after the Proposed Plan has been issued and public comments on the preferred alternative have been received. The state and community acceptance considerations will be formally evaluated and documented in the Record of Decision (ROD).

6.1 SCOPE OF THE OPERABLE UNIT 5 REMEDY DECISION

There are three key elements that together define the scope of the remedy decision for Operable Unit 5:

- Selection of a site-wide ***land use objective*** that meets the expectations of project stakeholders and that is achievable within physical and administrative constraints
- Selection of an appropriate ***residual risk level*** for the site that is protective of human health and the environment, technically achievable, and cost effective
- Selection of a ***preferred remedial alternative*** that best meets desired land use objectives and intended residual risk levels following remediation.

The comparative analysis summarizes the findings of the feasibility study (FS) with respect to each of these considerations. These findings form the basis for the tradeoff evaluations that are necessary in identifying the preferred remedy for Operable Unit 5.

As the comparative analysis will demonstrate, the residual risk level that is selected for Operable Unit 5 (from among the range of choices deemed acceptable by the NCP) is the key factor controlling the range of costs for the remedy. A much narrower cost range is embodied in the selection of the desired land use objective, primarily because the on-property soil remediation requirements for protection of the Great Miami Aquifer are indistinguishable for all four land use objectives. Similarly, the cost differentials associated with the remedial alternatives themselves are overshadowed by the differentials

accompanying the selection of the residual risk level. Thus the controlling factor on cost is not necessarily the land use or the remedial alternative sought, but rather the carcinogenic risk level deemed to be appropriate by the decision makers for the conditions present.

Sections 6.2 and 6.3 summarize the respective land use objectives and residual risk considerations identified through the FS, and Section 6.4 presents the comparison of the remedial alternatives with respect to the seven evaluation criteria specified in the NCP.

6.2 EVALUATION OF LAND USE OBJECTIVES

As discussed throughout the FS, four broad land use objectives were used to guide the alternative development process and establish land use-specific cleanup levels for the Fernald Environmental Management Project (FEMP). The land use objectives serve as a point of departure for evaluating site physical constraints (e.g., 1050-acre size, physical distance to off-property receptors, groundwater protection requirements, and quantities of affected media) on land use choices. While the land use objectives each differ in their strategic intentions, the physical constraints of the site ultimately govern the measurable technical distinctions that can be maintained among the objectives. Comparisons of the four objectives are summarized below.

6.2.1 Comparison of Land Use Objectives 1 and 2

Land use Objective 1 examines the viability of returning the entire on-property area to full unrestricted use (defined as suitable for residential farming) following remediation. Under this objective, no institutional controls are needed and there are no restricted waste management areas anywhere on property.

In order to meet the requirements of this objective, no material from any of the operable units can remain on site if concentration levels exceed levels protective of the hypothetical resident farmer. Waste materials from all of the operable units must therefore be sent off site along with the vast majority of Operable Unit 5 soil.

Under the constraint that all of the operable units must select off-site disposal alternatives to meet the intentions of Objective 1, the viability of off-site disposal capacity becomes significantly more uncertain with the corresponding increase in volumes that are required to be shipped. To place the off-site disposal capacity requirements of this land use objective into perspective, the combined total volume of material (for all operable units) that would require off-site shipment and disposal to meet a 10^{-5} unrestricted use risk level is more than 3 million cubic yards. When 10^{-6} requirements are considered, the total increases to more than 10 million cubic yards. Licensed off-site disposal capacity would need to be available on a continuous basis for at least 20 years to meet these needs.

Objective 1 presumes that the entire site (including all of the production and waste storage areas) can be restored to levels protective of the resident farmer with sufficient certainty to "walk away" from the property without the need for additional institutional care or access control. If institutional arrangements are put in place to address site uncertainties or the practicalities of removing all wastes and contaminated media from the property, then Objective 1 will converge with the intentions of Objective 2.

From a practical perspective, uncertainties regarding cleanup will always remain at the site, even if monitoring data show that cleanup levels have been obtained for unrestricted use. The greatest uncertainties will be present in the former production area and the waste storage areas (Operable Units 1, 3 and 4), where contaminant concentrations have been highest and the greatest volume of affected environmental media resides. It is not realistic to consider that these areas would ever be restored with sufficient certainty to walk away and allow residential farming without any additional access or institutional controls.

Objective 2 shares the same basic intentions as Objective 1 (freeing as much land as possible for agricultural use) while also allowing on-site disposal of materials that meet protective, site-specific waste acceptance criteria. Conversely, Objective 1 shifts the burden for these materials to another off-site location, regardless of the fact that the materials can meet waste acceptance criteria at their present location. Objective 2 thus seeks a more balanced perspective -- through the use of waste acceptance criteria thresholds -- to identify those materials which require off-site disposal and those materials which can remain on site and still meet site-specific protective requirements for unrestricted use. As indicated in Section 5.0, approximately 90 percent of the on-property area could potentially be made available for farming under Land Use Objective 2 (when 10^{-5} risk levels are considered) which compares favorably to the expectations for cleanup under Land Use Objective 1.

By virtue of these considerations, coupled with the need for all of the operable units to ship their materials off site under Objective 1, Land Use Objective 2 is considered the more appropriate for returning the FEMP on-property area to residential farming.

6.2.2 Comparison of Land Use Objectives 2 and 3

A comparison of Land Use Objectives 2 and 3 provides insight into the incremental costs and technical considerations required to achieve farming as opposed to other, nonfarming land uses. The non-farming land uses considered under Land Use Objective 3 (commercial/industrial, recreational, and green space use) are consistent with the alternative land uses under consideration by the Fernald Citizens Task Force. Preliminary recommendations by the Task Force indicate a preference for returning the FEMP on-property area to productive use, but for uses other than residential farming.

Selection of Objective 3 as the representative land use for Operable Unit 5 will thus result in concurrence between the FEMP's intentions and the indicated desires of the Task Force.

The soil cleanup levels associated with return of the FEMP on-property area to residential farming fall below those that can be readily tracked with hand-held instruments, resulting in a more expensive analytical program to implement and certify the success of the remedial effort. Many of the soil remediation levels for on-property farming require cleanup to levels at or near soil background levels or to analytical detection limits. At these low levels, the ability to track and verify the success of the remedial effort becomes much more difficult, relying almost exclusively on statistical procedures to distinguish remedial levels from natural variations in background levels. Conversely, soil cleanup levels for the nonfarming land uses can be readily distinguished from background, are verifiable with laboratory analytical methods, and can be tracked confidently in the field with hand-held instruments during execution of the cleanup activities. Thus, selection of Land Use Objective 3 as the representative land use objective will result in a more certain and verifiable action that can be relied on with confidence over the long term. Based on these primary considerations, Objective 3 is retained in preference to Objective 2 for consideration as the representative land use objective.

6.2.3 Comparison of Land Use Objectives 3 and 4

Under Land Use Objective 4, no special consideration is given to freeing on-property areas for alternative use, and the establishment of a consolidated waste management area is not a necessary requirement unless needed indirectly to satisfy reasonable maximum exposure (RME)-based protective constraints. The intention of this objective is to minimize the amount of soil excavation to that necessary to meet remedial requirements for an on-property trespasser and protection of groundwater receptors beyond the property fence line. Maximum reliance on institutional controls to restrict access to on-property areas forms the strategic basis of Land Use Objective 4.

Protection of off-property groundwater, however, becomes the controlling factor for the cross-media cleanup levels that are necessary under Objective 4. The groundwater attenuation distances between the 1050-acre property fence line and the representative consolidation area footprints under Objective 3 are not sufficient to allow for a meaningful reduction in cross-media cleanup levels between Objectives 3 and 4. The total volume of soil that requires excavation for groundwater protection purposes is practically identical for Objectives 3 and 4, resulting in little overall cost differential between the two objectives. Once the cross-media preliminary remediation levels (PRLs) are satisfied for Objective 4, the incremental excavation volumes required to achieve land use Objective 3's remaining PRLs are negligible.

Land Use Objective 4 also presents several other programmatic constraints that make it less attractive than the others. Once groundwater protection requirements are satisfied, Objective 4 then relies on

access prohibitions and institutional controls to protect all RME receptors (beyond the hypothetical trespasser) from the presence of residual contamination on the property. While it is a valid assumption that long-term institutional controls (such as rights of ownership) can effectively prohibit site development for residential farming or commercial/industrial use, it is not valid to assume that the same controls can prohibit the casual recreational user from entering the property over the long term. Therefore, Objective 3 offers significant advantages over Objective 4, because of the lower level of reliance on institutional controls to effectively regulate and control long-term land use. Because Land Use Objective 3 results in less restrictive and therefore more preferable land use opportunities than Objective 4, with little incremental increase in cost, Objective 3 can be retained in preference to Objective 4 as the representative land use objective.

On the basis of the foregoing comparisons, Land Use Objective 3 is deemed most appropriate for consideration as the candidate land use objective for Operable Unit 5.

6.3 RESIDUAL RISK LEVEL CONSIDERATIONS

As indicated in the NCP, the U.S. Environmental Protection Agency (EPA) can select an appropriate residual risk level from among a range of choices for a site being remediated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The preamble to the NCP specifies the factors EPA is to consider in deciding where within the 10^{-4} to 10^{-6} residual risk range media cleanup standards should be established; these factors include:

- The cumulative effect of multiple contaminants and multiple exposure pathways
- Exposure factor uncertainties
- Population sensitivities
- Impacts on environmental receptors that are not addressed by human health considerations
- Cross-media impacts
- Detection/quantification limits for contaminants
- Ability to monitor and control the movement of contaminants
- Technical limits to remediation
- Background levels of risk.

In April 1991, EPA issued a policy directive entitled "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (OSWER Directive 9355.0-30) which clarified where within the NCP carcinogenic risk range EPA is expected to take action. As specified in the directive, action is not generally warranted unless cumulative carcinogenic risks exceed 10^{-4}, (provided there are no adverse environmental impacts), the noncarcinogenic hazard index (HI) is less than 1, and cross-media impacts do not exceed maximum concentration levels (MCL) or nonzero maximum concentration level goals (MCLGs) in groundwater used as a drinking water source. Thus 10^{-4} is the current regulatory-

based point of departure for selecting an appropriate residual risk level from within the prescribed NCP risk range.

As indicated earlier, the greatest cost differentials within the scope of the Operable Unit 5 remedy decision occur in the selection of the target residual risk levels. These cost differentials are a direct result of the increases in soil volumes that accompany lower risk-based cleanup levels. Examples of these cost differentials for the resident farmer risk-based excavation cases are presented below, using total uranium risk levels to illustrate representative excavation volumes.

For the 10^{-6} residual risk levels for the resident farmer, the corresponding soil excavation volume is over 9 million cubic yards. For 10^{-5} levels, the volumes decrease to approximately 2.7 million cubic yards, and at hazard index (HI)=1 levels, the volumes decrease to approximately 1.6 million cubic yards. As noted in Section 2.0, the affected soil volumes that exceed HI=1 risk levels for total uranium are all confined to the FEMP's on-property area. Thus, under current conditions without further action, all off-property areas fall within the prescribed risk range indicated by the NCP. A pivotal issue confronting decision makers, therefore, is where within the prescribed risk range the appropriate value should be selected. Some of the primary considerations affecting this decision are highlighted below, using the resident farmer risk-based levels for total uranium as illustrative examples.

The lower-end 10^{-6} residual risk level to the resident farmer for soil is one alternative that decision makers must consider during their deliberations. Selection of a 10^{-6} residual risk level to the resident farmer as the point of departure for soil presents a number of practical concerns and technical constraints, as follows:

- The 10^{-6} affected area occupies approximately 10.2 square miles of off-property land
- The 10^{-6} affected area represents over 9 million cubic yards of soil
- The 10^{-6} residual risk level is close to background and also close to the quantitative laboratory analytical detection limit for uranium and other contaminants of concern. These constraints affect the ability to track and monitor the affected areas and the progress/success of remediation to the 10^{-6} level. The same laboratory analytical constraints are virtually eliminated at the 10^{-5} risk level and above. Hand-held field-screening methods for real-time excavation control and hot-spot identification become technically viable at approximately the HI=1 risk levels for uranium and above.
- Remediation to a 10^{-6} residual risk level would cause significant physical disturbance to off-property wetlands, habitats, cultural resources, natural vegetative communities and cultivated croplands. While these same concerns are present at the 10^{-5} residual risk level, their significance is diminished. Additionally, at an HI=1 risk level for uranium, negligible off-property areas would be disturbed and few on-property natural wetlands

would be affected. Removal of soil to the 10^{-6} level would remove tremendous quantities of topsoil from currently productive agricultural lands.

The foregoing paragraphs discuss soil volume considerations accompanying cleanup levels for the resident farmer scenarios. Expanding on this concept, Figure 6-1 displays the affected soil volume/soil concentration relationships for all of the total uranium soil PRLs under consideration in the FS. The soil volume/soil concentration curve clearly indicates the concentration levels beyond which the incremental additional soil volume to be removed for disposal becomes substantial and disproportionate to the incremental degree of protection it may achieve over a lower-preference cleanup action. Generally, at concentration levels between 50 and 30 ppm, there is a distinctive breakpoint in the curve, indicating that soil volumes are increasing disproportionately to the incremental decrease in uranium concentration. At concentration levels of 50 ppm and higher, there is a more balanced, proportional relationship between soil volume and the corresponding change in concentration level.

It also needs to be recognized as part of the Operable Unit 5 remedy decision that the residual risk levels under consideration are based on long-term hypothetical conditions that apply to RME receptors representing each category of land use. Under current (actual) conditions, large portions of the FEMP exhibit existing measured concentrations in soil that are protective of a number of the surface-based uses requiring minimum access restrictions. These alternate land uses could be considered for application to select portions of the FEMP property (without additional cleanup) based on the results of ongoing environmental monitoring programs currently in place.

6.4 COMPARISON OF THE ALTERNATIVES

This section presents the results of the comparison of the remedial alternatives using the NCP evaluation criteria as the framework for identifying the technical and administrative differences between the alternatives. Highlights of the individual alternative evaluations are provided to assist in the decision of which alternative best qualifies as the preferred alternative for Operable Unit 5.

6.4.1 Threshold Criteria

The NCP categorizes overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements (ARARs) as threshold criteria which must be attained by the selected remedial action. To facilitate the comparative analysis process, the key points discussed in Section 5.0 pertaining to each of the evaluation criteria have been arrayed in tables. Table 6-1 provides a summary of key technical data associated with each of the remedial alternatives. Table 6-2 presents a summary of the comparison of the alternatives against each of the seven evaluation criteria, including the present worth cost of each alternative. Table 6-3 provides a summary of the projected environmental resource impacts associated with each of the alternatives under consideration.

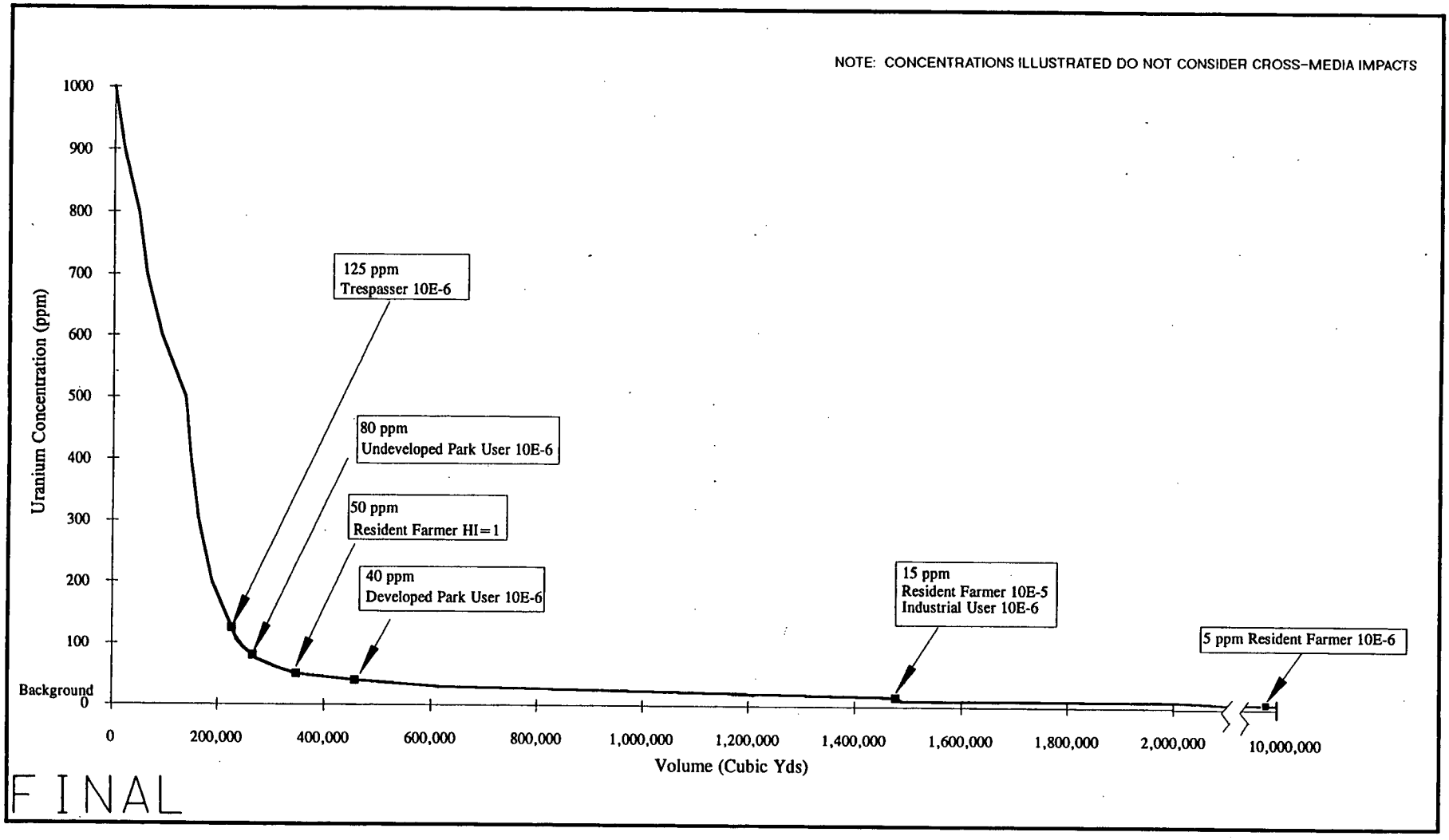


FIGURE 6 - 1.

COMPARISON OF AFFECTED SOIL VOLUME FOR VARIOUS URANIUM SOIL CONCENTRATIONS

000560

TABLE 6-1
DATA SUMMARY FOR REMEDIAL ALTERNATIVES

Alternative/L and Use Objective [a]	Risk Case PRL [b]	On-property Soil Excavation (10^6 yd^3)	Off-property Soil Excavation (10^6 yd^3)	Off-property Transport (10^6 yd^3)	Rail Cars (loads)	Disposal Facility (10^6 yd^3)	Consolidation w/Earthen Cover (10^6 yd^3)
1/1	1	4.45	5.2	9.35	165,000	0	0
	2	2.34	0.4	2.4	42,000	0	0
2A/2	1	4.45	5.2	0.05	880 [c]	9.30	0
	2	2.34	0.4	0.025	440	2.37	0
2C/2	1	4.45	5.2	9.35	165,000	0	0
	2	2.34	0.4	1.16	20,400	0	1.24
3A/3	3	1.99	0.4	0.025	440	2.34	0
	4	1.8	0.4	0.025	440	1.75	0
	5	1.79	0.4	0.025	440	1.75	0
	6	1.78	0.001	0.025	440	1.75	0
	7	1.79	0.001	0.025	440	1.75	0
3C/3	3	1.99	0.4	1.15	20,200	0	1.22
	4	1.8	0.4	1.13	19,900	0	0.652
	5	1.79	0.4	1.12	19,700	0	0.652
	6	1.79	0.001	1.12	19,700	0	0.652
	7	1.8	0.001	1.12	19,700	0	0.652
4A/4	8	1.79	0.4	0.025	440	1.75	0
	9	1.78	0.001	0.025	440	1.75	0
4C/4	8	1.79	0.4	1.12	19,700	0	0.652
	9	1.78	0.001	1.12	19,700	0	0.652
No action		0	0	0	0	0	0

[a] 1) Full unrestricted use
2) Establishment of a consolidated waste management area with unrestricted use of the remaining areas of the property.
3) Establishment of a consolidated waste management area with restricted use of the remaining areas of the property.
4) Restricted use of the entire on-property area.

[b] Refer to Table 2-18; target risk cases evaluated in Feasibility Study for uranium PRLs for soil for each risk case.

[c] For off-site transport quantities of 50,000 yd^3 or less, shipment may actually be made by truck rather than by rail.

TABLE 6-2
OPERABLE UNIT 5
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs[a]	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present Worth Cost vs. Risk Case (Millions of Dollars)
1. Excavate and dispose of soil off property; extract, treat and discharge groundwater	Protective of hypothetical on-property farmer for entire site	Complies with all ARARs	Totally effective and permanent; 100% of contaminated soil leaves the site	No treatment of soil/sediment	High impacts primarily associated with material handling and transportation	Technically implementable; uncertainties for disposal capacity; administratively difficult	$4330/Case 1 1240/Case 2
2A. Excavate and dispose of soil in on-property facility; off-property disposal of soil not meeting facility waste acceptance criteria; extract, treat, and discharge groundwater	Protective of hypothetical on-property farmer for portions of the FEMP and of the trespasser for disposal area	Complies with all ARARs (with waiver)	Effective and permanent; requires continued minimal maintenance; 0.5% of Case 1 and 0.9% of Case 2 contaminated soil leaves the site	No treatment of soil/sediment	Moderate impacts	Technically implementable; moderate project complexity; low administrative difficulty	$2290/Case 1 720/Case 2
2C. Excavate and dispose of heavily contaminated soil off property; consolidate slightly contaminated soil; extract, treat, and discharge groundwater	Protective of hypothetical on-property farmer for portions of the FEMP and of the trespasser for consolidation area	Complies with all ARARs (with waiver)	Highly effective and permanent; approximately 100% of Case 1 and 42% of Case 2 contaminated soil leaves the site	No treatment of soil/sediment	High impacts primarily associated with material handling and transportation	Technically implementable; uncertainties for disposal capacity; administrative difficulty	$4330/Case 1 910/Case 2
3A. Excavate and dispose of soil in on-property facility; off-property disposal of soil not meeting facility waste acceptance criteria; extract, treat, and discharge groundwater	Protective of hypothetical on-property industrial worker and recreational user for portions of the FEMP and of the trespasser for disposal area	Complies with all ARARs (with waiver)	Effective and permanent; requires minimal continued maintenance; approximately 1% of Case 3, 1.13% of Case 4, 1.14% of Case 5, 1.4% of Case 6, and 1.39% of Case 7 contaminated soil leaves the site	No treatment of soil/sediment	Moderate impacts	Technically implementable; moderate complexity; low administrative difficulty	$630/Case 3 630/Case 4 610/Case 5 580/Case 6 580/Case 7

TABLE 6-2 (Continued)

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs[a]	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume Through Treatment	Short-Term Effectiveness	Implementability	Present Worth Cost vs. Risk Case (Millions of Dollars)
3C. Excavate and dispose of heavily contaminated soil off property; consolidate slightly contaminated soil; extract, treat, and discharge groundwater	Protective of hypothetical on-property industrial worker and recreational user for portions of the FEMP and of the trespasser for disposal area	Complies with all ARARs (with waiver)	Highly effective and permanent; approximately 48% of Case 3, 51% of Case 4, 51% of Case 5, 62.6% of Case 6, and 62.2% of Case 7 contaminated soil leaves the site	No treatment of soil/sediment	High impacts primarily associated with material handling and transportation	Technically implementable; uncertainties for disposal capacity; administrative difficulty	$820/Case 3 800/Case 4 770/Case 5 830/Case 6 770/Case 7
4A. Excavate and dispose of soil in on-property facility; extract, treat, and discharge groundwater	Protective; requires access controls; all areas of FEMP protective of trespasser	Complies with all ARARs (with waiver)	Effective and permanent; requires minimal continued maintenance; approximately 1.14% of Case 8 and 1.4% of Case 9 contaminated soil leaves the site	No treatment of soil/sediment	Moderate impacts	Technically implementable; moderate technical complexity; moderate administrative difficulty	$610/Case 8 580/Case 9
4C. Excavate and dispose of soil off property; extract, treat, and discharge groundwater	Protective; requires access controls to portions of FEMP; all areas protective of trespasser	Complies with all ARARs (with waiver)	Highly effective and permanent; approximately 51% of Case 8 and 62% of Case 9 contaminated soil leaves the site	No treatment of soil/sediment	High impacts	Technically implementable; uncertainties for future disposal capacity; administrative difficulty	$800/Case 8 780/Case 9
No action	Not protective	Does not meet ARARs	Not effective over the long-term	No treatment	No impacts; access controls continue	Not administratively feasible	0

[a]Applicable and appropriate requirement or relevant

TABLE 6-3

SUMMARY OF ENVIRONMENTAL IMPACTS FOR REMEDIAL ALTERNATIVES

Alternative	Risk Case	Soil and Geology	Water Quality and Hydrology	Air Quality	Biotic Resources	Wetlands and Floodplains	Socioeconomics and Land Use	Cultural Resources	Transport Impacts
No Action		No further impacts	Potential for release to surface and groundwater	Potential for release to ambient air	Potential exposure to ecological receptors	Potential for release to 36 acres of wetlands	Restriction of site's future use	No impacts	No impacts
1	1	171 acres committed to off-property disposal	Minor impacts assuming monitoring and controls.	Fugitive dust emissions; minor impacts assuming controls.	Minor impacts at off-property disposal facility.	36 acres of wetlands lost	Up to 13% annual increase over 22 years in consolidated metropolitan statistical area (CMSA), slowing to 2.5% annual increase for remaining 53 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 4.6×10^{-7} along rail route to off-property disposal facility
1	2	44 acres committed to off-property disposal	Minor impacts assuming monitoring and controls.	Fugitive dust emissions; minor impacts assuming controls.	Minor impacts at off-property disposal facility.	17 acres of wetlands lost	Up to 5% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 1.1×10^{-7} along rail route to off-property disposal facility

TABLE 6-3 (continued)

Alternative	Risk Case	Soil and Geology	Water Quality and Hydrology	Air Quality	Biotic Resources	Wetlands and Floodplains	Socioeconomics and Land Use	Cultural Resources	Transport Impacts
2A	1	301 acres committed to on-property disposal; 0.9 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls	Permanent disruption of 57 acres of terrestrial habitat; minor impacts at off-property disposal facility.	36 acres of wetlands lost	Up to 22% annual increase over 22 years in CMSA, slowing to 2.5% annual increase for remaining 53 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 2.8×10^{-8} along truck route to off-property disposal facility
2A	2	137.6 acres committed to on-property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 57.5 acres of terrestrial habitat; minor impacts at off-property disposal facility.	17 acres of wetlands lost	Up to 7% annual increase over 22 years in CMSA, slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 1.4×10^{-8} along truck route to off-property disposal facility.
2C	1	171 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Minor impacts at off-property disposal facility.	36 acres of wetlands lost	Up to 13% annual increase over 22 years in CMSA, slowing to 2.5% annual increase for remaining 53 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 4.6×10^{-7} along rail route to off-property disposal facility.

7069

000565

TABLE 6-3 (continued)

Alternative	Risk Case	Soil and Geology	Water Quality and Hydrology	Air Quality	Biotic Resources	Wetlands and Floodplains	Socioeconomics and Land Use	Cultural Resources	Transport Impacts
2C	2	107.2 acres committed to on-property disposal; 21 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 29 acres of terrestrial habitat; minor impacts at off-property disposal facility.	17 acres of wetlands lost	Up to 13% annual increase over 22 years in CMSA, slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 8.6×10^{-8} along rail route to off-property disposal facility.
3A	3	137.6 acres committed to on-property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 57.5 acres of terrestrial habitat; minor impacts at off-property disposal facility.	17 acres of wetlands lost	Up to 4.7% annual increase over 22 years in CMSA, slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 1.4×10^{-8} along truck route to off-property disposal facility.
3A	4	137.6 acres committed to on-property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 57.5 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6.4% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ICLR of 1.4×10^{-8} along truck route to off-property disposal facility

000566

TABLE 6-3 (continued)

Alternative	Risk Case	Soil and Geology	Water Quality and Hydrology	Air Quality	Biotic Resources	Wetlands and Floodplains	Socioeconomics and Land Use	Cultural Resources	Transport Impacts
3A	5	137.6 acres committed to on-property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 57.5 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6.4% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ICLR of 1.4×10^{-8} along truck route to off-property disposal facility
3A	6	137.6 acres committed to on-property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 57.5 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6.4% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture.	No impact due to identification and management	ICLR of 1.4×10^{-8} along truck route to off-property disposal facility
3A	7	137.6 acres committed to on- property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 57.5 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6.4% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture.	No impact due to identification and management	ICLR of 1.4×10^{-8} along truck route to off-property disposal facility

TABLE 6-3 (continued)

Alternative	Risk Case	Soil and Geology	Water Quality and Hydrology	Air Quality	Biotic Resources	Wetlands and Floodplains	Socioeconomics and Land Use	Cultural Resources	Transport Impacts
3C	3	107.2 acres committed to on- property disposal; 21 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 29 acres of terrestrial habitat; minor impacts at off-property disposal facility.	17 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 8.5×10^{-8} along rail route to off-property disposal facility.
3C	4	94.8 acres committed to on-property disposal; 21 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 25 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ICLR of 8.3×10^{-8} along rail route to off-property disposal facility
3C	5	94.8 acres committed to on-property disposal; 20 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 25 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ICLR of 8.3×10^{-8} along rail route to off-property disposal facility

TABLE 6-3 (continued)

Alternative	Risk Case	Soil and Geology	Water Quality and Hydrology	Air Quality	Biotic Resources	Wetlands and Floodplains	Socioeconomics and Land Use	Cultural Resources	Transport Impacts
3C	6	94.8 acres committed to on-property disposal; 20 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 25 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture.	No impact due to identification and management	ICLR of 8.3×10^{-8} along rail route to off-property disposal facility
3C	7	94.8 acres committed to on-property disposal; 20 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 25 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA, slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture.	No impact due to identification and management	ILCR of 8.3×10^{-8} along rail route to off-property disposal facility.
4A	8	118.2 acres committed to on-property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 13.7 acres of terrestrial habitat; minor impact at off-property disposal facility.	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA, slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ICLR of 1.4×10^{-8} along truck route to off-property disposal facility

TABLE 6-3 (continued)

Alternative	Risk Case	Soil and Geology	Water Quality and Hydrology	Air Quality	Biotic Resources	Wetlands and Floodplains	Socioeconomics and Land Use	Cultural Resources	Transport Impacts
4A	9	118.2 acres committed to on-property disposal; 0.5 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 13.7 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA, slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture.	No impact due to identification and management	ILCR of 1.4×10^{-8} along truck route to off-property disposal facility.
4C	8	92.3 acres committed to on-property disposal; 20 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 6.3 acres of terrestrial habitat; minor impacts at off-property disposal facility.	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA, slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture, commercial, and residential.	No impact due to identification and management	ILCR of 8.3×10^{-8} along rail route to off-property disposal facility.
4C	9	92.3 acres committed to on-property disposal; 20 acres committed to off-property disposal	Minor impacts assuming monitoring and controls	Fugitive dust emissions; minor impacts assuming controls.	Permanent disruption of 6.3 acres of terrestrial habitat; minor impacts at off-property disposal facility	9 acres of wetlands lost	Up to 6% annual increase over 22 years in CMSA slowing to 1.7% annual increase for remaining 8 years. If selected, socioeconomic impacts from off-property excavation will be assessed. Land-use to be impacted would include areas zoned for agriculture.	No impact due to identification and management	ILCR of 8.3×10^{-8} along rail route to off-property disposal facility.

000570

6.4.1.1 Overall Protection of Human Health and the Environment

All of the action alternatives would provide permanent solutions and adequately protect human health and the environment. The no-action alternative would allow for continued migration of site contaminants and would not provide for the protection of human health and the environment. Alternative 1 ranks the highest in terms of the degree of protectiveness, as measured by reduced uncertainty and long-term effectiveness. Alternative 1 involves the removal of contaminated soil and sediment from the site to a permitted off-site disposal facility. This alternative provides a high level of certainty for continued long-term protectiveness and requires no provisions for perpetual institutional controls or five-year CERCLA reviews. Future uncertainties on the availability of off-site disposal capacity could affect the implementability of this alternative, potentially causing delays in the attainment of the remedial objectives.

Alternatives applying the use of the on-property disposal facility provide the highest level of protectiveness for land uses involving on-property disposal. For alternatives relying on an engineered disposal facility, conservative design assumptions and the adoption of concentration-based waste acceptance criteria would supplement existing site geology to ensure the long-term performance of the disposal system. Modeling runs completed for the FS on the performance of the disposal facility demonstrate that even in the presence of hypothetical failure modes considered through Monte-Carlo simulations, there is an 80 percent likelihood that the disposal facility can protect the aquifer for a 1000-year performance period, as indicated by the performance assessment in Appendix F.

Alternatives relying on on-property disposal typically presented the lowest overall short-term risk to remediation workers and off-property residents. Short-term risks are those occurring during implementation of the remedial action and include mechanical hazards, transportation related injuries/fatalities, and impacts due to releases (i.e., fugitive dust, etc) during construction activities. For the on-property disposal alternatives, short-term risks were directly related to the quantity of material excavated (i.e., the remediation levels) and placed in the disposal facility. The larger the quantity excavated, the higher the associated short-term risks.

Alternatives employing the disposal facility would adequately protect flora and fauna, including aquatic life in Paddys Run and the Great Miami Aquifer. For select remediation levels (i.e., 10^{-6} ILCR to the resident farmer), significant acreage of forested wetlands and forested areas both on and off the FEMP property would be excavated. For alternatives not contemplating a residential farming land use at the FEMP, no areas of forested wetlands on or off the FEMP property would be disturbed.

6.4.1.2 Compliance With Applicable or Relevant and Appropriate Requirements

The only alternatives that comply with ARARs are the complete off-site disposal alternatives. All other alternatives would require a CERCLA waiver from State of Ohio solid waste disposal facility siting requirements, and would be compliant with ARARs upon receipt of the waiver. In general, to be granted the waivers, the FEMP would be required to adopt an engineering design that would, when coupled with existing site geologic conditions, ensure the long-term protection of human health and the environment.

Each of the alternatives, except the no-action alternative, includes an aggressive aquifer pump-and-treat component aimed at restoring the Great Miami Aquifer to its full beneficial use within a reasonable time frame. This groundwater recovery component would reduce the existing concentration of uranium to below proposed drinking water standards at all points within the aquifer in an estimated time of 27 years. Each of the alternatives are designed to prevent future concentrations in the aquifer from exceeding existing and proposed drinking water standards through removal of these soils and sediment that are capable of creating cross-media impacts.

Each of the alternatives relying on on-property disposal (i.e., capping systems or disposal facilities) would employ design considerations found in the federal Uranium Mill Tailing Remediation Act and RCRA to ensure the long-term performance of the disposal system. These standards would require the use of multilayered capping and lining systems, the development of contaminant- and material-specific waste acceptance criteria, and use of a design which ensures protectiveness for 200 to 1000 years. Long-term monitoring, including groundwater and other indicator media, would be provided for all alternatives involving on-property disposal, as required to demonstrate the continued performance of the disposal system.

6.4.2 Primary Balancing Criteria

The NCP establishes five criteria that form the basis for the comparative analysis of viable remedial alternatives. These are termed balancing criteria, as they are used to evaluate the relative tradeoffs among alternatives passing through the threshold criteria screen. The no-action alternative is carried forward as the baseline alternative for comparison purposes in accordance with the NCP.

6.4.2.1 Long-Term Effectiveness and Permanence

Long-term effectiveness is evaluated through two criteria: the magnitude of the residual risk remaining at the site after the cleanup and the adequacy and reliability of any required engineering or institutional controls. Remedial alternatives employing off-site disposal as the principal means of addressing contaminated soil and sediment would require the least amount of contaminated material to remain at the site. Alternative 1 would include the removal of all contaminated material from the site

with no long-term requirements for continued institutional controls, surveillance, or maintenance activities at the facility.

Each of the alternatives would ensure the attainment of the remediation levels through the implementation of a verification sampling program before remediation and the completion of a certification sampling program following completion of remediation activities. All alternatives would employ excavation to remove perched groundwater zones presenting unacceptable risks to future receptors or the underlying aquifer. Each alternative also employs pump-and-treat technologies to attain health-protective levels in the Great Miami Aquifer.

Each of the alternatives employing a disposal facility or central consolidation area relies on engineering measures and institutional controls to ensure the long-term performance of the remedy and maintain the protection of human health and the environment over time. The highest level of certainty associated with the long-term performance of the engineering controls is associated with the use of a central consolidation area which provides for more heavily contaminated soil being shipped off site for disposal. The remaining material would exhibit low concentrations of contaminants which present lower overall risks to potential intruders in the event the planned institutional controls were to fail in the future.

Long-term environmental impacts associated with the construction of the on-property disposal facility or consolidation area would permanently commit up to 301 acres of land, including up to 68 acres of terrestrial habitat in the form of woodlands and the pine plantation. Between 9 and 36 acres of freshwater wetlands could be lost depending on the cleanup level selected. The 100- and 500-year floodplains of Paddys Run and the Great Miami River would not be permanently altered as a result of backfilling and regrading activities. No significant long-term impacts are expected for water quality and hydrology, air quality, socioeconomics, or cultural resources.

Alternatives which rely upon continued institutional controls, such as continued federal ownership, to preclude the occasional visiting receptor (i.e., recreational user) would have significant uncertainty in the ability of these controls to provide long-term protectiveness. While proprietary rights of ownership would be highly effective in precluding future property development (i.e., construction of homes or businesses), these same controls would be much less effective in precluding the use of the property for hunting and other recreational activities over the long term.

6.4.2.2 Reduction of Toxicity, Mobility, or Volume Through Treatment

All of the alternatives rely upon treatment to address contaminated storm water and recovered groundwater before discharge to the Great Miami River. In general, two other treatment options were considered for application to Operable Unit 5 contaminated media. The first was soil washing,

which involves the use of physical and chemical processes to reduce contaminant levels in soil. The second was the use of cement stabilization to address site soil, which involves mixing the soil with cement to generate a solid monolithic product. The soil washing process evaluated in the FS is a hybrid system which uses both sodium carbonate and dilute sulfuric acid extractants coupled with physical separation operations at the front end of the system (refer to Appendix L for details). Treatability data, from bench- and pilot-scale results, indicated that the process was unsuccessful in consistently meeting the proposed mass-based cleanup levels required (2 to 45 ppm total uranium, depending on the leachability coefficient). More importantly, the results indicated a lack of effectiveness in reducing uranium mobility in treated soil and providing the required level of protectiveness to the Great Miami Aquifer. As a result, the physical/chemical hybrid soil washing process was eliminated from consideration as the leading remedial alternative for soil remediation.

Physical separation technology, coupling innovative physical separation techniques with conventional size fractionation operations and chemical amendments for reducing uranium mobility, is currently being evaluated for potential applications at the FEMP. Cement stabilization was not adopted as a major component of any of the alternatives because of the significant cost of applying the technology and the increased volumes due to the addition of cement additives.

It should be recognized that each of the proposed alternatives will require in excess of 20 years to complete soil cleanup activities and in excess of 27 years to complete groundwater restoration. Additionally, for those alternatives relying on the availability of off-site disposal capacity there is significant uncertainty in the continued availability of this capacity over the 20-year soil cleanup. During this time the FEMP will continue to evaluate emerging technologies, such as soil washing, to potentially apply to the selected remedy to promote cost effectiveness, waste minimization and to reduce potential vulnerabilities to completing the remedial action due to unavailability of off-site disposal capacity.

6.4.2.3 Short-Term Effectiveness

The evaluation of the alternatives under this criterion addresses effects during the construction and implementation phase of remedial actions. Short-term effectiveness evaluates the potential impacts to workers, the public and the environment associated with performing a remedial alternative. Critical considerations in the assessment of the Operable Unit 5 alternatives are: the projected amount of work hours to accomplish a given alternative, the quantity of soil to be excavated, the estimated fugitive dust generated by material movements, and the haul time to the off-site disposal facility.

By definition, the no-action alternative presents the least short-term impacts. All the action alternatives involve remedial activities such as earthmoving, construction and operation of treatment facilities, and material transport. All action alternatives would create an impact and pose some risk to

the environment, workers and the public. These impacts can be effectively controlled through the application of mitigative measures such as dust suppression techniques and rigorous worker health and safety programs.

In general, those alternatives relying upon off-site disposal as the principal means for material disposition present the highest overall short-term risk. The most significant element of short-term risk for these alternatives is due to the projected injuries and fatalities estimated to result as a consequence of transporting such large quantities of material.

Alternatives relying on on-site disposal in an engineered facility would present the lowest overall risks. The most significant element of short-term risk associated with this set of remedial alternatives is attributable to projected injuries related to mechanical hazards. Such injuries would be minimized at DOE facilities, such as the FEMP, through the adoption of strict health and safety program requirements during the implementation of remedial actions.

As part of the short-term risk assessment, estimates were completed for each alternative of the projected risks to individuals neighboring the FEMP due to the conduct of remedial activities. These risks were estimated on the basis of modeling projections of the potential releases of dust during excavation, soil transport, and disposal activity. For alternatives considered in the FS, the highest calculated risk to the maximally exposed individual over the 22-year soil cleanup process would not be expected to exceed a 10^{-6} incremental lifetime cancer risk (ILCR).

Short-term impacts associated with the action alternatives would include temporary on-property disruption of up to approximately 42 acres of land from construction of support facilities and 930 acres from soil excavation, resulting in the temporary loss of habitat. Off-property soil excavation would temporarily disturb up to 6446 acres of land (assuming cleanup at the 10^{-6} level). Appropriate engineering controls would minimize fugitive dust emissions during excavation activities.

6.4.2.4 Implementability

This evaluation criterion addresses the technical and administrative feasibility of implementing the remedial alternatives. Alternatives involving the on-property disposal of contaminated soil and sediment are considered readily implementable through the use of existing technologies and construction methods.

The availability of off-site disposal capacity over the duration of the remedial actions presents considerable uncertainty. Discussions with personnel associated with a representative off-site disposal facility indicate that the disposal site could be expanded to accommodate a greater volume of low-level radioactive or mixed wastes. The availability of this expanded capacity or alternate capacity at

some future (yet to be constructed) site is unclear and is compounded by the up to 22-year duration of remedial actions to address contaminated soil and sediment. For these reasons, alternatives relying on off-site disposal are considered less implementable than the on-site alternatives, and may mean delays to accommodate administrative or capacity issues.

The aquifer restoration component of the alternatives are considered implementable through reliance on available groundwater extraction and treatment technologies. There is considerable uncertainty in the amount of time required to attain remediation levels for uranium and several other contaminants. This uncertainty is due to the limited ability to predict the tendency of the soil particles composing the aquifer system to release the contaminants to the groundwater for extraction. The FEMP will continue to investigate other technologies, such as reinjection, to enhance contaminant recovery and reduce the time needed to restore the aquifer. Reinjection would potentially involve the pumping of treated groundwater back into the aquifer to increase the rate of flow and create a flushing effect in order to speed contaminant removal.

Attaining PRLs at the 10^{-6} residual risk level for residential farming may prove difficult as many of the cleanup levels would be difficult to distinguish from natural background concentrations. Clear delineation of the boundaries of required excavation would not be able to rely on real-time field monitoring due to the insensitivity of these analytical techniques at these required detection levels. At the 10^{-6} residual risk level, all verification and certification sampling would need to be conducted at a full-scale analytical laboratory. The typical turnaround times associated with this type of laboratory would prove problematic to maintaining the continuity of field activities including excavation and backfill.

At the 10^{-6} residual risk level and to a lesser extent at the 10^{-5} residual risk level, access to off-property locations to conduct remedial activities would be required. Gaining such access may prove problematic and cause significant delay. In the event voluntary access cannot be acquired, access to the private properties would need to be sought through the Department of Justice, a time-consuming and relatively unpredictable process.

Depending on the residual risk level selected, the construction of the capping and lining systems associated with the on-property disposal facilities would likely require the import of large quantities of synthetic and clay materials to the FEMP. A material source survey conducted by the FEMP has concluded that these materials are regionally available.

The alternatives relying on off-site disposal at a permitted commercial facility as a principal component of the proposed response contain considerable uncertainty on the implementability of the action. These activities would require considerable coordination with various states and municipalities

to facilitate the transportation of such large quantities of hazardous materials. This uncertainty would be compounded if the same decision framework was extended to the waste materials comprising the other FEMP operable units. While the FEMP currently makes almost daily off-site shipments of materials for off-property disposal at the Nevada Test Site, the amount of train and/or truck shipments to accommodate the collective total of all of the operable unit waste volumes would greatly exceed the current shipping schedule and extend for up to 22 years.

6.4.2.5 Cost Considerations

Cost estimates are used in the FS process to provide a basis for comparison among alternatives. Estimates are typically provided to an accuracy range of +50 percent (real cost would be 50 percent higher than the estimate) to -30 percent (real cost would be 30 percent lower than the estimate) because of the uncertainties in the available information used to develop them. To provide a fair basis of comparison for alternatives, cost estimates for alternatives are presented in present worth costs. Present worth costs reflect the quantity of money which would need to be placed in a bank today at a set interest rate, termed the discount rate, to pay for the remedial action over the life of the project.

Cost estimates were developed for each remedial alternative at three points within the acceptable residual risk range (i.e., HI=1, 10^{-5}, and 10^{-6}). Figure 6-2 displays the present worth costs for each of the alternatives, including a breakout of the costs associated with each remedial component comprising the alternatives. As shown, the key factor that dominates the remedial alternative costs is the target residual risk level. Alternatives targeted at a residual risk level of 10^{-6} for uranium (shown as Case 1 in Figure 6-2) ranged in present worth cost from $2.3 billion to $4.5 billion. Conversely, alternatives targeted at a residual risk level of HI=1 for uranium (shown as Case 7 in Figure 6-2) ranged in present worth costs from $580 million to almost $770 million.

Clearly, as the incremental risk levels become progressively more stringent, there is a corresponding increase in the contaminated soil volume that requires attention, and the costs. In general, for alternatives pursuing restoration to a 10^{-6} ILCR to the resident farmer (Alternatives 1, 2A and 2C), in excess of 80 percent of the projected cost for these alternatives is associated with addressing the cleanup of contaminated soil and the remaining 20 percent is attributed to the recovery and treatment of contaminated groundwater. For all other alternatives, approximately 60 to 75 percent of the projected costs are associated with soil cleanup and the remaining 25 to 40 percent are attributed to groundwater recovery and treatment. For the groundwater recovery and treatment cost component, in excess of 80 percent of the projected costs are attributed to the construction, operation, maintenance and final dismantlement of the groundwater treatment facility.

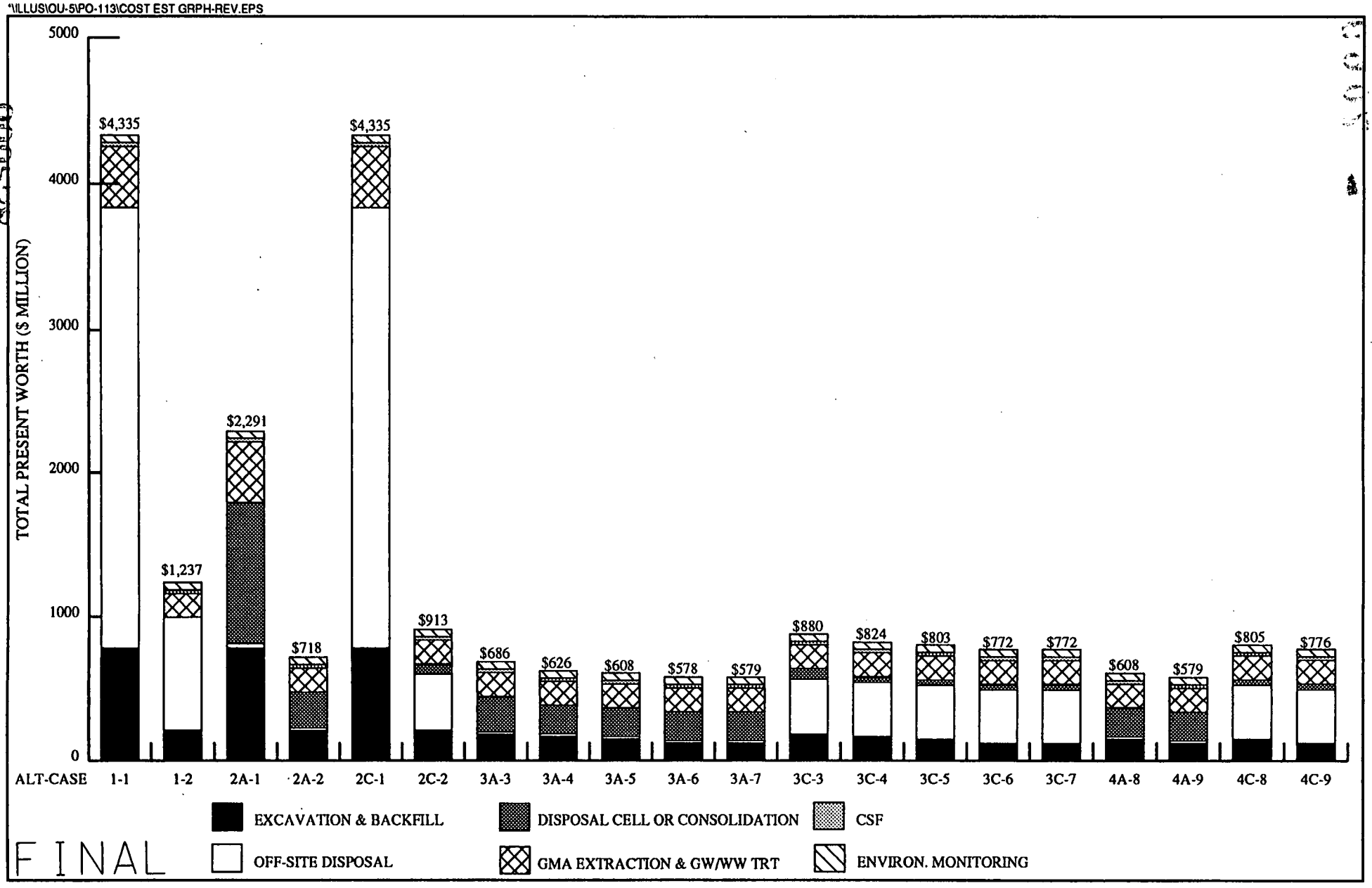
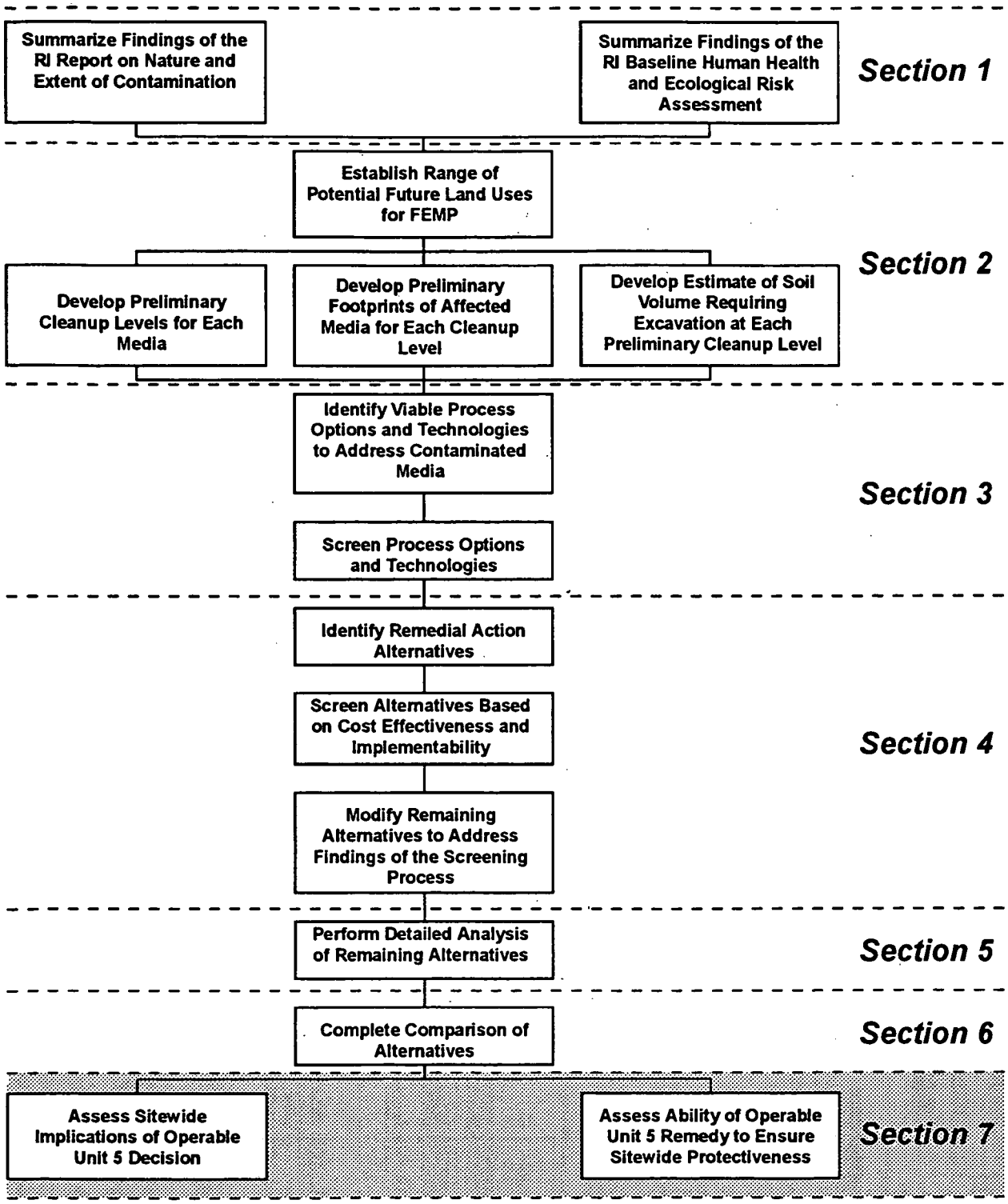


FIGURE 6-2. TOTAL PRESENT WORTH COSTS BY ALTERNATIVE AND RISK CASE

005578

Section 7.0


Summarize Findings of the RI Report on Nature and Extent of Contamination
Summarize Findings of the RI Baseline Human Health and Ecological Risk Assessment
Section 1
Establish Range of Potential Future Land Uses for FEMP
Develop Preliminary Cleanup Levels for Each Media
Develop Preliminary Footprints of Affected Media for Each Cleanup Level
Develop Estimate of Soil Volume Requiring Excavation at Each Preliminary Cleanup Level
Section 2
Identify Viable Process Options and Technologies to Address Contaminated Media
Screen Process Options and Technologies
Section 3
Identify Remedial Action Alternatives
Screen Alternatives Based on Cost Effectiveness and Implementability
Modify Remaining Alternatives to Address Findings of the Screening Process
Section 4
Perform Detailed Analysis of Remaining Alternatives
Section 5
Complete Comparison of Alternatives
Section 6
Assess Sitewide Implications of Operable Unit 5 Decision
Assess Ability of Operable Unit 5 Remedy to Ensure Sitewide Protectiveness
Section 7

7.0 SITE-WIDE INTEGRATION OF REMEDIAL ACTIONS

The purpose of this section is to present a perspective of the site-wide implications associated with the Operable Unit 5 remedy decision. Operable Unit 5 is the fourth operable unit to issue a Feasibility Study (FS) Report and Proposed Plan for comment. Operable Unit 3 will be the final operable unit to issue a FS Report and Proposed Plan (anticipated in 1996).

Each of the prior operable unit FS Reports has provided a progressive evaluation of the projected Fernald Environmental Management Project (FEMP) site-wide remedy within the Comprehensive Response Action Risk Evaluation (CRARE), using the best information available at the time for predicting postremediation site conditions. To complete such an evaluation, each CRARE has adopted a projected site-wide remedy which incorporates the selected, preferred (i.e., identified in a Proposed Plan), or leading alternative for the other operable units, as appropriate. The intent of this evaluation is to progressively monitor the interfaces among all five operable units so that the final adopted remedy is well thought out, cost-effective, and ensures the long-term protection of human health and the environment.

Section 7.1 is a summarizes the adopted site-wide remedy including the types and estimated quantities of remedial wastes, waste disposition, and schedules for remedial actions. Also presented are long-term custodial care, maintenance and monitoring considerations, and key uncertainties associated with implementing the adopted site-wide remedy.

Section 7.2 summarizes the results of the Operable Unit 5 CRARE (Appendix H). The CRARE estimates the cumulative, postremediation residual on-property human health risks for 1000 years following the completion of all remedial actions identified by the site-wide remedy. Section 7.3 presents a summary of the significant features of the adopted site-wide remedy.

7.1 ADOPTED SITE-WIDE REMEDY

The adopted site-wide remedy encompasses the selected, preferred, or leading alternative for each of the five individual FEMP operable units. Table 7-1 summarizes the identified preferred alternatives and estimated present worth costs. Because the FS for Operable Unit 3 is ongoing, the leading remedial alternative identified in the Site-Wide Characterization Report and its preliminary total estimated project cost is listed. Remedies are listed for purposes of presenting this overview and for completing the assessment of the postremediation site conditions for the Operable Unit 5 FS Report. The identification of the projected alternatives should not be regarded as a preselection by either the DOE or EPA as an alternative for any individual operable unit. The representative Operable Unit 5

TABLE 7-1

PROJECTED ALTERNATIVES COMPRISING THE ADOPTED SITE-WIDE REMEDY

Operable Unit	Description	Alternative Adopted for Site-Wide Remedy	Present Worth Cost, $
1	Waste pits	• Excavation of pit contents, caps, berms, and lining systems • Excavation of heavily contaminated soil underlying the pits • Drying excavated soil and wastes, as required • Shipment of excavated material by rail to an off-property disposal facility	330,000,000
2	Other waste units	• Excavation of waste materials and adjacent heavily contaminated soil • Shipment by rail to an off-property disposal facility of excavated material not meeting waste acceptance criteria (WAC) for on-property disposal facility • Placement of excavated material meeting WAC in central on-property, above-grade disposal facility	110,000,000
3	Production facilities and inventories	• Off-property shipment of remaining waste and product inventories, including thorium compounds and decontamination residues • Decontamination and demolition of all structures and facilities • Recycling for reuse of general debris and equipment to the maximum extent practical • Off-property disposal of rubble and debris not meeting WAC for on-property disposal facility • On-property disposal of rubble and debris meeting WAC for facility	920,000,000 *
4	Silos 1-4	• Removal and vitrification of waste inventories, off-property disposal at Nevada Test Site • Excavation of contaminated soil and placement in an on-property disposal facility, consistent with WAC • Decontamination and demolition of silo structures and support facilities • Placement of rubble and debris meeting WAC for on-property facility	110,000,000
5	Environmental media	• Excavation of contaminated soil from the general site areas and any surrounding properties and placement of excavated material meeting WAC in a central on-property, aboveground disposal facility • Shipment of excavated material not meeting WAC for on-property disposal facility to an off-property disposal facility • Disposal of process residuals generated by the advanced wastewater treatment (AWWT) and groundwater treatment facility operations per the same criteria as contaminated soil • Drying excavated soil and wastes, as required • Pumping and treating contaminated groundwater in the groundwater treatment facility	740,000,000

* Estimate being revised; subject to change.

remedial alternative identified for CRARE analysis was Alternative 3A, Case 7 (explained in detail in Section 4.3.3).

Estimated costs are those developed and used for alternative evaluation in the FS Reports for Operable Units 1, 2, 4 and 5, and are provided for information only. The preliminary costs indicated for Operable Unit 3 are based on current estimates for the interim Record of Decision (IROD) remedial activities. The estimate does not include costs for disposal of legacy wastes or any removal actions. The sum of the individual cost estimates does not necessarily reflect the total cost of the adopted site-wide remedy because economies will result from integrated planning, common tasks, and shared overheads.

The adopted site-wide remedy employs various waste disposal approaches and treatment technologies that are readily available and appropriate for the various operable unit waste types and volumes; these approaches and technologies have been evaluated throughout the RI/FS process. Operable Unit 1 proposes to excavate and dry the pit contents and associated materials for off-property disposal. Operable Units 2, 3, and 5 have identified preferred or leading alternatives that contemplate the construction of an on-property disposal facility for waste materials meeting waste acceptance criteria developed as part of their respective FS Reports. Materials exceeding the criteria for on-property disposal will either be shipped to a permitted commercial facility or the Nevada Test Site (NTS). Operable Unit 4 has selected vitrification as the treatment technology for the silo contents; construction of a pilot vitrification plant has been initiated. Pilot operations will be used to establish design criteria and process parameters for the full-scale facility which is expected to become operational in 1997. Vitrified material will be shipped to the NTS.

7.1.1 Waste Types and Estimated Volumes

Operable Units 1 - 4 are considered to be source operable units because they involve waste materials handling and disposal practices which have been identified as the continuing primary sources of contamination of the FEMP environmental media. The Operable Unit 1 waste pit materials, Operable Unit 4 silo contents, and some waste from Operable Unit 3 are considered to be a principal threat because of the nature and concentrations of their constituents. Additionally, the remaining legacy waste currently stored on property is also considered to constitute a principal threat. The land-disposed waste materials in Operable Unit 2, the contaminated soil and groundwater adjacent to both Operable Units 1 and 4, and the site-wide contaminated environmental media comprising Operable Unit 5 are termed a secondary threat because lesser concentrations of contaminants are distributed over a greater volume of material. Table 7-2 presents projected estimates for the volumes of contaminated soil and miscellaneous materials requiring on-property or off-property disposal, in accordance with the adopted site-wide remedy.

Soil volumes estimated to be generated by the other operable units have been evaluated as part of this FS Report, and their quantities are included in the total volume projected for Operable Unit 5. In addition to the total estimated quantity of contaminated soil, another 20,000 cubic yards would be excavated and expected to meet criteria for unrestricted use as backfill. About 1000 cubic yards of contaminated soil would be excavated from off-property.

TABLE 7-2
PROJECTED DISPOSITION OF FEMP WASTE MATERIALS
(Assumed for CRARE Analysis)

Material	Total Estimated Quantity (cubic yards)	On-Property Disposal (cubic yards)	Off-Property Disposal (cubic yards)
Total OU5 soil	1,775,000	1,750,000	25,000
Total miscellaneous waste			
OU1	628,200	0	628,200
OU2	348,600	345,000	3600
OU3	303,496	297,960	5536
OU4	16,996	3000	13,996
OU5	60,000	30,000	30,000
Subtotal	1,357,292	675,960	681,332
Total soil and miscellaneous	3,132,292	2,425,960	706,332
Legacy waste	29,300	0	29,300
Overall total	3,161,592	2,425,960	735,632

Miscellaneous remedial waste includes remedial waste pit materials, caps, berms and liners from Operable Unit 1, waste from Operable Unit 3, silo material from Operable Unit 4, and other miscellaneous wastes from Operable Units 2 and 5. The remediation of miscellaneous wastes by each operable unit is addressed by its respective FS Report.

This assessment estimates that nearly all of the contaminated soil and 43 percent of miscellaneous remedial wastes would meet waste acceptance criteria for disposal in an on-property disposal facility. This assumes that half of the contaminated equipment waste generated by Operable Unit 3 meets the acceptance criteria for on-property disposal.

Approximately 75 percent of the overall contaminated soil and miscellaneous remedial waste are considered as secondary threat materials and have been assumed, for CRARE analysis, to meet waste acceptance criteria for on-property disposal. The remaining 25 percent of contaminated soil and miscellaneous remedial waste, together with legacy waste, comprise the assumed principal threat

materials. Off-property disposition of principal threat materials is consistent with the expectations of the National Contingency Plan (NCP), given the site-specific constraints that are present at the FEMP.

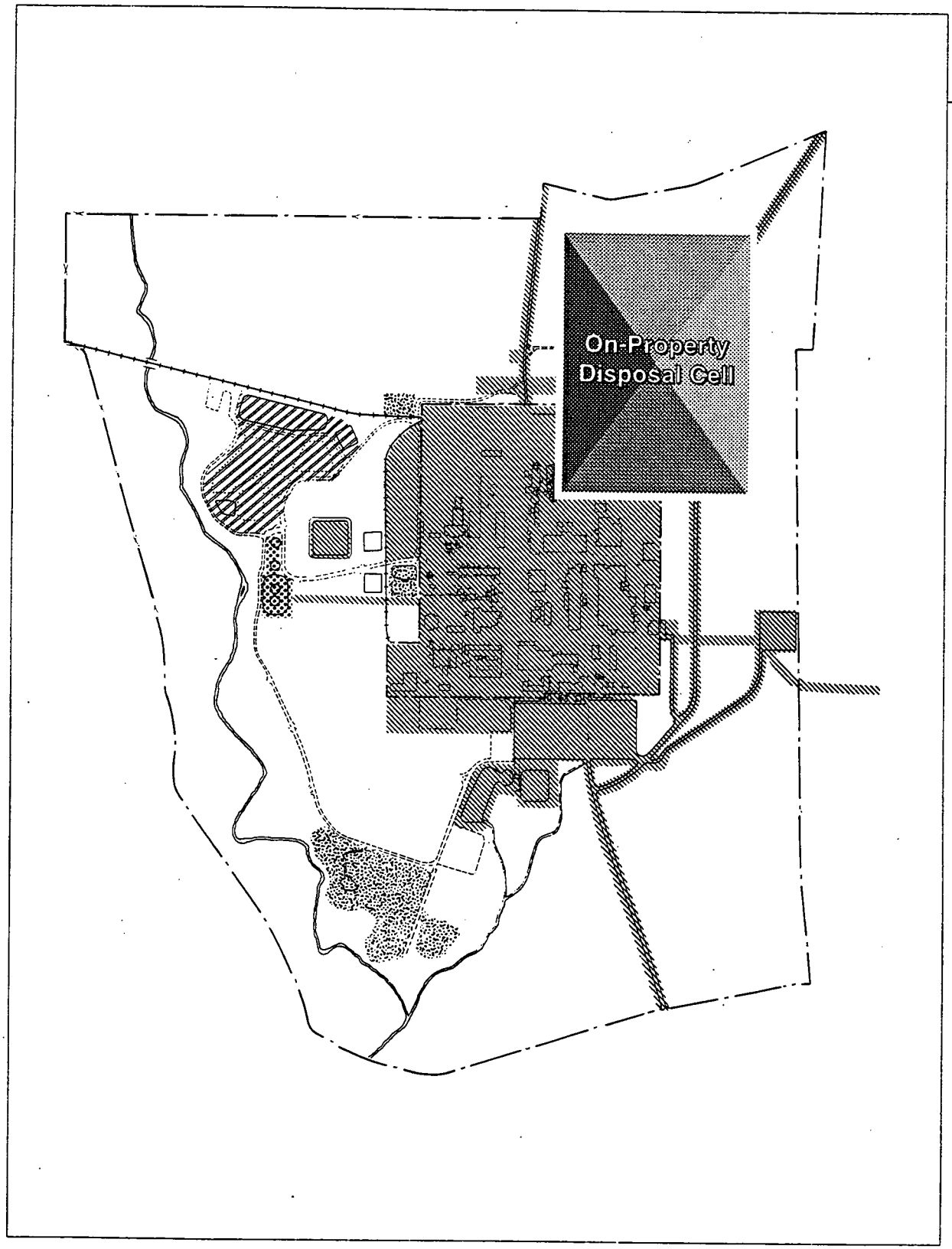
In general, the adopted site-wide remedy incorporates a balanced approach to waste disposition. Higher concentration materials, deemed to represent the principal threat at the FEMP, would be treated (if required) and shipped off property for disposal. Secondary threat materials exhibiting lesser concentrations would be permanently disposed of in the on-property engineered facility. The adopted alternatives and/or the projected volumes are anticipated to change as the remedy selection process is finalized in the RODs for the individual operable units.

7.1.2 On-Property Disposal Facility

As previously discussed, the adopted site-wide remedy used for CRARE analysis assumes on-property disposal is applied to the secondary threat materials. Table 7-3 lists the types and quantities of wastes expected to meet waste acceptance criteria for on-property disposal. The quantities given are in-place cubic yards (see Table 7-2); no allowances have been made for the volume following excavation, decontamination, treatment and/or containerization.

The engineered disposal facility for the adopted site-wide remedy is estimated to be 2260 feet by 1600 feet by 40 feet high. Figure 7-1 illustrates the area that could be potentially occupied by the facility, superimposed on current FEMP features. Based on currently available data, it is believed that the area shown would be suitable for construction of the disposal facility because it is on that portion of the property where the thickness of the gray clay is greater than 12 feet, residential wells are no closer than 1000 feet, the site boundary is no closer than 300 feet, and it would support the disposal of as much as 3 million cubic yards of waste material.

Although the exact location of the disposal facility will be determined through the remedial design stage of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) process, the U.S. Department of Energy (DOE) has initiated a predesign investigation of hydrogeologic and geotechnical characteristics in order to optimize the location. Based upon the final outcome of the investigation, the facility location will be recommended to the regulatory agencies for approval. The performance requirements for the cap and liner system for the on-property disposal facility are being established based on information from the individual operable units. The actual cap and liner system will be finalized during design of the facility. Three major on-property disposal facility uncertainties are: 1) the final waste volumes and characteristics must be defined; 2) completion of the administrative process to a CERCLA waiver; and 3) the acceptability of on-property disposal to the regulators, Fernald Citizens Task Force, and other stakeholders.



LEGEND: Operable Unit 1 Operable Unit 2 Operable Unit 3 Operable Unit 4 Operable Unit 5 (Not Shown)

FINAL

FIGURE 7-1. LOCATION OF ON-PROPERTY DISPOSAL CELL ADOPTED FOR SITE-WIDE REMEDY ANALYSIS IN CRARE

000585

TABLE 7-3

MATERIAL ASSUMED TO MEET WASTE ACCEPTANCE CRITERIA FOR ON-PROPERTY DISPOSAL
(Assumed for CRARE Analysis)

Source	Material		Quantity (cubic yards)
OU2	Solid waste landfill material		18,000
	South Field material		120,000
	Lime sludge ponds material		18,000
	Active fly ash pile material		80,000
	Inactive fly ash pile material		109,000
		Subtotal	345,000
OU3	Windows, wood, insulation		58,571
	Asphalt and concrete		167,797
	Structural steel		2274
	Equipment, conduit/wire, piping		64,485
	Painted light gauge metals		224
	Brick		766
	Transite, floor tile, fire brick		3843
		Subtotal	297,960
OU4	Concrete		3000
		Subtotal	3000
OU5	Soil		1,750,000
	Sludge - groundwater/wastewater treatment facilities		30,000
		Subtotal	1,780,000
		Total	2,425,960

7.1.3 Off-Property Disposal

This section provides information on the material assumed, as part of the adopted criteria remedy, to be disposed of off-property. Table 7-4 lists these wastes. Assumed quantities given are in-place cubic yards and no allowances have been made for volumes following excavation, treatment, and/or containerization.

TABLE 7-4

WASTE EXPECTED TO BE SHIPPED OFF PROPERTY
(Assumed For CRARE Analysis)

Source	Waste Type	Disposition	Quantity (Cubic Yards)
OU1	Pit materials and sludges	Disposal	473,400
	Soil from caps	Disposal	114,200
	Soil from liners	Disposal	40,600
	Subtotal		628,200
OU2	Solid waste landfill materials	Disposal	100
	Inactive flyash pile materials	Disposal	3500
	Subtotal		3600
OU3	Process related piping and equipment	Recycle	5536
	Subtotal		5536
OU4	Silo 3 material	Disposal	5090
	Silos 1 & 2 sludge and bentogrout	Disposal	8900
	Decant sump system sludge	Disposal	6
	Subtotal		13,996
OU5	Soil	Disposal	25,000
	Sludge - groundwater/waste water treatment facilities	Disposal	30,000
	Subtotal		55,000
	Total Disposal (does not include legacy waste)		
	Total (does not include legacy waste)		706,332

7.1.4 Schedules for Remedial Actions

The U.S. Environmental Protection Agency (EPA) has approved the RI and FS Reports and the ROD for Operable Unit 1. Both the RI and FS Reports for Operable Unit 2 are approved and the ROD is being reviewed by EPA; an engineered on-property disposal facility is central to the preferred remedial alternative. An interim ROD for Operable Unit 3 has been approved by EPA in advance of the final ROD to be issued in April 1997. EPA has approved the RI and FS Reports and ROD for Operable Unit 4. For Operable Unit 5, the final RI Report was approved in March 1995; the draft final FS report is projected for submittal in March 1995. The anticipated schedule for implementation of the adopted site-wide remedy is presented in Figure 7-2.

7.1.5 Long-Term Custodial Care, Maintenance, and Monitoring

Elements common to all five operable units considered as part of the adopted site-wide remedy include the following:

- Continued federal ownership of the FEMP property
- Maintenance and surveillance of the on-property disposal facility
- Restrictions placed in the FEMP property deed
- Long-term environmental monitoring program
- EPA performance reviews of site conditions every five years.

These elements are discussed below.

Site Ownership and Landlord Responsibilities

Under the adopted site-wide remedy, the area of the FEMP property dedicated to waste disposal is assumed to remain under the ownership of the federal government which would exercise its rights of ownership to preclude further development of the property. Following remediation, portions or all of the FEMP property outside the disposal facility area are assumed to be available for alternative uses. For purposes of the CRARE, the future land use is assumed to be an undeveloped park. Active access controls are assumed to be discontinued following the attainment of remedial action objectives for soil and miscellaneous remedial wastes.

Deed Restrictions and Defining Property Limits

The likelihood of protracted exposure at the on-property disposal facility is low because the community at large is expected to retain awareness of the site and permanent markers would be in place. To comply with ORC 3742.02, the adopted site-wide remedy assumes protective covenants to restrict future mining, drilling, and residential development would be recorded as deed restrictions to accompany future land conveyances.

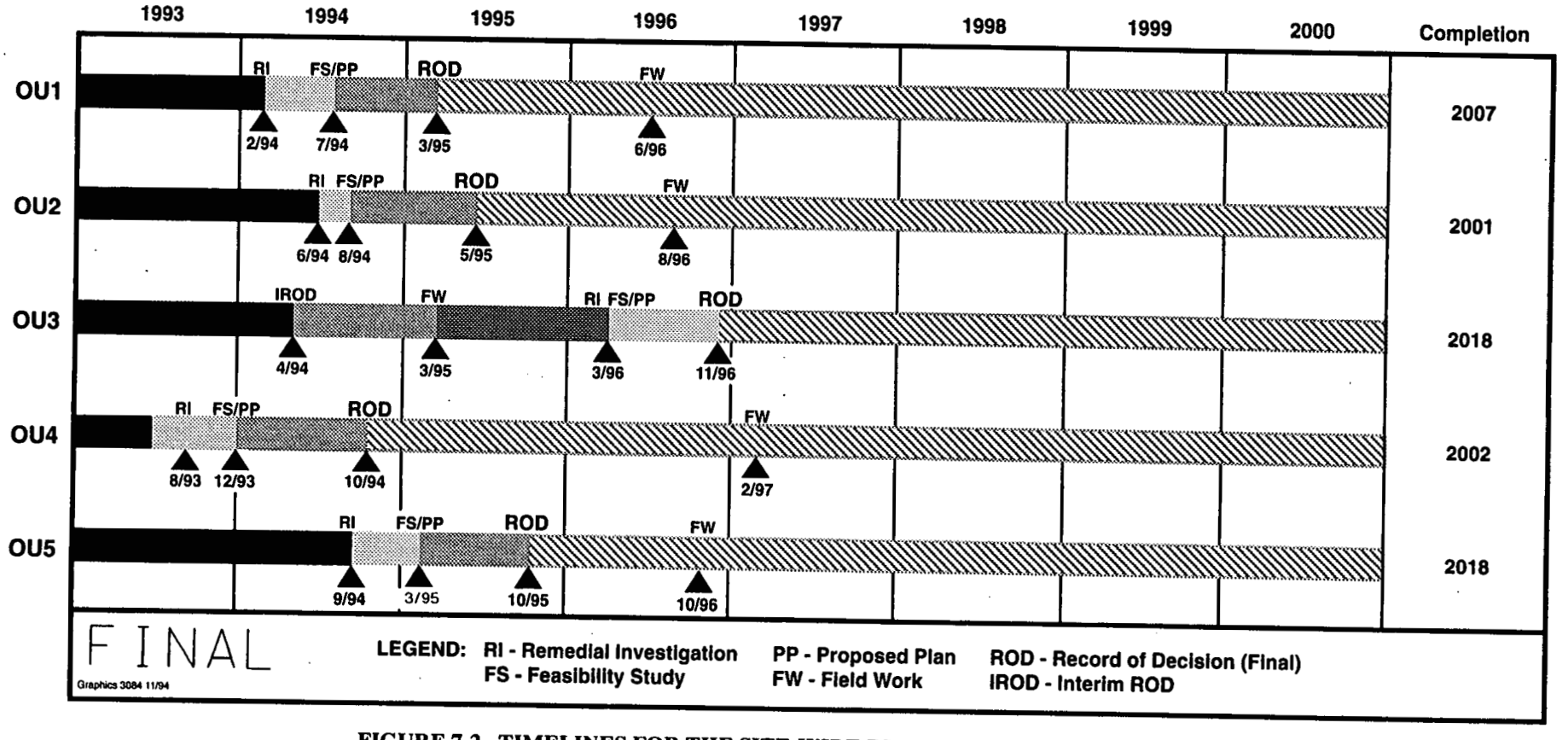


FIGURE 7-2. TIMELINES FOR THE SITE-WIDE REMEDIATION OF THE FEMP

000589

Long-Term Monitoring and Periodic CERCLA Reviews

Deterioration of the multimedia caps over waste material left on property could result in the release of radon gas and contaminated particulates to the air, and water infiltration could result in leaching of contaminated material to surface water and groundwater if the cap or liner is breached. The on-property facility caps are designed for and assumed to last up to 1000 years (the end of the CRARE time frame). The CRARE (Appendix H) does not consider scenarios associated with cap deterioration. If deterioration of the containment system is detected, the DOE would take any necessary actions to ensure protection of human health and the environment. In the unlikely event that institutional controls are lost at some time in the distant future, deterioration of the containment system without corrective measures could result in the eventual release of contaminants and potential future impacts on human health and the environment. Based on the results of the CRARE (summarized in Section 7.2.4), these future impacts would not likely be significant.

Long-term environmental monitoring of groundwater would detect releases from the on-property disposal facility and provide the data necessary to evaluate and implement appropriate response actions. Groundwater would be monitored before, during, and after remedial activities. If adverse effects were detected in any of these media, work would be stopped until the effects were controlled and/or appropriate response actions were implemented.

Because the adopted site-wide remedy includes on-property disposal of remedial wastes, EPA would continue to conduct performance reviews in accordance with the Amended Consent Agreement. The five-year reviews would include an independent assessment of trends in monitoring results, verification of maintenance activities, and field inspections to ensure that waste containment structures were intact and functioning properly. Based on the findings of the reviews, monitoring plans would be adjusted and corrective actions implemented.

7.1.6 Key Uncertainties for the Adopted Site-Wide Remedy

The evaluations completed in this FS Report conclude the adopted site-wide remedy would provide for the protection of human health and the environment for 1000 years or more, including attaining the adopted land use objective and providing for the long-term protection of the quality of water in the Great Miami Aquifer. In completing the Operable Unit 5 FS and those for the other operable units, DOE has acknowledged that uncertainties exist that may impact the course of remedial action once field work is underway. Uncertainties can be managed by emphasizing conservatism for any assumptions made and by planning for additional data evaluation and assessment as the remedial actions are implemented. By acknowledging the existence of uncertainties, bounding assumptions on the conservative side, and planning for an iterative approach to implementation of the remedial actions, DOE and FEMP stakeholders can proceed with the decision-making process.

The adopted site-wide remedy must incorporate and address the uncertainties associated with the major elements of selected, preferred, or leading remedial alternatives for each of the FEMP operable units. These include uncertainties pertaining to:

- Volume estimates for site-wide contaminated soil
- Hydrogeological and geotechnical characteristics of the proposed on-property disposal facility location
- Capacities of off-property disposal facilities over the projected 22 years required for soil remediation
- Time ultimately required for groundwater remediation
- Ability to maintain institutional controls over a 1000-year period.

Table 7-5 summarizes the approach to managing and planning for each of these uncertainties.

7.2 RESIDUAL RISK ASSESSMENT FOR THE ADOPTED SITE-WIDE REMEDY

The evaluation of the adopted site-wide remedy performed for this FS included a risk analysis of the postremedial site conditions. The purpose of this risk analysis was to determine whether the adopted site-wide remedy, including the representative Operable Unit 5 remedial alternative, could ensure the long-term protection of human health consistent with the adopted land use objective. The adopted land use objective is that of attaining a cleanup which provides for the protection of hypothetical on-property undeveloped park (recreational) users and an off-property farmer.

Sources of contamination remaining at the FEMP following complete implementation of the adopted site-wide remedy include residual concentrations of contaminants in soil and groundwater and the waste materials contained within the on-property disposal facility. The CRARE examined the long-term performance of the disposal facility and considered the possible loss of institutional controls (i.e., continued federal ownership, deed restrictions). The following sections provide a summary of the CRARE approach and results. Appendix H contains the detailed methods and results for the CRARE.

7.2.1 Identification of Constituents of Concern

The nature and extent of residual soil and groundwater contamination and the waste disposed of on-property in the disposal facility were identified using Appendix R of the Site-Wide Characterization Report (DOE 1993e), and the Operable Units 1, 2, 4, and 5 RI and/or FS reports. Wastes to be disposed of on site were traced, media by media, from their source and then taken into consideration in the development of the CRARE list of constituents of concern (COC) list. Fate and transport modeling analysis was applied to determine if significant quantities of COCs would reach groundwater within the 1000-year time frame. While it is conceivable that volatile and semivolatile organic chemicals would be evaporated or degraded 1000 years after the site remediation, they were retained on the COC lists to build conservatism into the analysis.

TABLE 7-5

MANAGING UNCERTAINTIES

Uncertainty	Management and Planning Approach
Soil volume estimates	The Operable Unit 5 FS has incorporated an excavation footprint verification component within each alternative evaluated to provide for field verification of volume estimates. A completion-of-remediation certification component is also included to ensure that final remediation goals are met.
On-property disposal facility location	A predesign investigation will be developed and implemented to provide further verification that the proposed on-property disposal facility location has hydrogeological and geotechnical characteristics which, when combined with engineered features and waste acceptance criteria, can provide long-term protection of human health and the environment.
Off-property disposal facility capacity	DOE will continue to evaluate treatment technologies which may be appropriately applied to small quantities of contaminated soil to meet the waste acceptance criteria for the on-property disposal facility. Considering the time frame for soil excavation and disposition (22 years), it is conceivable that viable technologies may emerge and provide a means to minimize impacts due to changing compliance status of off-property facilities and waste volume competition from other sites.
Groundwater remediation time	Predesign treatability investigations will be performed to acquire additional data regarding the desorption of uranium over time from the sand and gravel comprising the aquifer, as this pertains to the time required for groundwater remediation. The additional data will permit optimization of groundwater extraction well configurations, sizing of treatment facilities, and treatment time estimates.
Long-term maintenance of institutional controls	The CRARE for the adopted site-wide remedy considers impacts from long-term residual risks in the event of the loss of institutional controls and the failure of the on-property disposal facility over time. An array of receptors, representing a range of possible future land uses resulting from the loss of institutional controls, were evaluated to project what risks might occur. The results of the evaluation predict that the loss of institutional controls would not result in unacceptable residual risks to the receptors considered.

7.2.2 Receptors

The following target and reference reasonable maximum exposure (RME) receptors were evaluated in the CRARE:

Target Receptor

- Undeveloped park user
- Off-property resident farm adult
- Off-property resident farm child

Reference Receptor

- On-property farm adult
- On-property farm child
- Commercial/industrial user
- Developed park user
- Wildlife reserve user
- Expanded trespasser
- Great Miami River user
- Meat and milk user

These receptors represent a wide array of potential land uses. Target receptors are those incorporated in the design of both the Operable Unit 5 representative remedial alternative and the adopted site-wide remedy. They are chosen for a specific land use objective. The estimated risks of these target receptors provide a measurement of the completeness and effectiveness for both the representative remedial alternative and the adopted site-wide remedy. The reference receptors were included in the CRARE risk analysis to provide an understanding of the magnitude of potential risks to a variety of receptors in the event of failure of the institutional controls proposed as part of the remedial alternatives.

7.2.3 Pathways of Exposure

The pathways considered in the CRARE include the following:

- Inhalation of volatile vapors, radon gas, and particulates
- Incidental ingestion of soil, sediment, surface water, and groundwater
- Dermal contact with soil, sediment, surface water, and groundwater
- External radiation exposure
- Ingestion of groundwater (perched or Great Miami Aquifer)
- Ingestion of farm products (milk, meat, vegetables, and fruit).

While these exposure pathways are receptor specific, the significant pathways for most receptors are the inhalation of fugitive particulates, the consumption of drinking water, and dermal contact with soil. External radiation was a significant pathway of concern for all on-property receptors.

Risk Assessment Uncertainties

Health risk assessments contain various elements that contribute to uncertainty and potentially impact the accuracy of the risk estimates. Understanding the uncertainties inherent in the development of risk estimates is essential when interpreting the results for risk management decisions. The Oper yble Unit 5 CRARE included principal sources of uncertainty such as the future disposition of the FEMP property and residual wastes, placement of the disposal facility on the site, volume and nature

COCs left in the site soil and disposal facility, accuracy of the fate and transport modeling used in developing the exposure point concentrations, and toxicity of the COCs.

The CRARE employed conservative assumptions and health-protective values from the literature when site-specific values were not available. The approach is consistent with EPA guidance. Adopting these factors ensures the final estimate of risk is more conservative, meaning that while the magnitude of uncertainty is high, the probability that the actual risks have been underestimated is low.

7.2.4 Receptor Risk Reduction

In order to evaluate the effectiveness of the adopted site-wide remedy in the context of the Operable Unit 5 CRARE, a comparison of preremedial and postremedial risk was conducted. The goal of this comparison was threefold:

- Quantify the risk reduction from preremedial to postremedial conditions for target and reference receptors evaluated in the CRARE
- Demonstrate efficacy of the Operable Unit 5 representative alternative from a site-wide perspective
- Provide information to support future land use decisions.

Initially, the baseline conditions for the receptors evaluated in the individual operable unit RI reports were reviewed. The receptors impacted by the highest risk due to site-specific radiological and chemical contamination were selected for purposes of comparison. Table 7-6 presents a summary comparison of Operable Unit 5 proposed cleanup levels with those of other operable units. Only constituents common to Operable Unit 5 are listed. The cleanup levels established in previous Records of Decision remain in effect without revision for areas within the boundaries of the respective operable units. Where the final soil remediation level for a specific constituent established through the Operable Unit 5 remedy decision process is more restrictive (i.e., lower) than that defined in the individual ROD for Operable Unit 1, 2, or 4, the final Operable Unit 5 remediation level will serve as the soil cleanup criteria within the boundary of the source operable units. This strategy allows consideration of operable unit-specific factors driving the cleanup levels (such as constituents of concern, hydrogeology, etc.) while still providing a basis for application of a consistent site-wide future land use.

Risks impacting these receptors included all contributions from naturally occurring background. The receptors calculated to receive maximal impact from site contamination were compared in Table 7-7 to the same type of receptor evaluated under postremedial site conditions in the OU5 CRARE. The difference between these receptors "pairs" is referred to as the "risk reduction" for this receptor

TABLE 7-6
PROPOSED CLEANUP LEVELS FOR SOIL IN OPERABLE UNITS 1, 2, 4, AND 5

	OU1[a] Federal Ownership Receptor: Expanded Trespasser HI = 1 or ILCR = 10^{-6}									OU2[b] Federal Ownership Receptor: Expanded Trespasser Cleanup Levels											OU4[c] Federal Ownership Receptor: Expanded Trespasser Proposed Remediation Levels	OU5[d] Undeveloped Park User	
	Surface Soil	Sub-surface Pit 1	Sub-surface Pit 2	Sub-surface Pit 3	Sub-surface Pit 4	Sub-surface Pit 5	Sub-surface Pit 6	Sub-surface Burn Pit	Sub-surface Clear Well	Inactive Flyash Pile (over GMA) ILCR= 10^{-6}	Inactive Flyash Pile (over soil) ILCR= 10^{-6}	HI=0.2	South Field (over GMA) ILCR= 10^{-6}	HI=0.2	South Field (over Soil) ILCR= 10^{-6}	HI=0.2	Lime Sludge Ponds ILCR= 10^{-6}	Solid Waste Landfill ILCR= 10^{-6}	Active Flyash Pile ILCR= 10^{-6}	HI=0.2	Soil[e] (pCi/g)	Preliminary Remediation Levels	Basis[f]
Radionuclides (pCi/g):																							
Cesium-137	1.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.4	R
Lead-210	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.99	NA	78	38	R
Radium-226	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.8	1.8	NA	1.8	NA	1.8	NA	1.8	1.8	1.8	NA	2	1.7	R
Radium-228	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.0	2.0	NA	2.0	NA	2.0	NA	2.0	2.0	2.0	NA	2	1.8	R
Technetium-99	NA	NA	5.5	0.75	0.26	1.4	7.3	140	9.9	NA	NA	NA	71	NA	71	NA	NA	NA	NA	NA	NR[g]	0.26	C
Thorium-228	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.8	1.8	NA	1.8	NA	1.8	NA	1.8	1.8	1.8	NA	2	1.7	R
Thorium-230	902	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	402[h]	NA	402[h]	NA	NA	NA	NA	NA	NA	280	R
Thorium-232	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.5	1.5	NA	1.5	NA	1.5	NA	1.5	1.5	1.5	NA	NA	1.5	R
Uranium-234	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.68[h]	4.24[h]	NA[h]	8.7[h]	NA[h]	4.2[h]	NA[h]	196	62.9	8.7[h]	NA	NA	NA	NA
Uranium-235/236	9.3	NA	NA	NA	NA	NA	NA	NA	NA	7.79[h]	3.35[h]	NA[h]	7.8[h]	NA[h]	3.4[h]	NA[h]	195	63.1	7.8[h]	NA	NA	NA	NA
Uranium-238	56	13000	NA	NA	11000	NA	NA	NA	NA	6.12[h]	3.22[h]	NA[h]	6.1[h]	57.3[h,i]	3.2[h]	16.7[h,i]	45.3	12.9	6.1[h]	57.3[h,i]	60	NA	NA
Uranium, total (K_d=325 L/kg)(mg/kg)*[j]	190	NA	NA	NA	NA	NA	NA	NA	NA	24.8[h]	24.8[h]	NA[h]	24.8[h]	118[h]	24.8[h]	NA[h]	136	38.6	28[h]	172[h]	NA	82	R
Uranium, total (K_d=15 L/kg)(mg/kg)*[j]	190	NA	NA	NA	NA	NA	NA	NA	NA	NA[h]	NA	NA[h]	NA	NA	NA	NA	NA	NA	NA	NA	NA	20	C
Chemicals (mg/kg):																							
Aroclor-1260	NA	NA	NA	NA	NA	NA	NA	NA	NA	16.9	NA	NA	25	NA	25	NA	NA	NA	NA	NA	NA	0.13	R
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.777	NA	0.777	NA	NA	NA	NA	NA	NR	2.0	B
Beryllium	2.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.5	R
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.157	NA	0.157	NA	NA	NA	NA	NA	NR	2.0	R
Indeno(1,2,3-od)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.496	NA	0.496	NA	NA	NA	NA	NA	NR	20	B
Lead	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	400	NA	NA	NA	NA	NA	NA	NA	NA	26	B
PCBs, total	0.78	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a]Cleanup levels taken from the Operable Unit 1 Final Record of Decision for Remedial Actions, March 1995, Tables 9-2 and 9-3.
[b]Operable Unit 2 information excerpted from Operable Unit 2 FS, March 1, 1995, Table 2-23
[c]Operable Unit 4 Proposed Remediation Levels taken from Operable Unit 4 Final Record of Decision, December 1994, Table 9-2
[d]Values taken from Table 2-12 in Section 2.0
[e]Sum of background and Preliminary Remediation Level
[f]NA = Not applicable
[g]NR = No remediation required
[h]Cleanup level is due to the off-property resident farmer receptor
[i]This value is determined by calculating the uranium-238 concentration in total uranium
[j]Cross-media impacts were evaluated for these mobile constituents for OU5

[f]ND = No toxicity data available for the development of risk-based Preliminary Remediation Goals
A = ARAR-based Preliminary Remediation Levels
B = Benchmark Toxicity Value
BR = Background
C = Cross-media impact to groundwater to meet ARARs
D = Detection limit
R = Risk-based Preliminary Remediation Levels

000595

TABLE 7-7
COMPARISON OF MAXIMUM PREREMEDIAL RISKS TO SITE-WIDE POSTREMEDIAL RISKS FOR COMMON RECEPTORS
(Shading denotes target receptors)

Receptor	Maximum Preremedial Risks[a]	Sitewide Residual Risk[b]	Percentage of Risk Reduction[c]
On-Property Resident Farmer			
Radionuclide Risk (ILCR)	1.0E+00[d]	1.3E-03	
Chemical Risk (ILCR)	2.0E-01[d]	2.7E-04	
Total Carcinogenic Risk (ILCR)	1.0E+00	1.6E-03	>99.9
Noncarcinogenic Risk (HI)	5.4E+02[e]	2.1E+00	99.6
On-Property Resident Child			
Radionuclide Risk (ILCR)	1.0E-01[d]	1.0E-04	
Chemical Risk (ILCR)	9.0E-02[d]	1.8E-04	
Total Carcinogenic Risk (ILCR)	1.9E-01	2.8E-04	>99.9
Noncarcinogenic Risk (HI)	2.0E+03[d]	1.0E+01	99.5
Commercial/Industrial (Groundskeeper)			
Radionuclide Risk (ILCR)	2.0E-02[d]	3.0E-04	
Chemical Risk (ILCR)	6.0E-04[d]	6.8E-06	
Total Carcinogenic Risk (ILCR)	2.1E-02	3.1E-04	98.5
Noncarcinogenic Risk (HI)	2.0E+01[d]	2.6E-01	98.7
Expanded Trespasser			
Radionuclide Risk (ILCR)	9.0E-03[d]	1.3E-05	
Chemical Risk (ILCR)	5.0E-04[d]	9.4E-07	
Total Carcinogenic Risk (ILCR)	9.5E-03	1.4E-05	99.9
Noncarcinogenic Risk (HI)	8.0E+01[d]	6.9E-02	99.9
Undeveloped-Park User			
Radionuclide Risk (ILCR)	2.0E-04[f]	2.0E-05	
Chemical Risk (ILCR)	2.5E-05[f]	1.3E-06	
Total Carcinogenic Risk (ILCR)	2.3E-04	2.1E-05	90.7
Noncarcinogenic Risk (HI)	1.7E+00[f]	5.9E-02	96.5
Off-Property Farm Resident (adult)			
Radionuclide Risk (ILCR)	2.2E-03[g]	8.9E-04	
Chemical Risk (ILCR)	3.0E-04[e]	1.8E-04	
Total Carcinogenic Risk (ILCR)	2.5E-03	1.1E-03	56.0[h]
Noncarcinogenic Risk (HI)	3.7E+01[g]	1.5E+00	95.9
Off-Property Farm Resident (child)			
Radionuclide Risk (ILCR)	1.8E-04[g]	7.0E-05	
Chemical Risk (ILCR)	7.0E-05[e]	8.4E-05	
Total Carcinogenic Risk (ILCR)	2.5E-04	1.5E-04	40.0[h]
Noncarcinogenic Risk (HI)	1.5E+02[g]	7.0E+00	95.3

[a] Maximum preremedial risk is the highest baseline risk value from Operable Unit 1, 2, 4, and 5 RI reports.
[b] Residual ILCRs and HIs based on projected postremedial site conditions.
[c] Percentage of hypothetical risk reduced from baseline condition to post-remediation conditions.
[d] Maximum ILCR and HI taken from OU4
[e] Maximum ILCR and HI taken from OU1
[f] Maximum ILCR taken from the OU5 (exposure from production area). Maximum HI taken from OU5 (exposure from Southeast Area).
[g] Maximum ILCR and HI taken from OU5 (exposure along Eastern Boundary)
[h] The lower percentages of risk reduction for the off-property receptors reflect the fact that baseline off-property risks were low (close to background). Therefore, the reduction of risk off-site would not appear as great as the reduction on-site.

achieved by the representative alternative. This risk reduction comparison is demonstrated in Figures 7-3 through 7-9 and receptors are discussed individually in the text below.

7.2.4.1 On-Property Farmer

Though not considered a target receptor under the Operable Unit 5 proposed land use, the adult reasonable maximum exposure (RME) on-property farmer has a preremedial carcinogenic risk of 1.0 and a noncarcoinogenic hazard index (HI) of 540. This maximally impacted receptor originates in the Operable Unit 1 baseline conditions and assumes exposure through the prescribed pathways for a period of 70 years. The preremedial/postremedial risk reduction achieved through cleanup is clearly demonstrated by comparison of the risk levels of these receptors. This risk level of the preremedial receptor indicated a cancer rate of unity (1) if exposure occurs over a lifetime.

Postremedial risks to this receptor are an incremental lifetime cancer risk (ILCR) of 1.6×10^{-3} and a HI of 2.1 respectively. The risk level achieved by conducting site cleanup is more than three orders of magnitude lower than the receptor exposed to preremedial (baseline) conditions. The percentage of risk reduction exhibited by this receptor is more than 99.9 percent or a more than a 1000-fold reduction over baseline conditions. The reduction in noncarcinogenic HIs for this same receptor is 99.6 percent or a nearly 100-fold reduction.

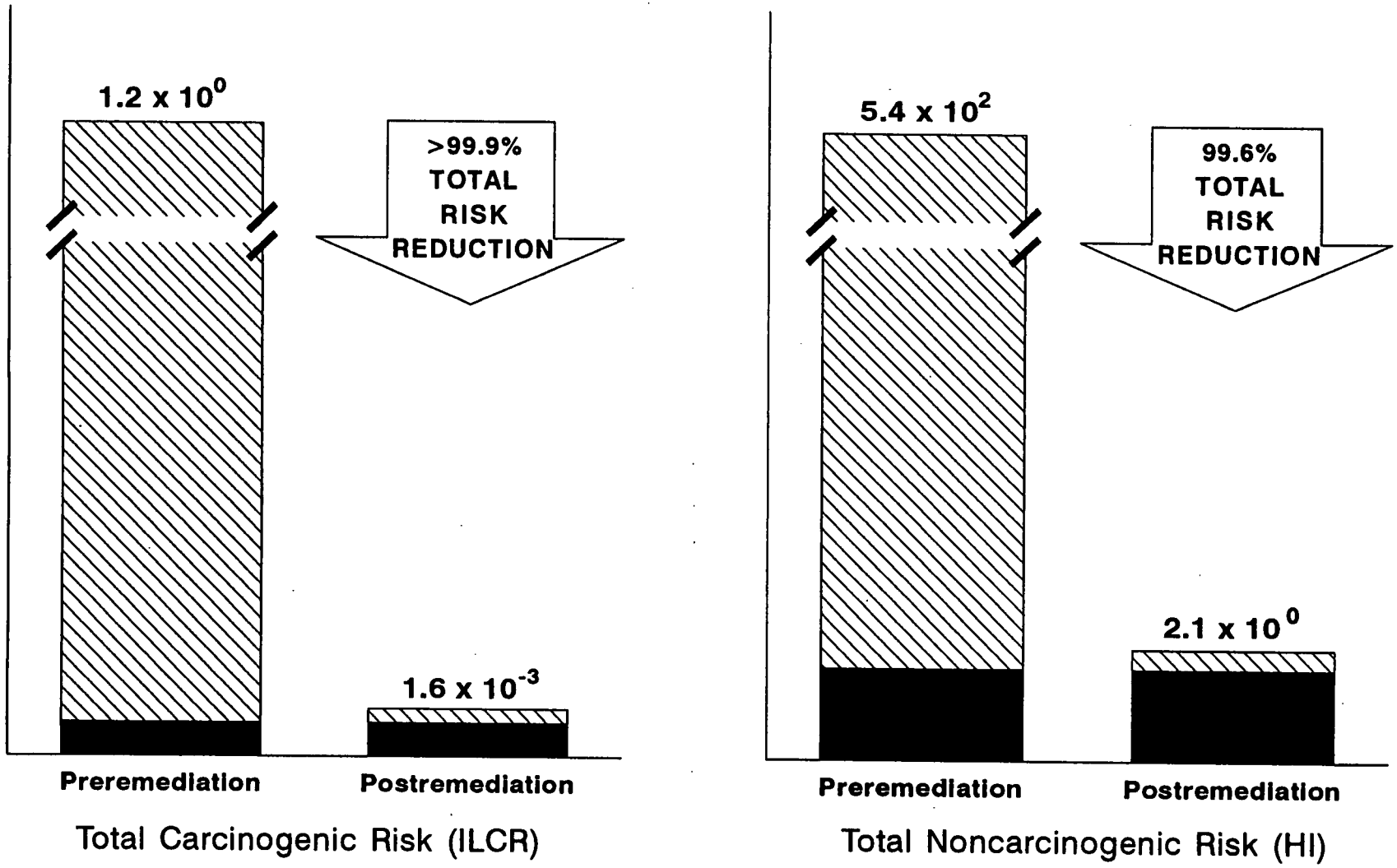
The on-property farm child also experiences a 99.9 percent reduction in cancer risk and a 99.5 decrease in toxicant risk when preremedial and postremedial risk levels are compared.

7.2.4.2 Groundskeeper

The groundskeeper is the receptor designated to represent a commercial industrial worker who is exposed to site-related contamination in the course of his/her occupation. Pathways of exposure and exposure parameters are commensurately less intensive than the on-property farmer. Total cancer risk for the commercial/industrial receptor is reduced from 2.1×10^{-2} to 3.1×10^{-4} for a reduction in potential risk of 98.5 percent. Noncancer risk or HI is reduced to 2.6×10^{-1}, a 98.7 percent or nearly a 100-fold reduction.

7.2.4.3 Expanded Trespasser

The expanded trespasser is a hypothetical receptor resulting from agreements on exposure parameters between FERMCO and EPA, Region V. This receptor represents the RME intruder scenario for the FEMP site given the continuation of access controls. The expanded trespasser from Operable Unit 4 (K-65 silos) was calculated to experience the most risk with an ILCR from the Operable Unit 4 baseline risk assessment of 9.5×10^{-3} and a HI of 80. A three-orders-of-magnitude risk reduction occurs when comparing preremedial to postremedial conditions. The OU5 CRARE postremedial expanded trespasser exhibits a ILCR of 1.4×10^{-5} and a HI of 6.9×10^{-2} resulting in 99.9 percent and 99.9 percent risk reductions, respectively.

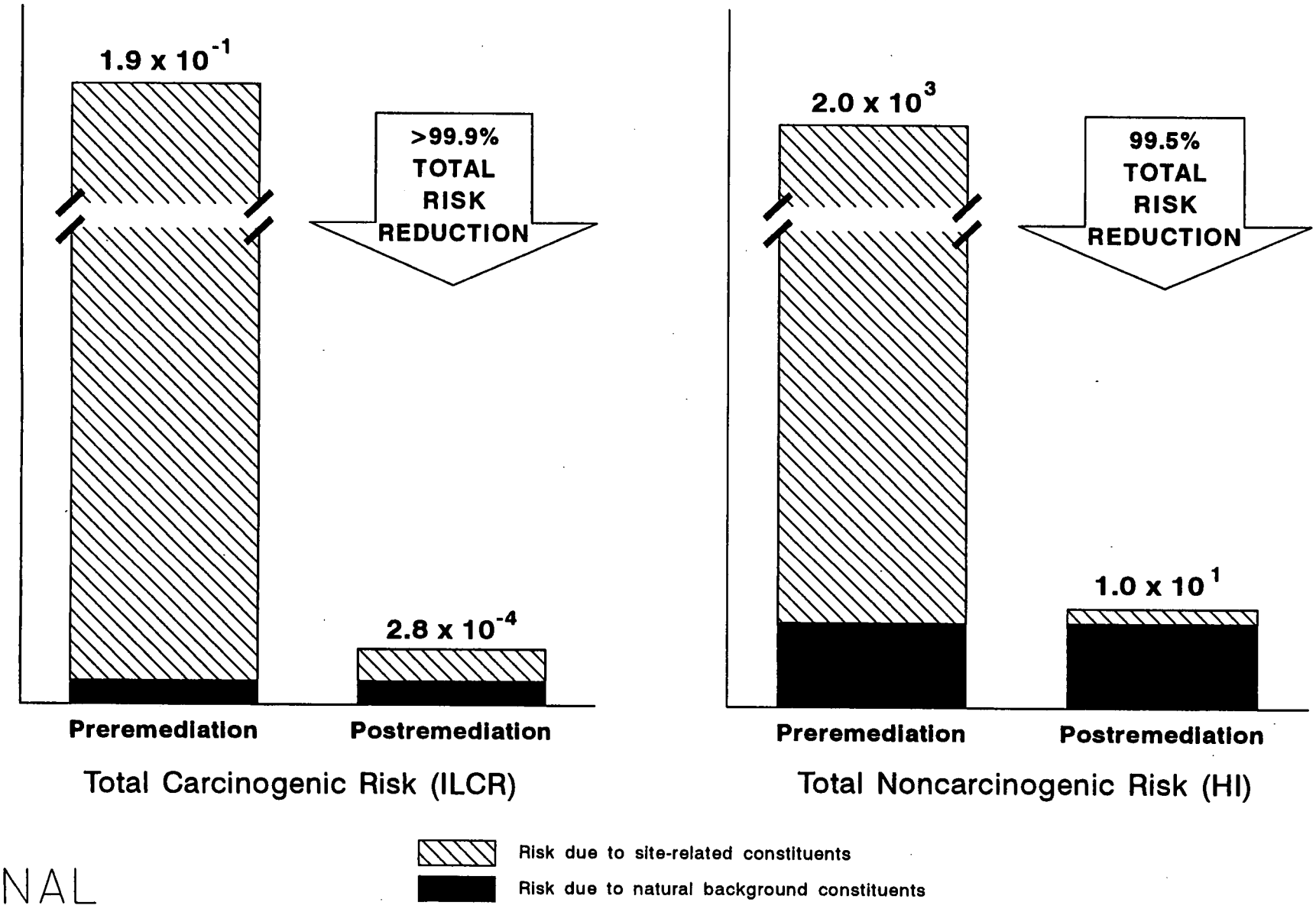


FINAL

FIGURE 7-3.
ON-PROPERTY RESIDENT FARMER
PROJECTED RISK REDUCTION BETWEEN PREREMEDIAL AND POSTREMEDIAL CONDITIONS

000598

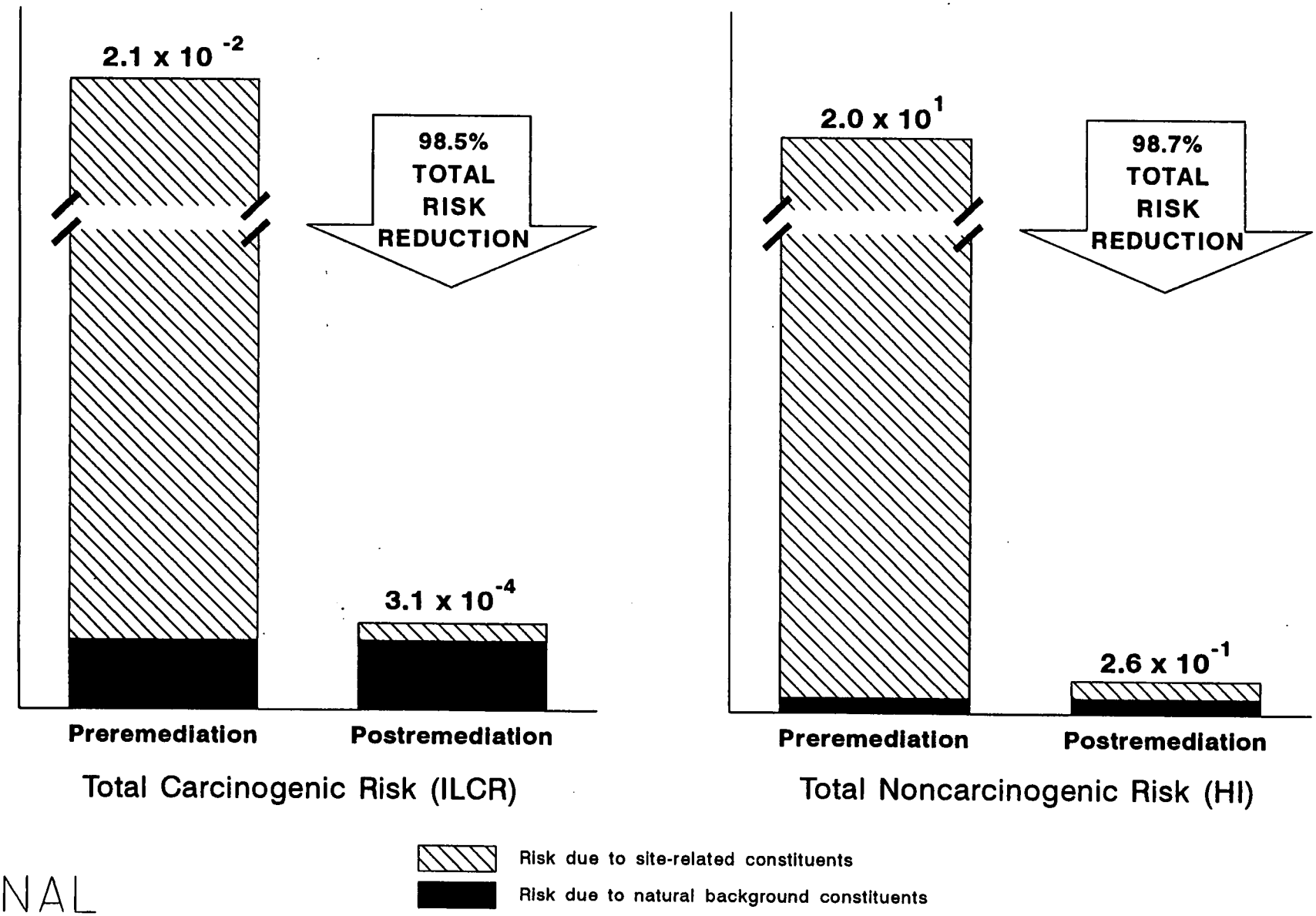
2069



FINAL

FIGURE 7-4.
ON-PROPERTY RESIDENT CHILD
PROJECTED RISK REDUCTION BETWEEN PREMEDIAL AND POSTREMEDIAL CONDITIONS

000599

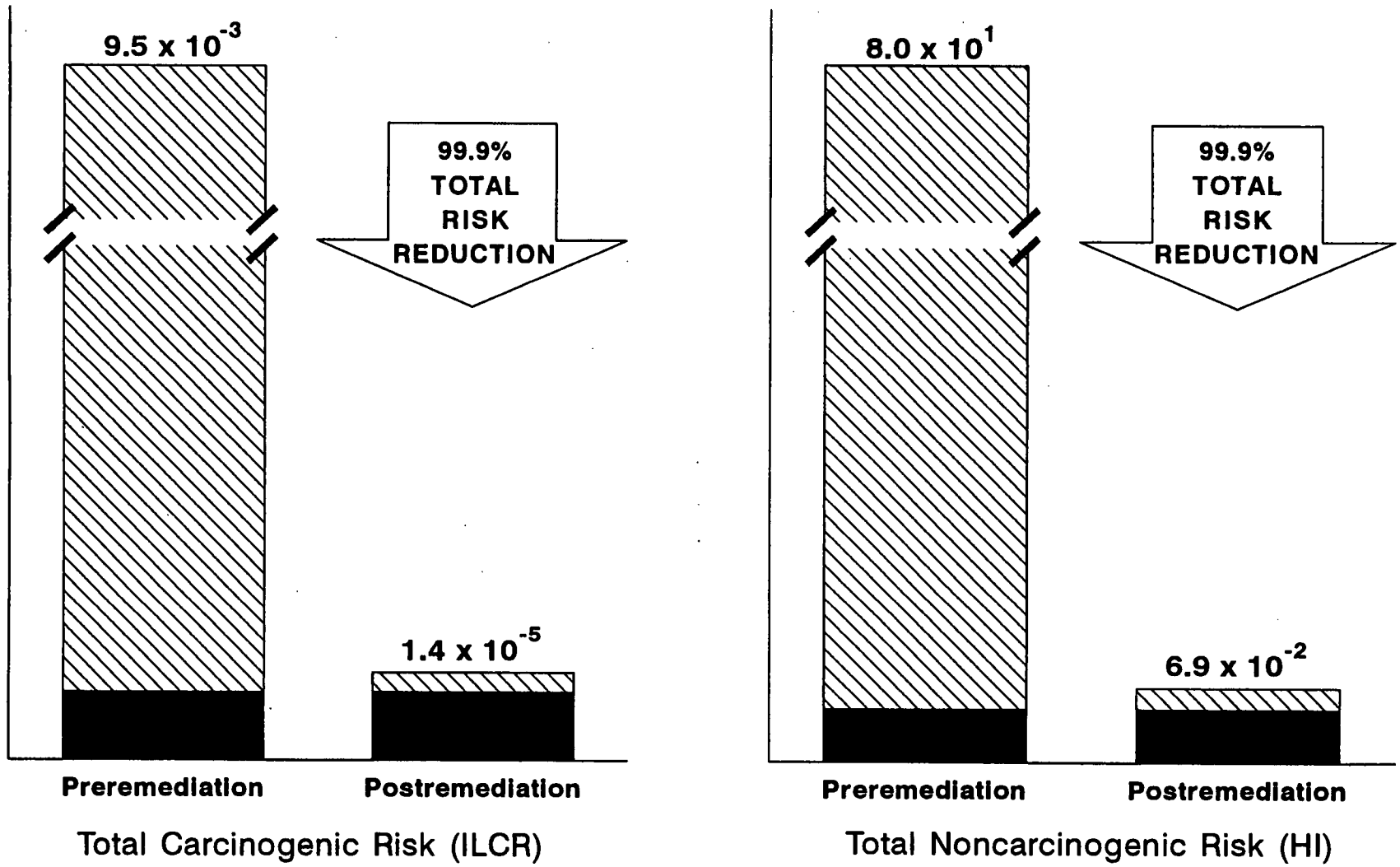


FINAL

FIGURE 7-5.
COMMERCIAL/INDUSTRIAL (GROUNDSKEEPER)
PROJECTED RISK REDUCTION BETWEEN PREREMEDIAL AND POSTREMEDIAL CONDITIONS

000300

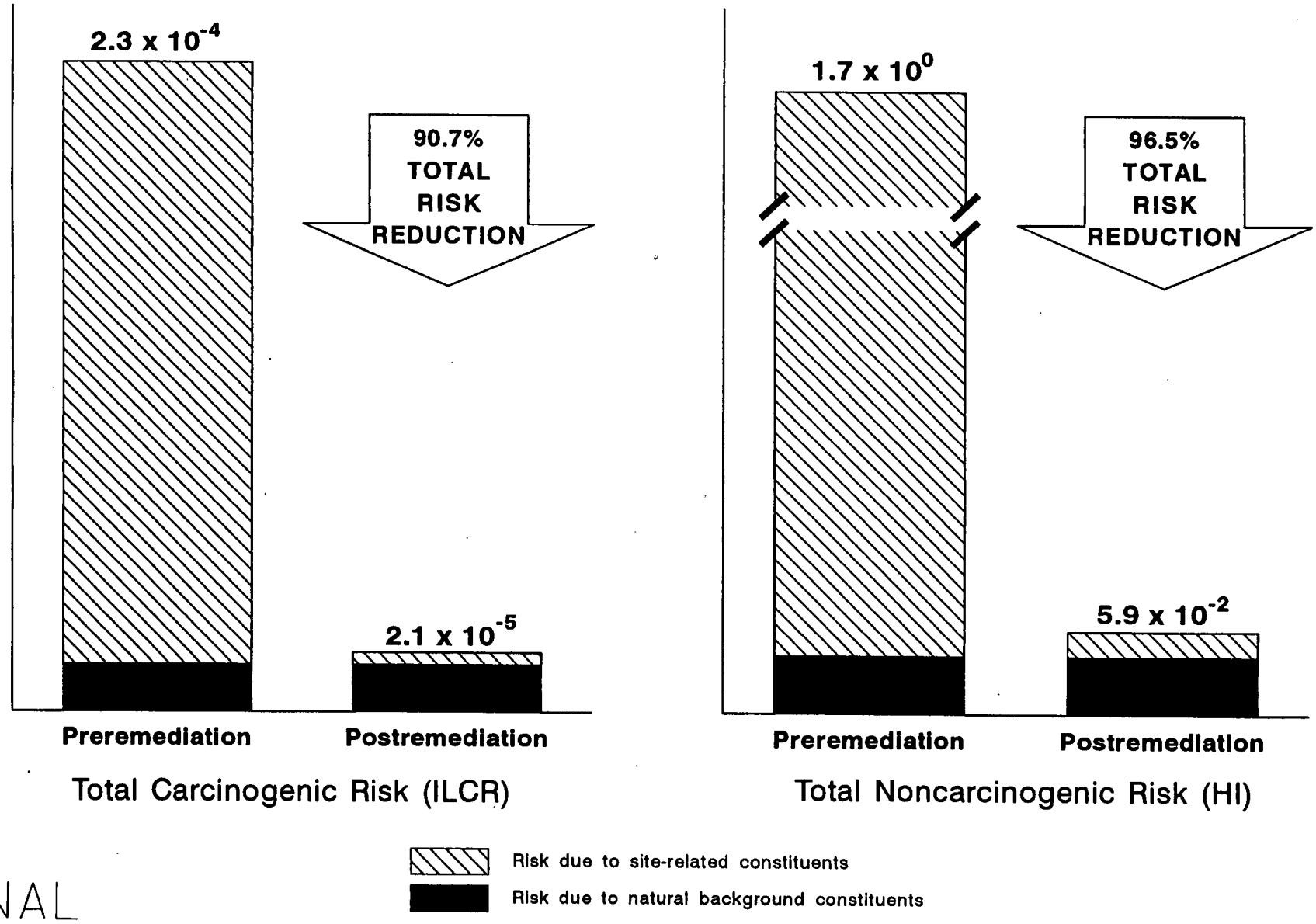
7069



FINAL

FIGURE 7-6.
EXPANDED TRESPASSER
PROJECTED RISK REDUCTION BETWEEN PREREMEDIAL AND POSTREMEDIAL CONDITIONS

000001



FINAL

FIGURE 7-7.
UNDEVELOPED-PARK USER
PROJECTED RISK REDUCTION BETWEEN PREREMEDIAL AND POSTREMEDIAL CONDITIONS

000602

2069

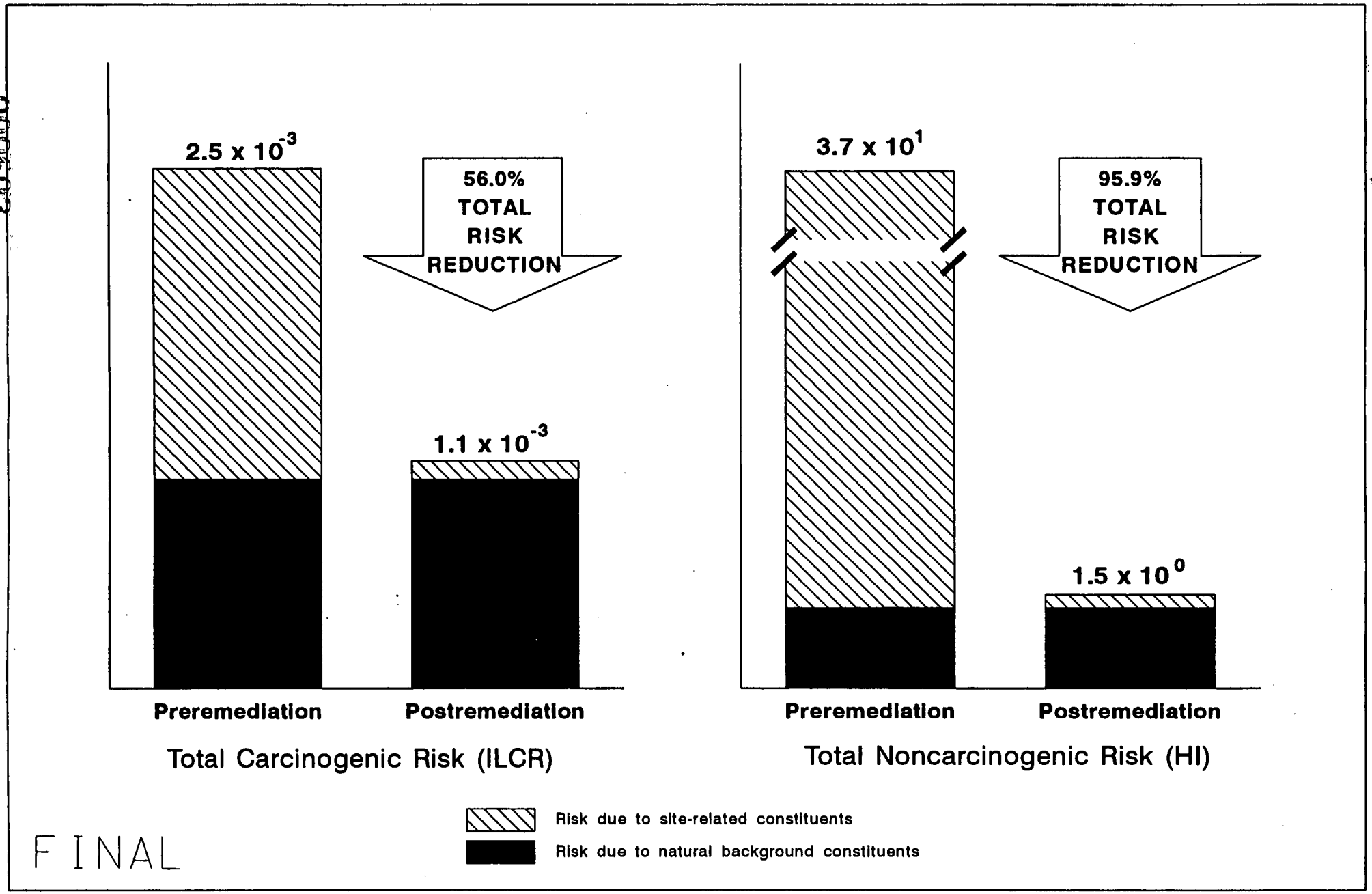
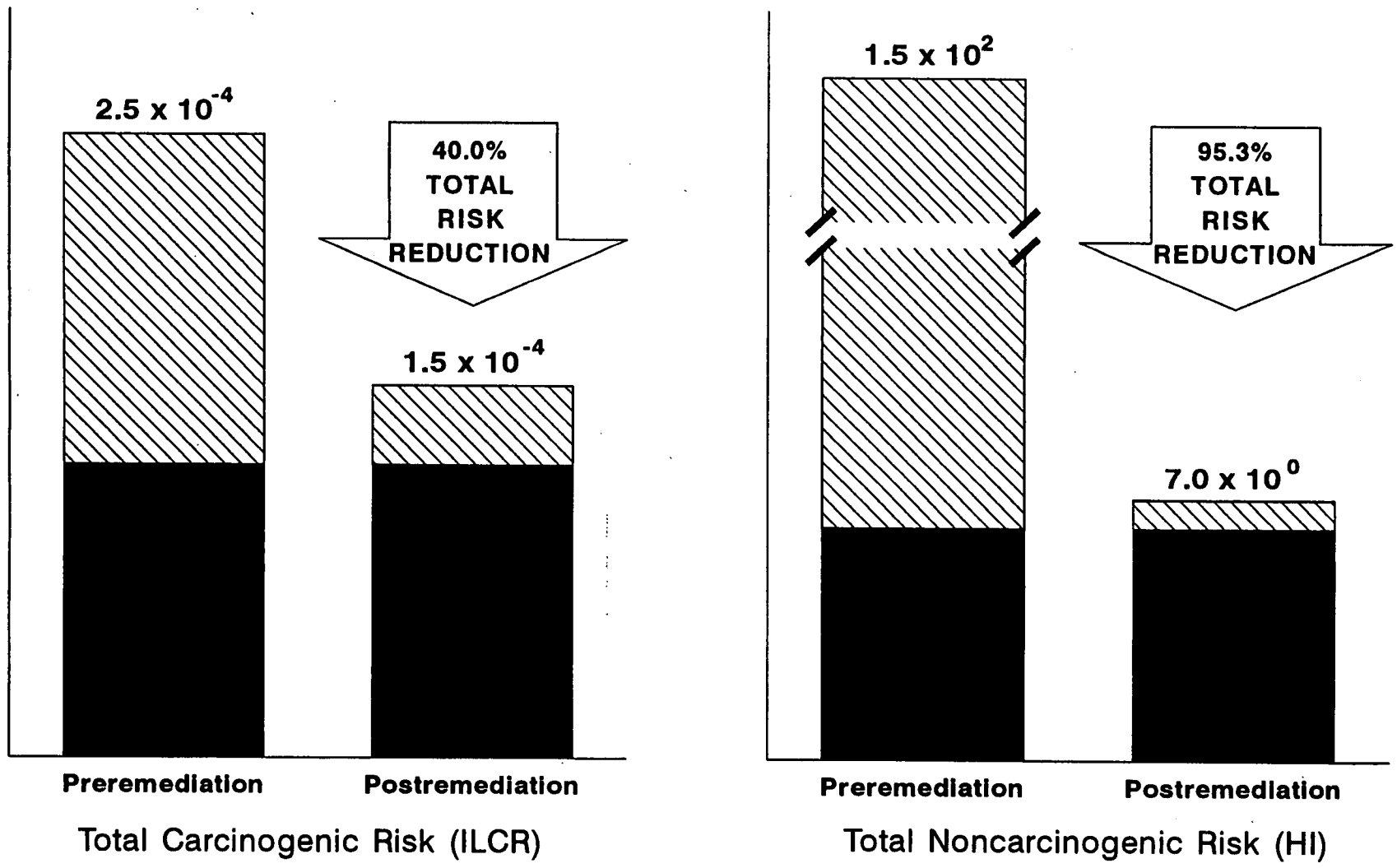


FIGURE 7-8.
OFF-PROPERTY RESIDENT FARMER
PROJECTED RISK REDUCTION BETWEEN PREREMEDIAL AND POSTREMEDIAL CONDITIONS

000003



FINAL

FIGURE 7-9.
OFF-PROPERTY RESIDENT CHILD
PROJECTED RISK REDUCTION BETWEEN PREREMEDIAL AND POSTREMEDIAL CONDITIONS

000004
20069

7.2.4.4 Undeveloped Park User

The undeveloped park user is considered a target receptor for the Operable Unit 5 representative alternative. The preremedial ILCR to this receptor is 2.3×10^{-4} and the postremedial risk is 2.1×10^{-5} for a net reduction of 90.7 percent. Noncarcinogenic risk was reduced from 1.7 to 5.9×10^{-2} for a 96.5 percent reduction.

7.2.4.5 Off-Property Resident Farmer

The off-property farmer represents the RME receptor conducting an agricultural lifestyle who resides in close proximity to the site but not within the property boundary. The off-property farm adult receptor experiences a preremedial carcinogenic risk of 2.5×10^{-3} which is reduced to 1.1×10^{-3} for a 56 percent reduction in total carcinogenic risk. Noncarcinogenic risk, as indicated by HI, decreases from 37 to 1.5 for a reduction of 95.9 percent.

The off-property farm child receptor ILCR decreases by 40 percent and HI decreases by 95.3 percent.

7.2.5 Interpretation of the Risk Reduction Results

It is apparent that risk reduction is greater for certain evaluated receptors than for others, as explained by the following statements:

- Receptors with more intensive exposure parameters to the contaminated environmental media will have a greater proportion of risk reduction as a result of remediation. This is demonstrated when comparing the higher carcinogenic risk reduction achieved by the commercial industrial worker (groundskeeper), 98.5 percent, than by the recreational receptor (undeveloped park user), 90.7 percent.

- Receptors that are located centrally, rather than peripherally with respect to the FEMP, are more likely to exhibit risk reduction as a result of remediation. This trend is apparent when comparing the reduction achieved by the on-property resident farm adult and child to the off-property farm adult and child.

- Receptors exposed to relatively concentrated sources of contamination (such as the K-65 silos which are subsequently removed in the course of remediation) exhibit a large degree of risk reduction. The expanded trespasser receptor is an example of this.

- Receptors with preremedial risk levels most elevated above the risk attributed to background will benefit the most from remediation, as illustrated by the trend in risk reduction among the receptors evaluated.

Conversely, the evaluated receptors benefiting least from the remediation are:

- Receptors that have less intensive exposure parameters than the on-property farm adult and child. The commercial industrial receptor and the undeveloped park user exhibit significant risk reduction as a result of remediation but the reduction is an order of magnitude less than the reduction achieved by the on-property farmer.

- Receptors subjected to site-related risks that are only marginally increased above naturally occurring background risk. The off-property farm adult and child illustrate this point. Even though this set of off-property receptors is in close proximity to the site boundary and are situated downwind in the maximum modeled airborne contamination plume, their preremedial total risks are only marginally above background due to their distance from the areas of greatest contamination. As a result, the percentage of risk reduction that is possible due to remediation is limited.

7.2.5.1 Background

The contribution of naturally occurring background constituents to total risk needs to be understood when comparing preremedial to postremedial risk and warrants discussion. Background constituents contributing to calculated risks are naturally present in the environmental media and their contributions are included as a component of the total residual risk impacting evaluated receptors. Background risk can be divided into the following:

- Risk from naturally occurring radionuclides present in soil and water including the uranium, thorium, and radium decay chains and their daughters. These radionuclides mainly contribute toILCR and naturally occurring uranium also has a contribution to the HI.

- Inorganic constituents (mainly metals) that are naturally present in the soil and water on and around a site. Inorganics contribute to both noncarcinogenic and carcinogenic risk with noncarcinogenic risk predominating.

- Organic constituents are by definition manmade and therefore background for organics is assumed to be zero. In some instances anthropogenic constituents such as polynuclear aromatic hydrocarbons (PAHs) are present in the surface soils on or near a site. These may not be due to site contributions but may originate from depositions from ubiquitous coal-fired emissions in a historically industrial area. This "manmade background" has not been addressed as such and all organics encountered on and in the vicinity of the site are considered site-related constituents in the OU5 CRARE.

For the purpose of this comparison, naturally occurring background from both radiological constituents and inorganics are included as components of the total risk impacting evaluated receptors. For reference purposes these values have been illustrated in Figures 7-3 through 7-9.

Natural radiological and inorganic risk contributions from the geological strata and glacial till occupied by the FEMP have not been demonstrated to be excessive for any constituent. Because of this, no special considerations due to unusual background conditions on the FEMP site is anticipated. As the total preremedial risk for any receptor approaches background, the "incremental risk" or risk above naturally occurring background attributable to the site-related contamination decreases as a proportion of this total. Because remediation is only able to address this incremental component of total receptor risk, the percentage of risk reduction achieved by employing a remedial strategy will be limited by this incremental/background ratio. When incorporating naturally occurring background into the total risk experienced by a hypothetical receptor, the background contribution must be taken into consideration as the lower theoretical limit of risk reduction possible for a specified receptor/location scenario.

7.2.5.2 Conclusions

Implementation of the Operable Unit 5 representative alternative as a component of the adopted site-wide remedy will result in a significant reduction of risk to all receptors evaluated in the Operable Unit 5 CRARE. The reduction of risk calculated for any particular receptor is dependent on factors such as intensity of exposure parameters characteristic of that receptor, physical distance from the highest sources of contamination, and the ratio of total risk to risk contributions from naturally occurring background constituents.

The target receptors for the Operable Unit 5 representative alternative are land-use driven and consist of the undeveloped park user and the off-property farm adult and child. Remedial action under this alternative will result in a decrease in cancer risk of 90.7 percent and a decrease in noncancer risk of 96.5 percent for the undeveloped park user. The ILCR and HI for the off-property farmer adult will diminish by 56 percent and 95.9 percent, respectively. Cancer and toxicant risks for the off-property farmer child will be reduced by 40 percent and 95.3 percent, respectively.

The main reason risk reduction for the undeveloped park user receptor is less than reductions for other receptors is the relatively low intensity of exposure parameters characteristic of this receptor. The off-property farmer adult and child have identical intensity of exposure parameters as their on-property counterparts but are removed from the main sources of contamination. This distance results in preremedial risks only slightly above risks attributed to naturally occurring background radiological and chemical constituents which will not be impacted by remediation.

7.3 SIGNIFICANT FEATURES OF THE ADOPTED SITE-WIDE REMEDY

The adopted site-wide remedy portrays a balanced approach for the safe, acceptable, cost-effective, and timely disposition of both principal and secondary threat materials that will ensure the protectiveness of human health and the environment for 1000 years. The Proposed Plan that accompanies this FS Report presents an overall perspective of the postremediation site conditions and summary of the assessment of major factors and key uncertainties.

The implementation of the adopted site-wide remedy involves the application of technologies that are readily available. During the course of the 22-year period for the remediation of solid wastes, innovative technologies would continue to be assessed for potential application to improve the effectiveness and efficiencies of operations and waste minimization actions.

The eventual determination of the remedial actions to be taken at the FEMP will be established by the RODs for each operable unit. The decision-making process does not end with the ROD, but will be a continuing process throughout remedial actions until all objectives have been attained. The adopted site-wide remedy also achieves the best overall balance of short-term risks. During its

implementation, strict administrative controls would ensure the protection of both the site workers and the public.

Maximum use would be made of common on-property facilities and treatment processes for handling the different waste streams, consistent with the selected alternative of each operable unit. As the ROD for each operable unit becomes finalized, the remedial design/remedial action (RD/RA) for their implementation would already be in progress within the context of the adopted site-wide remedy. Stringent design standards would be established for the construction of the on-property disposal facility and waste acceptance criteria would be strictly applied during its operation. Any material suspected of jeopardizing the integrity of the facility or its long-term performance will be preferentially segregated for either treatment or shipment off property.

Key uncertainties associated with implementing the adopted site-wide remedy include: 1) estimated waste volumes and acceptable disposition; 2) duration of remedial actions; 3) residual risks to on-property receptors; and 4) maintaining institutional controls for 1000 years. These are briefly discussed below.

Estimated Waste Volumes and Disposition

The overall quantity of contaminated soil and miscellaneous wastes is estimated to be 3 million cubic yards, of which 75 percent would be disposed of in an on-property facility. The remaining 25 percent would be shipped for off-property disposal at a permitted, commercial facility or the DOE's NTS. Precision excavation techniques and real-time monitoring of soil excavation would be employed to minimize the generation of volumes for subsequent disposal. The generation of soil volumes in excess of approximately 2.3 million cubic yards would impact the facility capacity and escalate the estimated costs. The primary concern with off-property disposal is its continued availability to accommodate the entire projected volume of approximately 736,000 cubic yards over the 22-year remediation period. Because the great majority of this volume would be generated during the initial phases of remedial work, commercial disposal capacity is likely to be available for accommodating the entire volume.

Duration of Remedial Actions

Integration of the timelines for the remediation of each operable unit is already underway and indicates that remedial field work should be in progress for all five operable units by 1997 and continue until 2002, when Operable Units 2 and 4 are expected to reach their remedial objectives. Concurrent remedial actions for solid waste would continue until 2018, when all objectives of the adopted site-wide remedy would be attained. This time frame is compatible with the 27-year period required for groundwater remediation. Any extensions to be projected for completion of solid waste remediation that may arise from progressive findings during field work could have significant cost and time impacts.

Residual Risks to On-Property Receptors

Under the adopted site-wide remedy, portions of the FEMP property could be released from federal ownership to encourage future development. The postremediation condition of the FEMP suggests public land uses for all but 163 acres required for the on-property disposal facility, its perimeter, and support facilities. The adopted land use objective is that of attaining a cleanup which provides for the protection of hypothetical on-property industrial and/or undeveloped park (recreational) users and an off-property farmer. Maximum estimated risks to these receptors from residual contamination is within the acceptable 10^{-4} to 10^{-6} range.

Maintaining Institutional Controls for 1000 Years

The adopted site-wide remedy relies only on passive institutional controls rather than active access controls, which would be discontinued following the attainment of remedial action objectives for solid wastes. In the event of the loss of any of the controls, it has been projected that the remedy would continue to provide protectiveness for future hypothetical on- and off-property receptors.

The representative alternative for Operable Unit 5 coupled with the adopted site-wide remedy would remove the principal threat to human health and the environment and provide the opportunity to transform significant portions of the property into beneficial use.

BIBLIOGRAPHY

Baudo, R., J. Geisy and H. Muntau, eds., 1990 Sediments: Chemistry and Toxicity of In-Place Pollutants, Lewis Publishers, Inc., Ann Arbor, MI.

Beusen, J. M. and B. Neven, 1987, "Toxicity of Vanadium to Different Freshwater Organisms," Bulletin of Environmental Contamination and Toxicology, Vol. 39, pp. 194-201.

Boback, M. W., T. A. Dugan, D. A. Fleming, R. B. Grant and R. W. Keys, 1985, "History of FMPC Radionuclide Discharges," NLCO-2039, National Lead Co. of Ohio, Cincinnati, OH, prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Boback, M. W., T. A. Dugan, D. A. Fleming, R. B. Grant and R. W. Keys, 1987, "History of FMPC Radiological Discharges," FMPC-2082, revision to NLCO-2058, Westinghouse Materials Co. of Ohio, Cincinnati, OH, prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Canter, L. W., 1977, Environmental Impact Assessment, McGraw-Hill Publishing Co., New York, NY.

Clark, T. R., L. Elikan, C. A. Hill and B. L. Speicher, 1989, "History of FMPC Radionuclide Discharges-Revised Estimates of Uranium and Thorium Air Emissions from 1951-1987," Addendum to FMPC-2082, Westinghouse Materials Co. of Ohio, Cincinnati, OH, prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Direction des Substances Dangereuses, 1988, Contaminated Sites Rehabilitation Policy, Gouvernement du Quebec, Ministere de L'Environment, Sainte-Foy, Quebec, Canada.

Dove, G. D., 1961, "A Hydrologic Study of the Valley-Fill Deposits in the Venice Area, Ohio," Technical Report No. 4, Ohio Dept. of Natural Resources, Division of Water, Columbus, OH.

EBASCO Environmental, 1993, "Wetlands Delineation Report of the Fernald Environmental Management Project, Butler and Hamilton Counties, Ohio," prepared for FERMCO, Cincinnati, OH.

Fernald Environmental Restoration Management Corp., 1993, "1992 Fernald Site Environmental Report," FEMP-2290, prepared for U.S. Dept. of Energy, Fernald Field Office, Cincinnati, OH.

International Atomic Energy Agency, 1992, Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards, IAEA, Vienna, Austria.

IT Corp., 1986, "Final Interim Report - Air, Soil, Water, and Health Risk Assessment in the Vicinity of the FMPC, Fernald, Ohio," report and data package prepared for the U.S. Dept. of Energy in support of the Fernald litigation, Oak Ridge Operations Office, Oak Ridge, TN.

Jorgensen, S. E., S. Nors Nielsen, and L. A. Jorgensen, 1991, Handbook of Ecological Parameters and Ecotoxicology, CRC Press, Inc. Boca Raton, FL.

Kabata-Pendias, A. and H. Pendias, 1992, Trace Elements in Soils and Plants, 2nd Edition, CRC Press, Inc., Boca Raton, FL.

Long, E. R. and L. G. Morgan, 1991, "The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program," NOAA Technical Memorandum NOS OMA 52, National Oceanic and Atmosphere Administration, Seattle, WA.

McConnell, R. P., 1977, "Toxicity of Molybdenum to Rainbow Trout under Laboratory Conditions," Molybdenum in the Environment, Vol. 2: The Geochemistry, Cycling, and Industrial Uses of Molybdenum, W. R. Chappell and K. K. Peterson, eds., Marcel Dekker, New York, NY.

Missouri Department of Natural Resources, 1988, Agricultural Use of Municipall Wastewater Sludge - A Planning Guide, Missouri DNR, Division of Environmental Quality, Jefferson City, MO

NUS Corp., 1987, "Evaluation of Source Control Technologies, Douglassville Disposal Site, Berks County, Pennsylvania," NUS, Pittsburgh, PA.

Ohio Environmental Protection Agency, 1993, Ohio Water Quality Standards, OPEA, Division of Water Quality Planning and Assessment, Columbus, OH.

Parkhurst, B. R., R. G., Elder J. S. Meyer and D. A. Sanchez, 1984, "An Environmental Hazard Evaluation of Uranium in a Rocky Mountain Stream," Environmental Toxicology and Chemistry, Vol. 3, pp. 113-124.

Portland Cement Assn., 1991, "Solidification and Stabilization of Wastes Using Portland Cement," Portland Cement Assn., n.p.

Richardson, G. M., 1987, "Inventory of Cleanup Criteria and Methods to Select Criteria," Unpublished report, Committee on Industrial Site Decommissioning, Industrial Programs Branch, Environment Canada, Ottawa, Ontario, Canada.

Shacklette, H. T. and J. G. Boerngen, 1984, Elemental Concentrations in Soils and Other Surficial Materials of the Coterminous United States, U.S. Geological Survey Professional Paper 1270, U.S. Dept. of the Interior, Washington, DC.

Shindel, H. L., J. H. Klingler, J. P. Magnus and L. E. Trimble, 1987, "Water Resources Data, Ohio Water Year 1986," U.S. Geological Survey Water-Data Report OH-86-1, USGS, Columbus, OH.

Spieker, A. M., 1968c, "Groundwater Hydrology and Geology of the Lower Great Miami River Valley, Ohio," U.S. Geological Survey Professional Paper 605-A, available from U.S. Government Printing Office, Washington, DC.

Union of Socialist Soviet Republics State Committee for Science and Technology, 1984, Maximum Allowable Concentrations and Tentative Safe Exposure Levels of Harmful Substances in the Environmental Media, United Nations Environment Programme, Center of International projects, Geneva, Switzerland.

U.S. Army Corps of Engineers, 1987, "Wetlands Delineation Manual," Technical Report Y-87-1, COE Environmental Laboratory, Waterways Experiment Station, Vicksburg, MS.

U.S. Dept. of Energy, 1984, "Remedial Actions at the Former Vitro Chemical Company Site," DOE, South Salt Lake City, Salt Lake County, UT.

U.S. Dept. of Energy, 1991, "Nevada Test Site Annual Site Environmental Report, 1990," DOE/NV 10630.20, Nevada Field Office, Las Vegas NV.

U.S. Dept. of Energy, 1992a, "Risk Assessment Work Plan Addendum," Final Draft, FEMP, Remedial Investigation and Feasibility Study, DOE, Fernald Office, Cincinnati, OH.

U.S. Dept. of Energy, 1992b, "Treatability Study Work Plan for Operable Unit 5: Soil Washing," DOE, Fernald Office, Cincinnati, OH.

U.S. Dept. of Energy, 1993a, "CERCLA/RCRA Background Soil Study," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1993b, "Groundwater Modeling Evaluation Report and Improvement Plan," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1993c, "Groundwater Modeling Report - Summary of Model Development," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1993d, "Initial Screening of Alternatives for Operable Unit 5," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1993e, "Site-Wide Characterization Report," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1993f, "South Plume Removal Action Pumping Test Report," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1993g, "Surface Water Flow and Infiltration Model Summary Report," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994a, "Feasibility Study/Proposed Plan for Operable Unit 1," Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH

U.S. Dept. of Energy, 1994b, "Feasibility Study Report for Operable Unit 4," Final, Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH

U.S. Dept. of Energy, 1994c, "Operable Unit 3 Record of Decision for Interim Remedial Actions," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994d, "Proposed Plan for Remedial Actions at Operable Unit 2," Draft, Fernald Environmental Management Project, DOE/EA-0953, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994e, "Proposed Plan for Remedial Actions at Operable Unit 4," Final, Fernald Environmental Management Project, DOE/EA-0953, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994f, "Record of Decision for Remedial Actions at Operable Unit 4," Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994g, "SWIFT Great Miami Aquifer Model - Summary of Improvements Report," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1995a, "Feasibility Study Report/Proposed Plan for Operable Unit 2," Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH

U.S. Dept. of Energy, 1995b, "Record of Decision for Remedial Actions at Operable Unit 1," Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1995c, "Record of Decision for Remedial Actions at Operable Unit 2," Draft, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1995d, "Remedial Investigation Report for Operable Unit 2," Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1995e, "Remedial Investigation Report for Operable Unit 5," Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH.

U.S. Environmental Protection Agency, 1985, "Handbook of Remedial Action at Waste Disposal Sites (Revised)," EPA/625/6-85/006, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1988a, "Ambient Water Quality Criteria for Aluminum," EPA 440/4-88-008, Office of Water Regulations, Criteria and Standards Division, Washington, DC.

U.S. Environmental Protection Agency, 1988b, "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA," EPA/540/G-89/004, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1988c, "Superfund Exposure Assessment Manual," EPA/540/1-88/001, Office of Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1988d, "Technology Screening Guide for Treatment of CERCLA Soils and Sludges," EPA/540/2-88/004, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1989a, "Determining When Land Disposal Restrictions (LDRs) are applicable to CERCLA Response Actions," EPA Directive 9347.3-05FS, Washington, DC.

U.S. Environmental Protection Agency, 1989b, "Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A, Interim Final," EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1990d, "Exposure Factor Handbook," EPA/600/8-80/043, Washington, DC.

U.S. Environmental Protection Agency, 1991, "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions," OSWER Directive 9355.0-30, EPA, Office of Solid Waste and Emergency Response, Washington, DC.

U.S. Environmental Protection Agency, 1992a "General Methods for Remedial Operation Performance Evaluations for Pump-and-Treat Remediation," EPA/600R-92/002, Washington, DC.

U.S. Environmental Protection Agency, 1992b, "Handbook of Vitrification Technologies for Treatment of Hazardous and Radioactive Waste," EPA/625/R-92/002, Office of Research and Development, Washington, DC.

U.S. Environmental Protection Agency, 1993 "Guidance for Evaluating the Technical Impracticability of Groundwater Restoration," OSWER Directive 923A.2-25, EPA, Washington, DC

U.S. Environmental Protection Agency, 1994a, "Health Effects Assessment Summary Tables (HEAST)," Annual Update FY 1994, EPA 540-R-94-020, prepared by the Office of Health and Environmental Assessment for the Office of Solid Waste and Emergency Response and the Office of Water, Washington, DC.

U.S. Environmental Protection Agency, 1994b, "Selecting Exposure Route and Contaminants of Concern by Risk-Based Screening," EPA/903/R-94-001, Region III, Technical Guidance Manual, Philadelphia, PA.

U.S. Fish and Wildlife Service, 1987, "Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review," Report No. 11, FWS, Patuxent Wildlife Research Center, Laurel, MD.

Verschueren, K., 1983, Handbook of Environmental Data on Organic Chemicals, Van Nostrand Reinhold, New York, NY.

Weston, Inc., Roy F., 1987, "Characterization Investigation Study, Vol. 3: Radiological Survey of Surface Soils," Weston, Inc., West Chester, PA, prepared for Westinghouse Materials Co. of Ohio, Cincinnati, OH.

APPENDIX A

FEMP BACKGROUND INFORMATION

TABLE OF CONTENTS

	Page
List of Tables	ii
List of Figures	iii
List of Acronyms	v
A.1.0 Introduction	A-1-1
A.2.0 Description of Operable Unit 5	A-2-1
A.2.1 Soil	A-2-1
A.2.2 Site-Wide Groundwater Use and Hydrogeology	A-2-2
A.2.2.1 Groundwater Use	A-2-2
A.2.2.2 Site-Wide Hydrogeology	A-2-3
A.2.2.2.1 Hydrogeology of the Glacial Overburden	A-2-4
A.2.2.2.2 Interaction Between Perched Water and the Great Miami Aquifer	A-2-8
A.2.2.2.3 Hydrogeology of the Great Miami Aquifer	A-2-9
A.2.3 Surface Water	A-2-12
A.2.3.1 Surface Drainage on the FEMP	A-2-12
A.2.3.1.1 Controlled Drainage	A-2-13
A.2.3.1.2 Uncontrolled Drainage	A-2-14
A.2.3.1.3 Aquifer Recharge from Surface Streams	A-2-14
A.2.4 Flora and Fauna	A-2-15
A.2.4.2 Regional Ecology	A-2-15
A.2.4.3 Ecological Communities on the FEMP Site	A-2-16
A.2.5 Wetlands	A-2-17
A.2.6 Floodplains	A-2-17
A.2.7 Threatened and Endangered Species	A-2-17
A.2.8 Regional Cultural Resources	A-2-18
A.3.0 Site Description and History	A-3-1
A.3.1 Air Quality	A-3-1
A.3.2 Meteorology	A-3-2
A.3.3 Topography	A-3-3
A.3.4 Geologic History	A-3-3
A.4.0 History of FEMP Operations	A-4-1

TABLE OF CONTENTS
(Continued)

	Page
A.5.0 Nature and Extent of Contamination	A-5-1
A.5.1 Historical	A-5-1
A.5.1.1 Airborne Releases	A-5-1
A.5.1.2 Waterborne Releases	A-5-4
A.5.1.3 Nonroutine Releases	A-5-6
A.5.1.4 Leaching and Transport of Uranium	A-5-7
A.5.2 Operable Unit 5 RI Report Summarization	A-5-10
A.5.2.1 Surface and Subsurface Soil	A-5-10
A.5.2.1.1 On-Site Radiological Parameters	A-5-10
A.5.2.1.2 On-Property Inorganic and Organic Parameters	A-5-11
A.5.2.1.3 Off-Property Radiological Parameters	A-5-12
A.5.2.2 Groundwater	A-5-12
A.5.2.2.1 Perched Groundwater	A-5-17
A.5.2.2.2 Great Miami Aquifer Groundwater	A-5-15
A.5.2.3 Surface Water and Sediment	A-5-25
A.5.2.3.1 Surface Water	A-5-26
A.5.2.3.2 Sediment	A-5-28
A.5.2.4 Air and Direct Radiation	A-5-29
A.5.2.5 Biological Resources	A-5-30

LIST OF TABLES

A-1 Soil Series, Slopes, and Prime Agricultural Soil Classifications

A-2 Uranium Emissions from FEMP Airborne Releases (kg)

A-3 Estimate of Form of Uranium Stack Discharges by Decade (kg)

A-4 FEMP Uranium Emissions Summary (kg)

A-5 Characterization of Uranium Release Transport and Species Changes

References A-5-40

LIST OF FIGURES

A-1 RI/FS Operable Units

A-2 Operable Unit 5 Environmental Media Contamination Pathways

A-3 Soil Types Mapped Within FEMP Site Boundaries

A-4 On-Property Areas Where Construction has Breached Glacial Overburden

A-5 Generalized Cross Section of Buried Channel Aquifer at FEMP and Surrounding

A-6 On-Property Wells Exhibiting Greater Than One Gallon Per Minute Flow Rate

A-6-A Tributaries to Paddys Run and the Storm Sewer Outfall Ditch That Receive Perched Groundwater Flow

A-7 Great Miami Aquifer Generalized Groundwater Flow

A-8 Average Groundwater Elevations in the Great Miami Aquifer (1988 through 1993)

A-9 Major Features of the FEMP

A-10 Groundwater Elevations, Type 2 Wells, April 1993

A-11 Baseline Scenario Water Particle Tracking (Pumping at the SOWC Wells and FEMP Production Well)

A-12 Pumping Scenario Water Particle Tracking (Pumping at the SOWC Wells, FEMP Production Well, and South Plume Recovery Wells)

A-13 Surface Water Hydrology

A-14 Former Production Area Map

A-15 Surface Water Infiltration to the Great Miami Aquifer Along Paddys Run and the Storm Sewer Outfall Ditch

A-16 FEMP Habitat Types

A-17 Potential On-Property Grazing Areas and Surrounding Land Use

A-18 Approximate Boundaries of Jurisdictional Wetlands at FEMP

A-19 Great Miami River and Paddys Run 100-Year and 500-Year Floodplain

A-20 Paddys Run 100-Year and 500-Year Floodplain

A-21 FEMP Wind Rose Composite of 1987, 1988, 1989, 1991, and 1992

A-22 FEMP Topographic Map

A-23 General Stratigraphic Column for the FEMP Site

A-24 Three-Dimensional Bedrock Map of FEMP and Surrounding Area

A-25 Zones of Glacial Overburden (Based on Thickness of Gray Clay)

A-26 Generalized Cross Section of Glacial Overburden Zones

A-27 Study Area Geologic Cross Section Locations

A-28 Geologic Cross Section I-I Study Area

A-29 Geologic Cross Section II-II Study Area

A-30 Geologic Cross Section III-III Study Area

A-31 FEMP Integration with Other DOE Facilities

A-32 Uranium Metal Process Diagram

A-33 FEMP Outfall Line

LIST OF FIGURES
(Continued)

A-34 Groundwater Monitoring Well Completion Depths

A-35 Locations of Perched Groundwater Contaminated Areas

A-36 On-Property Total Uranium (μg/L) Groundwater Concentrations in the Glacial Overburden (Perched Groundwater), 1993 Snapshot Investigation

A-37 On-and Off-Property Total Uranium (μg/L) Groundwater Concentrations, Type 2 Wells (Upper Great Miami Aquifer), 1993 Snapshot Investigation

000619

LIST OF ACRONYMS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
BSL	biodenitrification surge lagoon
CDC	Centers for Disease Control
DOE	U. S. Department of Energy
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FMPC	Feed Materials Production Center
FS	feasibility study
HSL	Hazardous Substance List
NLO	National Lead of Ohio
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PRRS	Paddys Run Road Site
RAC	Radiological Assessments Corporation
RI/FS	remedial investigation/feasibility study
SCS	Soil Conservation Service
SOWC	Southwestern Ohio Water Company
SSOD	storm sewer outfall ditch
SVOC	semivolatile organic compound
SWIFT	Sandia Waste Isolation Flow and Transport [model]
SWRB	storm water retention basin
USGS	U. S. Geological Survey
VOC	volatile organic compounds
WEMCO	Westinghouse Environmental Management Company of Ohio
WMCO	Westinghouse Materials Company of Ohio

A.1.0 INTRODUCTION

Due to the voluminous amount of data generated by the Operable Unit 5 Remedial Investigation (RI), it was necessary to condense and summarize this information for inclusion in the Operable Unit 5 Feasibility Study (FS). A brief discussion of the data and conclusions is contained in Section 1.0 of this FS; more detailed information has been placed in this appendix. For additional detail, the reader should consult the Operable Unit 5 RI Report which is available in the Administrative Record.

Appendix A consists of the following sections:

- Description of Operable Unit 5
- Site Description and History
- History of FEMP Operations
- Nature and Extent of Contamination.

Because the English system is the traditional standard for geologic and geographic information at the FEMP, Operable Unit 5 RI/FS documents will use inches, feet, and miles throughout text, tables, and figures. The metric system is used by the laboratories testing and analytical reports for FEMP site samples. These data are entered in the database in metric units; therefore, all concentration units will be reported and discussed in metric units in the Operable Unit 5 FS. Also, because historical uranium production data was reported in metric units (kilograms and metric tons), this convention will be maintained.

A.2.0 DESCRIPTION OF OPERABLE UNIT 5

Operable Unit 5 is not limited to the FEMP property as such (Figure A-1), but includes affected areas on- and off-property. For the purpose of this document, references to the FEMP site will be made according to the Amended Consent Agreement definition of "site"; references to the FEMP property will be specifically indicated as such.

Figure A-2 lists the Operable Unit 5 environmental media contamination pathways. Media or pathways addressed by Operable Unit 5 site investigations included the following:

- Surface and subsurface soils on and off the FEMP property
- Surface water and sediment in on- and off-property drainage ditches, the Paddys Run corridor, and the Great Miami River
- Water quality and flow characteristics of the perched groundwater system on the FEMP property
- Regional groundwater quality and flow characteristics in the Great Miami Aquifer under and off the FEMP property
- Air quality on and off the FEMP property
- Direct radiation fields on and immediately adjacent to the FEMP property
- Surface water infiltration to the Great Miami Aquifer and on-property perched groundwater
- Terrestrial ecology on and adjacent to the FEMP property areas
- Aquatic ecology in Paddys Run, the Great Miami River, and wetlands on FEMP property.

To understand the transport mechanisms to these media, it is necessary to describe the composition of the surface and subsurface soils and sediment, the site-wide hydrogeology, surface water hydrology, the drainage features at and near the FEMP, and the regional ecology (including ecological communities, floodplains and wetlands, and threatened and endangered species) of the FEMP and surrounding areas.

A.2.1 Soil

Surface soil at the FEMP site is derived from the glacial overburden or the floodplain deposits of Paddys Run and the Great Miami River. The Butler County and Hamilton County Soil Surveys [U.S. Department of Agriculture (USDA) 1980, 1982] have 15 specific soil series or types mapped at the FEMP site (Figure A-3). The major soils identified by the Soil Conservation Service (SCS) as

occurring in the vicinity of the FEMP include the Russell-Xenia-Wynn, Fincastle-Xenia-Wynn, and Fox-Genessee associations (see Table A-1 for soil descriptions). Typically, these soils are light colored, acidic, and well drained. Most of these soils developed from wind-blown material (loess), except along river basins where the Fox-Genessee soils are of till origin. The soils are moderately high in productivity and are frequently used for growing cash crops and producing livestock. The Fincastle and Xenia silt loams cover large areas of the FEMP and west of the FEMP. These soils are light colored, medium acidic, and moderate in fertility and organic content.

Soils exist within the FEMP property boundaries that are classified as prime agricultural soils; however, there are no areas within the boundaries considered to be prime farmland. Prime farmland, as defined by the SCS, is land best suited to producing food, feed, forage, fiber, and oilseed crops. It has the soil quality, growing season, and moisture supply needed to sustain high crop yields if acceptable farming methods are used. Under the Farmland Policy Protection Act of 1981 (7 CFR 658), prime farmland does not include land already in or designated as urban or rural areas, nor can the designated land have more than 30 structures per 40-acre area. Soils do exist within the FEMP site boundaries that meet the requirements for prime agricultural soils as described by the USDA; however, the land use in the area does not meet the requirements of prime farmland as described by the Farmland Policy Protection Act.

The FEMP site was used primarily as farmland prior to construction of the FEMP. Physical activities involved with the construction of the FEMP significantly altered the preexisting soil distribution in the top soil/weathered soil (Figure A-4). Many areas on the FEMP site have little or no native soil present.

A.2.2 Site-Wide Groundwater Use and Hydrogeology

This section of the FS will examine FEMP groundwater use, the site-wide hydrogeology, the hydrogeology of the glacial overburden, and the Great Miami Aquifer hydrogeology. Additional detailed groundwater information can be found in Section 3.6 of the Operable Unit 5 RI Report.

A.2.2.1 Groundwater Use

The Great Miami Aquifer has been designated as a sole-source aquifer under Section 1424(e) of the Safe Water Drinking Act (FR 1988) and as such potentially affects the remediation requirements of the aquifer and contaminated soil. The buried aquifer is considered to be the sole source of drinking water for more than 600,000 people in southwestern Ohio. According to the EPA's groundwater protection strategy, the Great Miami Aquifer is categorized as a Class I aquifer.

Groundwater is the major source of water for industrial and domestic use in the area. Water supply calculations performed by the Ohio-Kentucky-Indiana Regional Council of Governments in 1988

indicated the Great Miami Aquifer provides 100 percent of the potable water for Butler County and 48 percent of the potable water for Hamilton County. The Cincinnati/Bolton Water Works and the Southwest Regional Water District maintain well fields east and northeast of the FEMP to supply domestic users.

Water is provided to consumers by commercial and municipal wellfields and by private groundwater wells. The estimated total pumping from the major wellfields averages more than 18 million gallons per day (Mgd). Within the greater Hamilton-New Baltimore area, there are seven major groundwater users who pump more than 100,000 gallons per day (gpd) from the Great Miami Aquifer. Additionally, there are many smaller industrial, commercial, agricultural, and private groundwater users in the area.

The Southwest Regional Water District (Water District) and the Harrison Township Water Company (Harrison Township) provide water to residents within a 5-mile radius of the FEMP. The Water District provides service to the majority of Morgan and Ross townships, with peak capacity of the plant at 3.6 Mgd and an average flow of 2.0 Mgd. Harrison Township operates a plant with a designed capacity of 2.4 Mgd, an operating peak capacity of 1.4 Mgd, and an average flow of 1.0 Mgd.

Some residents within a 5-mile radius of the FEMP are not served by a water district and must rely on private wells for the provision of potable water. Some of these wells are completed in the glacial overburden and some are completed in the Great Miami Aquifer. Some residences use bottled water or cisterns for water storage in areas having either poor water quality or a lack of available groundwater in the shallow subsurface. Cisterns are most prevalent in the uplands area, where bedrock is overlain by a thin veneer of glacial till.

A.2.2.2 Site-Wide Hydrogeology

The buried valley in which the Great Miami Aquifer occurs has a broad, relatively flat bottom, and steep valley walls (Figure A-5). This valley is filled with extensive deposits of sand and gravel that range in thickness from 120 to 200 feet in the valley to scattered silt and clay deposits only a few feet thick along the valley walls. Contained within the sand and gravel that underlies much of the FEMP property is a relatively continuous, clay interbed up to 20 feet in thickness. The clay interbed occurs at an approximate elevation of 460 feet and, where present, divides the aquifer into upper and lower sand and gravel units, referred to locally as the Upper Great Miami Aquifer and the Lower Great Miami Aquifer.

Large groundwater supplies occur in the sand and gravel deposits, allowing the aquifer to yield a considerable amount of water. In areas where the aquifer is 150 to 200 feet thick or more and

induced stream infiltration is available, water supply wells in the Great Miami Aquifer are the most productive; individual wells can yield 3000 gpm or more in these areas (Spieker 1968). In areas where the aquifer is capped by glacial till, subdivided by the clay interbed, and induced stream recharge is not available, wells generally yield 100 to 500 gpm, though wells of 1000 gpm are not uncommon. The bedrock outside the buried valleys has a lower hydraulic conductivity, and bedrock well yields are generally less than 10 gpm.

A.2.2.2.1 Hydrogeology of the Glacial Overburden

Overlying the Great Miami Aquifer throughout most of the FEMP property is a series of glacial overburden deposits. The glacial overburden is composed primarily of till: a dense, silty clay that contains discontinuous and isolated lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt. Lacustrine deposits overlie the till as superficial deposits under most of the FEMP site. The lacustrine deposits have at least one, and possibly more, laterally extensive permeable sand/silt strata. The glacial overburden exposed at the surface has relatively low permeability, so most of the precipitation that falls on it is lost to evaporation and surface water runoff. Limited infiltration occurs along the upper weathered portion of the overburden and in isolated areas where more permeable deposits of silt, sand, and gravel are the primary overburden constituents. The thickness of the glacial overburden ranges from 5 to 50 feet under the FEMP, but averages between 20 and 30 feet. Except for some scattered deposits, this overburden does not exist along the floodplain of the Great Miami River to the east and south of the FEMP site. On-property areas that lack overburden include certain reaches of Paddys Run and the SSOD where this material has been eroded away, allowing direct contact with the upper portion of the Great Miami Aquifer. Construction activities on-property have also resulted in removal of glacial overburden. Figure A-4 depicts the areas in which the glacial overburden has been removed by erosion or thinned by construction activities.

Erratically distributed pockets of silty sand and gravel within the glacial overburden contain zones of perched groundwater. Perched groundwater is separated from the underlying aquifer by the surrounding relatively impermeable clay and silt components of the overburden. These low-permeability units behave as an aquitard that can store groundwater but transmit it slowly downward from one more porous saturated zone to another. Depth to perched groundwater at the FEMP site ranges from 1 to 15 feet below the ground surface. This measurement can fluctuate seasonally by up to 10 feet at a single location, with the highest water levels occurring during the early spring and the lowest during the late fall.

West and southwest of the production area, sand and gravel outwash deposits of the buried valley are overlain by 5 to 10 feet of till that is in turn overlain by 15 to 20 feet of lacustrine sediment. The till is an unsorted mixture of clay, silt, sand, and pebble- to cobble-size material with 70 to 80 percent of

the material being clay and silt. The till contains sparse, thin, and discontinuous lenses of sand and gravel.

The lacustrine deposits are composed of clayey silt, silt, sand with appreciable fine fractions, and clean sands with silty/clayey sand being the dominant lithology. Strata that overlie the outwash unit were deposited by lower energy depositional lacustrine processes. The low-energy lacustrine sediment consists of clay, silty clay, clayey silt, silt, and fine sand with silty clay the dominant lithology. A loess cap probably overlies the lacustrine; however, it cannot be readily distinguished from the low-energy lacustrine deposits using the U.S. Geological Survey (USGS) soil description/classification methods used during the RI/FS. Elsewhere on the site, where the loess cap can be distinguished, loess is a clayey silt approximately 3 feet thick.

The conceptual model for groundwater flow in the glacial overburden is that the lacustrine strata has good but slow hydraulic communication and the till that underlies the lacustrine strata acts as an aquitard. Groundwater within the approximately 20 feet of lacustrine strata is predicted to flow at a lateral rate that is significantly greater than its downward rate. Therefore, groundwater is likely discharging westward to the bank of Paddys Run and southward in the pilot plant drainage ditch.

Seven wells completed in the glacial overburden were pumped to determine the rate and duration of flow. Information on flow and conductivity calculations and assumptions are contained in Section 3.0 of the RI Report. Well selection for the testing was based upon the amount of coarser grained sediment present and the apparent presence of a readily obtainable amount of groundwater. The purpose of pumping was to determine how much water the sediments would yield before a well went dry. A large, interconnected flow system should be able to yield water to a well faster and longer than a small discontinuous system.

Results of the yield tests indicated the calculated sustainable groundwater discharge from the glacial overburden ranged from less than 1 to 2.5 gpm. Only three areas are capable of supporting a one-week constant-rate test of approximately 2 to 2.5 gpm: a channel in the waste pit area/Well 11214; Plant 1/Well 1339; and Plant 8/Well 1785. The channel located in the waste pit area indicates smaller systems of interconnected yield exist. Most of these channel features are probably located south of the Shandon Tributary as this was the source of sediment during the time the glacial overburden was being deposited. Similar channel features located elsewhere on the FEMP property cannot be ruled out. The interconnected yield system located beneath Plants 1 and 8 is limited by the surrounding silts and clays which exhibit hydraulic conductivity values of 1×10^{-4} centimeters per second (cm/s) or less. It is possible that this area could sustain a yield of greater than 1 gpm for longer than a week.

Two locations in opposite corners of the production area (south of the pilot plant/Well 1259 and the northeast corner of the production area/Well 1274) went dry before a sustainable yield could be calculated. Although the test wells were screened in sand and gravel, a sustainable yield is dependent upon the migration of groundwater from the surrounding clay and silt sediment into the sand and gravel. As a body of silt, sand, or gravel yielded water to the pumping well, coarse-grained material rapidly dewatered because recharge is limited by the migration of water out of the surrounding clay-rich material. Yield test results support the observation that the low hydraulic conductivity of the clay and silt controls the movement of groundwater in the glacial overburden beneath the FEMP.

The results from all the hydraulic property tests in the glacial overburden at the FEMP indicate the following:

- Clays with low permeability control the migration of water and, therefore, the movement of contamination within the glacial overburden
- The potential migration of water and contamination within the glacial overburden is indicated to be very slow; specific discharge ranges from 4.24×10^{-5} feet per day (ft/day) to 7.95×10^{-5} ft/day
- There may be localized zones that could sustain a household water supply in the glacial overburden; however, yields from the glacial overburden are 1 to 2 gpm as opposed to thousands of gpm from the Great Miami Aquifer.

Figure A-6 shows the FEMP on-property area in the glacial overburden in which groundwater flow exceeds one gallon per minute based on 1993 yield tests.

The heterogeneous nature of the glacial overburden makes the interpretation of flow difficult. Silts, sands, and gravels found within the overburden exhibit apparent confined or semiconfined conditions, whereas clays exhibit unconfined conditions. Yield test results indicate the clay with low permeability controls the migration of water. Field observations indicate groundwater is generally encountered within the overburden sediments at a depth of 3 to 5 feet below the ground surface.

The fact that a perched groundwater system exists is the best indication the glacial overburden limits downward migration of groundwater. The fact that a perched water table exists throughout the area covered by the glacial overburden indicates this limitation to downward migration is uniformly present. The geologic cross sections presented in the Operable Unit 5 RI Report confirm the presence of till in the lowest part of the glacial overburden, as do outcrops along Paddys Run. The permeability tests on core samples indicated the hydraulic conductivities in the gray clay till beneath the FEMP are 3.9×10^{-9} to 1.0×10^{-6} cm/s. The geometric mean of slug tests conducted in gray clay is 1.87×10^{-6} cm/s. It is the low hydraulic conductivity of this widespread material that makes the perched groundwater system possible.

Water levels in the glacial overburden at many locations show seasonal cycles, with the highest water levels in the late winter or early spring and the lowest water levels in late autumn after the relatively dry summer. The highest water level elevations are located in the northeastern part of the FEMP and the lowest water elevations are located on the west and southwest sides of the property. Overall, the potential flow is from northeast to southwest. Since Paddys Run and the storm sewer outfall ditch (SSOD) have eroded completely through the glacial overburden, it is not possible for perched groundwater to travel laterally beyond either surface feature, restricting it to that portion of the glacial overburden east of Paddys Run and north of the SSOD. It is important to note there are no groundwater depressions in the areas where the glacial overburden has been thinned by construction activities, indicating that it remains a significant barrier to groundwater flow.

The larger tributaries to Paddys Run and the SSOD that receive perched groundwater flow (shown in Figure A-6A) include the following:

- The deep ditch on the north side of the railroad tracks that extends into the area of the solid waste landfill
- The pilot plant drainage ditch west from the pilot plant area that joins Paddys Run south of the K-65 silos
- Former drainage channels in the glacial overburden that have been filled by the active and inactive flyash piles
- The headwaters of the SSOD that collect water from the east side of the former production area
- The small stream in the very northeastern corner of the FEMP property that flows to the east of the FEMP
- Tributaries to the SSOD that enter from the east and southeast.

Local perturbations in the perched groundwater flow are due to localized drains. A distinct elongated north-south depression in the water table in the center of the former production area is aligned along the main line of the storm sewer system. The storm sewer is collecting a significant amount of infiltration and shallow groundwater in the central portion of the former production area. Routine analyses of water samples from manholes by National Lead of Ohio (NLO) and Westinghouse Environmental Management Company (WEMCO) confirmed that uranium-contaminated perched groundwater is entering the storm sewer system at a number of locations. A groundwater depression on the east side of the general sump may also be due to the presence of a drainage tile installed during the construction of the FEMP. This drainage tile extends from the northeast corner of Plant 8 south to the stormwater retention basin (SWRB).

A.2.2.2.2 Interaction Between Perched Water and the Great Miami Aquifer

A conceptual model of the study area hydrogeology was completed for the Operable Unit 5 RI Report. For this model, the groundwater pathway included both the glacial overburden and the Great Miami Aquifer. Contaminants must either move through or around the glacial overburden to get to the Great Miami Aquifer.

Groundwater present in the glacial overburden is perched above the Great Miami Aquifer water table. The perched water is generally found approximately 3 to 5 feet beneath ground surface and slopes to the west and southwest. Fluid pressures change with depth due to the presence of saturated sediments within and unsaturated sediments beneath the glacial overburden (zero at the water table, greater than atmospheric pressure for saturated sediments, and less than atmospheric conditions for unsaturated conditions). The Great Miami Aquifer water table slopes to the east and south towards the Great Miami River.

The glacial overburden deposit is both heterogeneous and anisotropic which complicates hydrogeologic interpretations. The glacial overburden consists of clay, silt, and gravel, with 60 to 80 percent consisting of silt and clay. The upper portion of the glacial overburden sediments is yellow-brown, indicating oxidation. Variations in sediment types, along with the lack of readily identifiable depositional features, complicate the characterization of flow pathways within the overburden deposit. The geometric mean of hydraulic conductivity from slug tests in the gray clay (1.87×10^{-6} cm/s) appears to control the movement of fluids. The glacial overburden appears to be acting like a giant sponge, which is very slowly dripping into the unsaturated sediment which lies above the water table in the Great Miami Aquifer.

A.2.2.2.3 Hydrogeology of the Great Miami Aquifer

The principal sources of aquifer recharge in the FEMP study area are direct precipitation and stream infiltration. Infiltration of rainfall and snowmelt is the dominant regional source of groundwater recharge, providing approximately 570,000 gpd per square mile (mi^2), or roughly 12 inches per year to the water table of the aquifer (Dove 1961). Much of the precipitation that runs off the glacial overburden on the FEMP property enters Paddys Run and the SSOD, both of which are subject to leakage directly to the aquifer along portions of their length. These streams are intermittent and provide recharge on a seasonal basis.

The pumping of the Southwestern Ohio Water Company (SOWC) supply wells, located at the Big Bend meander of the Great Miami River east of the FEMP site, causes a portion of the surface water to infiltrate through the bed of the river and recharge the aquifer. The collector wells (C-1 and C-2) are located on either side (south and north, respectively) of the Great Miami River in the Big Bend area.

In areas of the river not influenced by the pumping wells, groundwater flows from the aquifer to the river except during wet periods when the elevation of the water in the river is above the water table. Recharge to the aquifer from groundwater occurring in bedrock is limited due to its low permeability. However, erratically distributed joints and cracks allow small amounts of water to seep into the aquifer.

The generalized groundwater flow in the Great Miami Aquifer is shown in Figure A-7. Groundwater enters the FEMP from three separate flow systems: the Dry Fork Section of the New Haven Trough to the west, the Shandon Tributary to the north, and the Ross Section of the New Haven Trough to the northeast. Average groundwater elevations in the upper Great Miami Aquifer for 1988 through 1993 are depicted in Figure A-8.

Natural gradients cause the groundwater to exit the FEMP either by flowing east to the Great Miami River, upstream from New Baltimore, or south through the branch of the bedrock channel west of New Baltimore (Figure A-7). The Great Miami River is the ultimate receptor of all groundwater in the study area.

A mounding effect is present on the west side of the FEMP in the Paddys Run area. Figure A-10 is a groundwater elevation map for April 1993. The 524-foot contour is closed, indicating recharge from Paddys Run causes a mound on the water table; this mound has a significant impact on groundwater elevations beneath the FEMP. Four wells located along Paddys Run Road had water levels below 524 feet in April 1993, indicating that recharge is indeed from Paddys Run rather than increased recharge from farther west.

In conjunction with the mounding, a groundwater divide is present beneath the FEMP. The divide, a high ridge in the water table in which water flows downward away from the divide, runs northwest to southeast. The divide shifts slightly to the south in the area of the flyash piles (Figure A-9) and South Field (Figure A-9) during maximum recharge.

During average conditions, groundwater flows east under the waste storage and former production areas and as far south as the SWRB. Infiltration along the upper portion of the SSOD will also flow to the east. During high recharge conditions, the groundwater divide shifts slightly to the south and conforms with the Paddys Run channel.

The contours in the southern part of the FEMP are parallel to the alignment of Paddys Run and the lower part of the SSOD (Figure A-10). This pattern indicates that groundwater is infiltrating along an approximate 2000-foot-long, roughly linear, segment of the two streams. Groundwater is moving perpendicularly from the recharge area to the southeast. Under average conditions, flow is more

southerly south of the divide and more easterly north of the divide. Under all seasonal conditions, the groundwater south of the divide will flow to the south between the bedrock highs.

Groundwater Modeling

To determine the local pumping effect from one FEMP production well, the South Plume recovery wells, and the SOWC collector wells on the Great Miami Aquifer, particle tracking was performed with the improved Sandia Waste Isolation Flow and Transport (SWIFT) model. The SWIFT model was used to analyze the capture zone of pumping wells and to establish flow patterns.

Particle tracking is initiated at an arbitrary point and calculates the movement of a particle of water for a given time interval using the slope and direction of the groundwater gradient at that point. Chemical constituents typically move much slower than water as defined by their retardation factor. The capture zone analysis of significant pumping well systems defines the time of travel and direction of travel of a water particle over discrete flow lines by reverse tracking. By defining a certain time frame of interest, this analysis defines a theoretical water capture zone extending upgradient from each pumping well. In addition, forward particle tracking was performed to define flow lines from potential on-site sources and the model boundaries. Only forward tracking from source areas will be considered in this discussion.

This analysis considered pumping at three locations:

- The SOWC wells located east of the FEMP adjacent to the Great Miami River (Wells C-1 and C-2)
- The FEMP production well located beneath the former production area (P1)
- The recently installed South Plume recovery wells located south of the FEMP and south of Willey Road.

Baseline and pumping cases were considered in this analysis; the baseline case (Figure A-11) includes pumping at the SOWC wells and the FEMP production well while the pumping case (Figure A-12) includes pumping at all three of the locations. The SOWC wells and the FEMP production well were pumped during the baseline case because they were operating before the release of contaminant sources and, thus, their pumping needs to be considered when assessing historical flow and contaminant transport.

For forward tracking from the source areas, the following steps were conducted:

- Site documentation was reviewed to determine average pumping rates for the different pumping locations

- The recalibrated model was used to determine steady-state pressure fields for both baseline and pumping conditions; the SWIFT velocity output files were used as input to the particle tracking runs

- Forward tracking was conducted to define flow lines from on-site sources and considered cases of both pumping and not pumping the South Plume recovery wells.

The pumping rates considered in the analysis were obtained from the Miami Conservancy District and FEMP site information. The initial combined recovery well pumping rate was 2000 gpm total (400 gpm for each of the 5 wells). However, based on monitoring data and evaluation, these rates were decreased to 1500 gpm (300 gpm for each of the 5 wells). The FEMP production well (P-1) pumps at approximately 240 gpm from the lower Great Miami Aquifer. For the SOWC collector wells (C-1 and C-2), a slightly conservative value of 21 Mgd total was used for particle tracking analysis.

Forward tracking was conducted for a period of 100 years to depict water transport patterns from on-site sources to points of termination. This forward tracking considered cases of both pumping and not pumping the recovery wells. Particles were seeded in model Layer 1 (corresponding to Type 2 well screens) beneath the waste pits, silos, Plant 2/3, Plant 6, South Field, Paddys Run, and the SSOD (where contact with the Great Miami Aquifer occurs).

Figures A-11 and A-12 show the particle tracks for the South Plume recovery wells nonpumping and pumping scenarios, respectively. The capture by the SOWC wells C-1 and C-2 is significantly reduced by the pumping case (Figure A-12) compared to the nonpumping case (Figure A-11). The SOWC well capture in the nonpumping case extends under the waste pits. This simulation also shows that the FEMP production well (P-1) does not significantly capture any of these first layer particles. The groundwater divide occurring at the southeast corner of the FEMP shifts eastward approximately 1300 feet in the pumping case. This indicates that significantly more of the flow is pulled westward for the recovery wells.

Figure A-12 shows significant capture of particles by the South Plume recovery wells seeded along Paddys Run, SSOD, and the South Field. The westernmost wells capture from the reach of Paddys Run adjacent to Paddys Run Road and south of Willey Road. Particles seeded at the northern part of Paddys Run, the silos, the waste pits, and the production area are not captured by the South Plume recovery wells.

Additional details regarding the SWIFT Great Miami Aquifer model including steady-state simulations, forward tracking from the model boundary, and capture zone analysis can be found in the SWIFT Great Miami Aquifer Model - Summary of Improvements Report (DOE 1994d).

A.2.3 Surface Water

The FEMP is located within the Great Miami River Basin drainage (Figure A-13). The Great Miami River is the receiving stream for the FEMP waste water effluent discharge and represents the main surface water feature in the vicinity of the FEMP. The river flows generally to the southwest and has a drainage area of approximately 3360 square miles (mi^2) at the Hamilton gauge, which is located about 10 miles upstream from the FEMP discharge outfall.

The average discharge of the Great Miami River at Hamilton, based on 55 years of records, is 3305 cubic feet per second (ft^3/s) (Miami Conservancy District 1994). Using drainage area scaling, the corresponding average flow at the FEMP point of discharge has been estimated to be 3460 ft^3/s. The maximum discharge ever recorded for the Great Miami River at Hamilton occurred on March 26, 1913 and was estimated to be 352,000 ft^3/s. The maximum discharge since the construction in 1922 of 5 retaining basins, located approximately 7 miles upstream of Hamilton, was 108,000 ft^3/s and occurred on January 21, 1959. The 100-year-flood discharge has been calculated to be 81,455 ft^3/s for the site reach. The minimum daily discharge of 155 ft^3/s was recorded on September 27, 1941. This value is approximately half of the 7-day, 10-year low flow value ($Q_{7\text{-}10}$) of 267 ft^3/s, as computed by the USGS for the Hamilton gauge. This translates to 280 ft^3/s at the site reach for a 7-day, 10-year low flow.

A.2.3.1 Surface Drainage on the FEMP

Natural surface drainage from the FEMP is primarily to Paddys Run. Paddys Run originates north of the site, drains southward along the west side of the FEMP, and enters the Great Miami River approximately 1.5 miles south of the FEMP (Figure A-13). Paddys Run is an ungauged, 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 & Moore 1985). Peak flows have not been measured. Paddys Run loses flow to the underlying aquifer along much of its course on and south of the FEMP due to its highly permeable channel bottom which is eroded into the Great Miami Aquifer. Infiltration modeling discussed in Section 5.3.2 of the Operable Unit 5 RI Report indicates that recharge through the Paddys Run channel to the Great Miami Aquifer occurs at a rate of approximately 14 inches per year.

The course of Paddys Run has been artificially modified by FEMP construction activities at least twice: once in 1961 to prevent erosion of the Pit 3 west berm and once in 1970 to prevent erosion of Paddys Run Road. Sand and gravel were removed from the bed of Paddys Run, just south of the K-65 silos, between 1952 and 1985 (WMCO 1987) for FEMP construction activities. These modifications did not change the potential migration pathway because they did not breach the glacial overburden on the east side of Paddys Run where the FEMP contaminant source areas are located.

A principal drainage feature of the FEMP is a tributary to Paddys Run known as the SSOD. This drainage course originates east of the former production area, flows southwest across the southern portion of the site, and enters Paddys Run near the southwest corner of the property (Figure A-13). The stream bottom in the southern portion of this drainage course is composed of sand and gravel which is part of the Great Miami Aquifer. Given the geologic similarity, the vertical seepage rates through the stream bottom are similar to Paddys Run. Like Paddys Run, the SSOD drainage courses are generally dry in the summer and fall, with flows occurring during and immediately after precipitation.

The SSOD historically conveyed surface water runoff from the production area directly to Paddys Run when the capacity of the storm sewer lift station (Figure A-13), which diverts low-flow storm water to Manhole 175, was exceeded. The SWRB was constructed in October 1986 and expanded with construction of a second chamber in December 1988. After at least a 24-hour retention period to allow for settling of suspended solids, the water is pumped out of the basin to the Great Miami River via the FEMP's effluent line. The basin is designed to retain the runoff from a 10-year, 24-hour rainfall event; only in the event of an overflow would storm water from the production area now enter the SSOD.

Since the last overflow on May 17 and 18, 1990, the pumpout capacity of the basin has been increased as part of Removal Action 3. Construction of the east chamber of the SWRB necessitated relocation of a portion of the drainageway upstream of the storm sewer discharge point and the SWRB spillway. Since 1988 the flow from the headwater area on the eastern side of the production area has been directed around the east and southern sides of the east chamber of the SWRB. The storm sewer discharge point and the SWRB overflow are now on a short tributary to the main water course that makes up the SSOD drainage.

The completion of Removal Action 16 in August 1993 improved the collection of surface water runoff along the perimeter of the production area. Before Removal Action 16, surface water exited the west side of the production area into the waste storage area and the pilot plant drainage ditch on the west and exited the southeast corner of the production area, near the electrical substation, into the upper portion of the SSOD.

A.2.3.1.1 Controlled Drainage

Surface water has always been collected in the production area and discharged to the Great Miami River or the SSOD. With the installation of the SWRB, the former production area discharges to the SSOD have virtually been eliminated. The improvements in operation of the basin and the impact of Removal Action 16 have culminated in a reduction of contaminants being released from the FEMP.

Discharge from the basin occurs after particulate matter has settled out of the water, thus reducing the amount of contamination being discharged to the Great Miami River.

Waste pit surface runoff for Pits 1, 2 and 3 has been diverted to the Clearwell since the pits were capped. Surface water runoff from the perimeter area of the waste storage area previously entered Paddys Run through three tributaries. The southernmost of the three tributaries entered Paddys Run just south of the Clearwell and north of the silo area. Before construction of the storm water runoff controls of Removal Action 2 in 1992, this stream drained the area northeast of the biodenitrification surge lagoon [including the northwest corner of the former production area and the Plant 1 Pad (Figure A-14)]. The northern tributary drained along the north side of Pit 5 and entered Paddys Run immediately south of the railroad tracks. The smallest of the drainages was between Pits 3 and 5 and discharged into the basin area between Pit 3 and Paddys Run. Removal Action 2 diverted the flow of these three streams into a collection sump that allows for treatment of the water before discharge through Manhole 175 to the Great Miami River. The removal action also diverted the surface runoff from the area east and south of the biodenitrification surge lagoon to the pilot plant drainage ditch through a culvert.

The surface water runoff controls prevent the migration of contaminated surface water from the waste storage and production areas to Paddys Run and the SSOD and subsequent infiltration to the Great Miami Aquifer or surface flow to the Great Miami River.

A.2.3.1.2 Uncontrolled Drainage

Several drainageways on the FEMP property are not controlled and thus are potential pathways for surface contaminants to reach Paddys Run, the Great Miami Aquifer, or the Great Miami River. Beginning on the north side of the FEMP and moving counterclockwise around the FEMP, the uncontrolled drainages include the following:

North side drainage ditch
Pilot Plant drainage ditch
Southwest drainage ditch
South drainage ditches
Storm sewer outfall ditch
Southeast drainage ditches
East side drainage ditch
Northeast drainage ditch.

A.2.3.1.3 Aquifer Recharge from Surface Streams

Due to the very low hydraulic conductivity of the glacial overburden in the area of the FEMP, there is only minor recharge to the Great Miami Aquifer in areas where streams and wetlands occur on the

glacial overburden. In areas where streams have cut through the glacial overburden, there is a much greater potential for infiltration due to the high hydraulic conductivity of the Great Miami Aquifer.

Figure A-15 shows the areas where infiltration is most likely to occur due to the erosion of the stream through the glacial overburden; the figure also illustrates the gaining and losing stretches of Paddys Run and the SSOD. Between the waste pit area and a point just south of the SSOD, Paddys Run is losing water to the aquifer. In the half-mile stream interval south of the SSOD, Paddys Run may be losing to or receiving water from the aquifer depending on the season. Even in dry weather Paddys Run is always receiving water from the aquifer in the half-mile stretch of stream north of New Haven Road. From approximately New Haven Road to the Great Miami River, Paddys Run is again a losing or gaining stream depending on the season.

As a result of infiltration to the aquifer, sections of Paddys Run are dry much of the summer. Surface flow and aquifer recharge are greatest between late fall and early spring when storms are frequent and soil moisture levels are sufficient to provide a base flow between storm events. Because Paddys Run and the SSOD lose water to the underlying aquifer, these streams are a significant pathway to the aquifer for contaminant transport. Surface water discharges from the former production area to the SSOD and from the waste storage area to these losing surface streams are the major direct pathway by which contaminants reached the aquifer.

A.2.4 Flora and Fauna

This section describes the regional ecology, ecological communities on the FEMP site, the floodplains and wetlands, and threatened and endangered species at the FEMP site. A more detailed description is provided in the Operable Unit 4 FS-EIS (DOE 1994a).

A.2.4.2 Regional Ecology

The FEMP site and surrounding areas lie in a transition zone between two distinct sections of the Eastern Deciduous Forest Province: the oak-hickory and the beech-maple. The region is characterized by the presence of a mosaic of these forest types. The oak-hickory and beech-maple forest sections share many characteristics, including similar fauna and the presence of white oak as a common species. The beech-maple section covers northern Ohio, Indiana, and lower Michigan. It is bordered by oak-hickory to the southwest, mixed mesophytic to the southeast, and Appalachian oak to the east. Beech-maple forests are typically dominated by beech trees in the canopy, the uppermost layer of the forest, with sugar maples dominant in the understory, below the canopy. The oak-hickory section covers southwest Ohio, western Kentucky and Tennessee, and parts of Indiana, Illinois, Missouri, and Arkansas. The dominant species are oaks, with an abundance of hickories. The fauna vary little between the two forest sections and include white-tailed deer, gray fox, gray

squirrel, white-footed mouse, and short-tailed shrew; the cardinal, woodthrush, summer tanager, red-eyed vireo, and the hooded warbler; the box turtle, common garter snake, and timber rattlesnake.

A.2.4.3 Ecological Communities on the FEMP Site

Ecological communities on the FEMP site consist of grazed and ungrazed pastures, two pine plantations, deciduous woodlands, riparian woodlands, and the "reclaimed" flyash pile (Figures A-16 and A-17). The reclaimed flyash pile area coincides approximately with the South Field and the inactive flyash pile, and it was considered a distinct habitat due to the unique plant and animal species composition. A total of 47 species of trees and shrubs, 190 species of herbaceous plants, 20 mammal species, 98 bird species, 10 species of amphibians and reptiles, 21 species of fish, 47 families of benthic macroinvertebrates, and 132 families of terrestrial invertebrates inhabit the FEMP site.

Typical grasses found on the FEMP site are red fescue, Kentucky bluegrass, timothy, and red top. Herbs include teasel, red and white clovers, and goldenrod. The dominant tree species in the pine plantations are white and Austrian pine, with Norway spruce occurring occasionally. Common trees in the deciduous woodlands are white ash, American elm, shagbark hickory, and slippery elm. Dominant tree species in the riparian woodlands are eastern cottonwood, hackberry, American elm, and box elder. The reclaimed flyash pile area is dominated by American elm, eastern cottonwood, and black locust.

Mammal species observed on the FEMP site include the white-tailed deer, coyote, red fox, opossum, raccoon, groundhog, eastern cottontail, fox squirrel, and several species of bats. Common small mammals are the white-footed mouse, short-tailed shrew, meadow vole, meadow jumping mouse, and eastern chipmunk.

The most common birds breeding on site include the mourning dove, American robin, blue jay, American crow, American goldfinch, northern bobwhite, and common grackle. Species occurring in the greatest density are the goldfinch, song sparrow, and robin. Raptor species observed on site are the northern harrier, red-shouldered hawk, Cooper's hawk, red-tailed hawk, and American kestrel. In addition, the eastern screech owl and great horned owl have been observed in the vicinity of the FEMP site.

Amphibians and reptiles that occur at the FEMP include the American toad, spring peeper, eastern box turtle, and snapping turtle. Several species of snakes also occur on site, including the eastern garter snake, Butler's garter snake, black rat snake, northern water snake, and the queen snake.

Approximately 130 insect families from 15 orders are represented in FEMP site habitats. Leaf hoppers are abundant in all habitats, while less abundant groups include short-horned grasshoppers, leaf beetles, springtails, fruit flies, dark-winged fungus gnats, ants, bees, and wasps.

A.2.5 Wetlands

A wetlands delineation was conducted on the FEMP site December 11 through 18, 1992, and January 7 through 16, 1993. Wetlands were delineated using the Routine On-Site Methodology (Environmental Laboratory 1987). On-site waters of the United States were determined pursuant to 33 CFR 328 (1991). The Jurisdictional Delineation of Wetlands was approved in August 1993 by the Army Corps of Engineers, Louisville District (EBASCO Environmental 1993).

A total of 35.9 acres of freshwater wetlands were delineated on the FEMP site (Figure A-18). Delineated wetlands included 26.58 acres of palustrine forested wetlands in the north-central portion of the site, 6.95 acres of drainage ditches/swales located north and northwest of the former production area, and 2.37 acres of isolated persistent emergent and scrub/scrub wetlands along the northern property boundary just east of Paddys Run and near the northeast corner of the site.

A.2.6 Floodplains

Floodplains within the FEMP property are confined to the north-south corridor containing Paddys Run, which has also been designated as a water of the United States (Figures A-19 and A-20). Areas north of the main rail spur and south of Willey Road were not studied. Outside the boundaries of the FEMP property, the 100- and 500-year floodplains of the Great Miami River also extend northward along Paddys Run from the confluence of the two streams past the southern boundary of the FEMP property (Figures A-19 and A-20).

A study by PARSONS (1993) examined the 100- and 500-year floodplains along Paddys Run. The results of this study predicted a 100-year flood flow of approximately 11,150 cubic feet per second. Elevations range from 542 feet MSL at the southern boundary of the floodplain studied to 567 feet at the northern tip.

A.2.7 Threatened and Endangered Species

Suitable habitat for several state and federally listed threatened or endangered species exists on and nearby the FEMP property. To date, Sloan's crayfish, a state-listed threatened animal, is the only listed species known to reside on the FEMP property (St. John 1993, 1994). Surveys for the federally listed endangered Indiana bat (DOE 1993; Whitaker 1994) and the state listed endangered cave salamander (Davis 1994) have identified resident populations nearby, but not on the FEMP property. Surveys for several endangered plants, running buffalo clover, slender fingergrass, and mountain bindweed, and for one threatened plant, spring coralroot, did not find any populations of

these species on FEMP property. In addition to these potential resident species, the FEMP site provides short term habitat for a number of migratory birds. Endangered and threatened migratory birds spotted at the FEMP include the northern harrier, the northern waterbrush, the dark eyed junco, and the bald eagle.

A.2.8 Regional Cultural Resources

The population and cultural growth of an area are determined by factors such as geologic setting, surface waters, soils, vegetation, and climate. The FEMP property and surrounding area are located over a wide subterranean valley formed as a result of Pleistocene glaciation. The glacial outwash made the valley's soil rich and good for farming. The FEMP site and surrounding area are located near the Great Miami River, which provided a source of water for early residents. These combined factors made this area desirable as a settlement place, rich with diverse cultural resources as evidenced by the number of periods represented in the area's history. From prehistoric times to the late 18th century, five periods of Indian occupation are present at or near the FEMP site: the Paleo-Indian Occupation (12,000 BC - 8000 BC), the Archaic Occupation (8000 BC), the Woodland Tradition (2000 BC - 1000 AD), the Mississippian Tradition (1000AD - 1660AD), and Historic Times (1660 AD).

The Paleo-Indian Occupation was marked by the presence of the nomadic Paleo-Indian people. The Archaic Occupation consisted of the emergence of the Early Archaic People (8000 BC), the Middle Archaic People (6000 BC) and Late Archaic People (3000 BC - 2000 BC).

The Woodland Tradition (1000 BC - 1000 AD) consisted of the Early (1000 BC - 100 BC), Middle (100 BC - 500 BC), and Late (500 AD - 1000 AD). The presence of the Adena Indians delineates the Early Woodland period (1000 BC). The Adena Indians introduced three major changes into the Late Archaic, Early Woodland period: pottery making, horticulture and burial of the dead in earthen mounds. The Hopewell People characterize the Middle Woodland Tradition; the Woodland Indians were present during the late Woodland Tradition.

The Mississippian Tradition (1000 AD - 1660 AD) consisted of three phases: the Turpin Phase (1000 AD- 1250 AD), the Shomaker Phase (1250 AD - 1450 AD), and the Mariemont Phase (1450 AD - 1660 AD). During Historic Times (1660 AD), and as late as 1801, the Shawnee, Wyandot, Iroquois, and Miami Indians were still located in the area of the FEMP.

Additional detailed discussion of cultural resources can be found in the Operable Unit 2 FS.

A.3.0 SITE DESCRIPTION AND HISTORY

The FEMP is a 1050 acre facility located in southwestern Ohio, approximately 18 miles northwest of downtown Cincinnati. The facility is located just north of the small rural community of Fernald, and lies on the boundary between Hamilton and Butler counties (Figure 1-1). Of the total FEMP property, 850 acres are in Crosby Township of Hamilton County, and 200 acres are in Ross Township of Butler County.

Production of uranium metal at the FEMP was limited to a fenced, 136-acre tract of land known as the former production area, located near the center of the site (Figures A-1 and A-13). Large quantities of liquid and solid wastes were generated by various operations. Before 1984, solid and slurried wastes from FEMP processes were stored or disposed of in the on-site waste storage area, located west of the former production area (Figure A-8). The remaining FEMP property consists of forest and pasturelands, a portion of which is leased to nearby dairy farmers to graze livestock (Figures A-15 and A-16).

The land adjacent to the FEMP is primarily devoted to open land use such as agriculture and recreation. Commercial activity is generally restricted to the village of Venice (Ross), approximately 3 miles northeast of the facility, and along State Route (SR) 128 just south of Ross. Industrial use is concentrated in the areas south of the FEMP site, along Paddys Run Road, in Fernald, and in a small industrial park on SR 128 between Willey and New Haven roads. Residential units are situated immediately north of the FEMP site, in Ross, and directly east in a trailer park adjacent to the intersection of Willey Road and SR 128. Other residences located around the site are generally associated with farmsteads.

Because the area had been intensively used for agricultural purposes before the establishment of the FEMP, there is no land on or in the vicinity of the FEMP site where a predevelopment natural environment remains intact. A discussion of the FEMP and its surrounding environment is presented below and includes a description of physical, environmental, and demographic settings. Additional detailed discussion on each of these subjects is available in the RI Report for Operable Unit 5 (DOE 1995) and the Site-Wide Characterization Report (DOE 1993).

A.3.1 Air Quality

National Ambient Air Quality Standards (NAAQS) are health-protective standards that apply to the six pollutants regulated under the Clean Air Act (CAA) of 1990: inhalable (PM 10) particulates, carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, and lead. Extensive monitoring has been performed by the Southwestern Ohio Air Pollution Control Agency (SWOAPCA) in urban locations where the highest concentrations within its four-county jurisdiction (Hamilton, Butler, Warren, and

Clermont) are found. With the exception of ozone, pollutant concentrations at the FEMP site meet the NAAQS. Ozone is a widespread problem requiring regional control and abatement measures mandated by the CAA of 1990. Air quality standards for toxic compounds not regulated under the CAA are defined by individual states. The State of Ohio, acting through the SWOAPCA, has established standards for chemically toxic compounds including ammonia, hydrogen fluoride, and nitric acid, all of which have been historically released from the FEMP in small amounts. Estimates of the impacts to air quality resulting from FEMP releases have been developed using air dispersion modeling. The results of this modeling, which are supported by site monitoring results, appear to indicate that concentrations of air contaminants attributable to FEMP site operations have been well within limits set by the State of Ohio in recent years. The air modeling is discussed in detail in Section 5.0 of the Operable Unit 5 RI Report.

A.3.2 Meteorology

The FEMP has installed and maintains a site meteorological system providing site-specific data for wind speed and direction, ambient air temperature, lapse rate, dew point, temperature, relative humidity, barometric pressure, and precipitation. The system was used by the National Oceanic and Atmospheric Administration (NOAA) to examine the complexity of the local wind field at the FEMP site. Prevailing winds are generally from the southwest and west-southwest. Compiled wind rose information from the FEMP meteorological tower for the years 1987 through 1992 (with the exception of 1990) is shown in Figure A-21.

The average annual precipitation for the Cincinnati area for the period 1963 through 1992 was 40.86 inches and ranged from 27.99 inches in 1963 to 57.58 inches in 1990. The highest precipitation occurs during the spring and early summer. The maximum 24-hour rainfall event of record for the range of years defined above occurred in March 1964 when 5.21 inches fell. Precipitation is typically lowest in late summer and fall. Of the 40.86 inches annual average precipitation received for the FEMP area, the 50-year annual average water loss due to evapotranspiration is approximately 26 inches. Based on these two values, approximately 15 inches of annual precipitation is available for surface water runoff and aquifer recharge. Where glacial overburden is present, approximately 6 of the 15 inches recharges the Great Miami Aquifer and 9 of the 15 inches becomes surface water runoff.

The average annual snowfall for the 1963-64 to 1991-92 period was 22.9 inches, with the heaviest snowfall usually occurring in January. The maximum monthly snowfall for the range of years defined above was 31.5 inches and occurred in January 1978. The maximum recorded snowfall over a 24-hour period occurred in March 1968 when 9.8 inches were recorded at the Greater Cincinnati/Northern Kentucky International Airport.

The regional climate is defined as continental, with temperatures ranging from a monthly average of 29.2°F in January to 75.7°F in July. The highest temperature recorded from 1960 through 1989 was 103°F in July 1988, and the lowest was -25°F in January 1977. Average ambient air temperatures measured at the FEMP meteorological station for the years 1987 through 1992 ranged from 50.7°F to 55.4°F, with the highest annual average daily maximum temperature of 65.1°F and the lowest annual average daily minimum temperature of 41°F. The average number of days per year with a minimum temperature of 32°F or less is 109 days, and the average number of days per year with a maximum temperature of 90°F or greater is 20 days. Maximum frost depth ranges from 30 to 36 inches.

A.3.3 Topography

Maximum elevation along the northern boundary of the FEMP property (Figure A-22) is slightly higher than 700 feet. The former production area and waste storage areas rest on a relatively level plain at approximately 580 feet. The plain slopes from 600 feet along the eastern boundary of the FEMP property to 570 feet at the K-65 silos, and then drops off toward Paddys Run at an elevation of 550 feet. All natural surface drainage, including surface water on the FEMP site, is generally from east to west into Paddys Run, with the exception of the extreme northeast corner, where approximately 23 acres drain east toward the Great Miami River (Figure A-13). The three main drainage features on or near the FEMP are the SSOD, Paddys Run, and the Great Miami River (Figure A-13). The main topographic feature in the vicinity of the FEMP is the New Haven Trough, a relatively broad, flat-bottomed valley flanked on either side by bluffs that rise to a maximum of 300 feet above the general level of the valley floor.

Construction activities altered the topography of the FEMP in the production and waste storage areas. In 1952, the production area was extensively graded to create a land surface that sloped evenly from north to south. Rough grade maps from 1952 indicate up to 10 feet of surface material was removed from the northeast half of the production area and used to fill low areas in the southern and southwestern portions. During construction of the waste pits, that area was extensively regraded. On the west side of Pit 3 and the Clearwell, the top of the berm is approximately 30 feet above the original grade. Farther south along the edge of the Paddys Run corridor, the South Field and the flyash piles were emplaced partly on glacial overburden and partly on the Great Miami Aquifer where the glacial overburden had been eroded away by Paddys Run.

A.3.4 Geologic History

A detailed description of the geology of the FEMP and surrounding area is contained in the Operable Unit 5 RI Report (Section 3.4, Geology and Soil). The following summarizes the geologic description found in the RI Report. A general stratigraphic column for the FEMP is presented in Figure A-23.

In Late Ordovician time (approximately 450 million years ago), sediment that would become a predominantly flat-lying shale with thin interbedded limestone was deposited in a shallow sea. This shale is the relatively impermeable bedrock which now underlies the FEMP area and forms the highlands surrounding the Great Miami River and its tributaries (Figure A-24).

During the mid- to late-Pleistocene period, three major continental glaciers advanced to the north of the Cincinnati area. These were the Kansan (more than 1.2 million years ago), Illinoian (approximately 125,000 to 400,000 years ago), and Wisconsin (approximately 11,000 to 70,000 years ago) glacial episodes.

The drainage system that developed south of the advancing ice sheets was known as the Deep Stage Drainage System. In the Cincinnati area, the Deep Stage Drainage System was composed of the ancestral Ohio River and three major tributaries: the Miami River, the East Fork of the Little Miami River, and the Licking River. The Miami River followed much the same channel as the present-day Great Miami River from Middletown to Ross. The East Fork of the Little Miami River entered the Cincinnati area from the northeast. The Licking River came in from the south in essentially its present-day channel, but continued to the north of the present-day Ohio River.

These three rivers combined to form what is known as the ancestral Ohio River which entered the Cincinnati area from the east along the present-day channel of the Ohio River, then turned northeast through the valley now occupied by the Little Miami River. There it was joined by the East Fork and flowed west through the Norwood Trough to the Mill Creek Valley, where it joined the Licking River. The stream then flowed north through the Mill Creek Valley and turned west to join the Miami River south of Hamilton. It continued to the southwest through the New Haven Trough to near Harrison, where it turned and flowed south through what is now the Whitewater River Valley.

Several tributary streams of later importance entered the main stream in the vicinity of the FEMP. Two streams originated near Miamitown: one flowed north to join the main stream between Shandon and Fernald and the other flowed south following the course of the present-day Great Miami River. Two other small streams originated near New Baltimore and flowed north to the main stream. The Dry Fork of the Whitewater River, which now lies to the west of the area, formerly turned east to Shandon and then flowed south through what is now the Paddys Run Valley.

During the time of Deep Stage Drainage and the early stages of Illinoian Glaciation, the river valleys cut deeply into the shale bedrock to depths up to 200 feet below current valley floor elevations. As the Illinoian ice sheet advanced into the area, ice began to block the Miami River and its confluence with the ancestral Ohio River. This caused water to pond in the Mill Creek Valley. For a time,

water still flowed to the west along the front of the advancing ice sheet and carved the present-day Great Miami River Valley along the tributary system near Miamitown.

When the confluence of the Miami River and the ancestral Ohio River was completely blocked, the ponded water in the Mill Creek Valley rose until it overflowed low divides and carved outlets at Anderson's Ferry and at what is now downtown Cincinnati. This created the present-day channel of the Ohio River. As the ice retreated, the valleys of the Deep Stage Drainage were filled with well-sorted sand and gravel outwash deposits, and the Great Miami and Ohio rivers were established in their present-day channels.

The last stage of glaciation, the Wisconsin, was much less disruptive to the drainage in the area. The ice sheet advanced only as far as the south side of the FEMP. The main effect of this glacial advance in the area was the displacement of the Dry Fork of the Whitewater River from its historic channel into its present-day channel. As it retreated, the ice deposited a moraine which formed a dam and lake over much of what is now the FEMP. The dam was breached, draining the lake permanently. The lake basin is now part of the Paddys Run drainage basin.

Since the last retreat of continental glaciers, the streams in the area have removed portions of the glacial overburden and lacustrine mantle. The Great Miami River has eroded laterally to remove glacial overburden east of the FEMP and has exposed a wide floodplain in direct contact with the glaciofluvial outwash deposits that comprise the buried valley aquifer. Paddys Run and the SSOD are also in contact with these deposits in their lower reaches. The FEMP itself is located on a dissected till plain and lacustrine deposits left by the Wisconsian Glaciation.

The glacial history of the FEMP is in part reflected in the shape of current land forms. This history of ice movement is significant because the resulting geologic deposits now influence the migration of contaminants at the FEMP.

A small ice sheet moved down what is now Paddys Run Valley, depositing glacial overburden on top of the valley fill deposits. The ice was confined laterally by the steep bluffs on either side of the valley. When the ice reached the New Haven Trough, it was no longer confined and spread laterally as it crossed the trough. As the ice moved forward, it deposited a layer of till and pushed up a low ridge at its leading edge. The low ridge west of Paddys Run is the topographic expression of the terminal moraine from this ice advance (Figure A-22). The farthest advance of the southern edge was at least to the bedrock bluffs on the south side of the New Haven Trough and may have been as far as the Great Miami River, south of Fernald. The rising topography on the east side of the FEMP suggests the crest of the terminal moraine was slightly east of the eastern edge of the FEMP. However, lateral erosion by the Great Miami River has removed this material.

As the ice retreated, a lake formed behind the terminal moraine; the shores of the lake reached a maximum elevation of approximately 580 to 585 feet. Eventually, due to a potential combination of erosion at the outlet of the lake and lateral erosion by the Great Miami River, the moraine dam failed and the lake drained. Ultimately, a large meander of the Great Miami River cut laterally north of New Haven Road and completely removed the terminal moraine. Paddys Run has since eroded its valley down into and through the glacial overburden into the aquifer (south of the K-65 silos).

As the ice retreated, it left a small recessional moraine located in the northwestern portion of the FEMP east of Paddys Run. During the formation of this moraine, sand and silt were washed into the lake that formed on the FEMP. The glacial overburden is made up of till formed by the ice advance, the lake fill that formed behind the terminal moraine, and gravel and silt from the recessional moraine.

The postglacial topography of the FEMP has remained the same except for erosion along Paddys Run and the SSOD. The topography of areas where little or no erosion has occurred can be used to infer glacial depositional features left by the ice as the glacier receded, such as till uplands, a lacustrine basin, and Paddys Run channel. The till uplands are areas with elevations above approximately 580 feet where the topography reflects a combination of processes, where glaciers deposit sediment at their front, or as they retreat and melt in place.

Surficial lacustrine deposits filled the basin north of the terminal moraine. Lacustrine sediment is present only at elevations below 580 to 590 feet, indicating the former outlet of the lake and the shoreline of the lake was approximately 585 feet; RI/FS data confirm this elevation. The extremely flat topography west of the storm water retention basin (SWRB) is typical of filled lacustrine basins. Other areas with lacustrine sediment have been dissected by erosion or modified by construction and grading.

The Illinoian outwash deposits in the buried valleys and the Wisconsin glacial overburden are of primary concern because they both contain groundwater which is a potential pathway for contaminants to receptors. The valley fill has regional significance and the glacial overburden, due to its very limited lateral extent, has local significance only under the FEMP property itself.

During the Illinoian glacial retreat about 125,000 years ago, the Deep Stage Valley, including the New Haven Trough, was filled with about 200 feet of glaciofluvial sediment deposited by water running from the margins of the glaciers. The deposits consist mainly of well-sorted sand and gravel. The thick sand and gravel deposits in the bedrock troughs formed the present-day Great Miami Aquifer. A blanket of poorly sorted clay-rich glacial overburden was then deposited on top of this sediment during the Wisconsin ice advance, about 20,000 years ago. Since the last retreat of

continental glaciers, the streams in the area have removed much of the glacial overburden and lacustrine mantle left by the ice sheets. Postglacial erosion by the Great Miami River and its tributaries removed significant portions of the glacial overburden and left terrace remnants which stand topographically higher than surrounding bottom lands. The Great Miami River has eroded through the glacial overburden and is now in direct contact with the glaciofluvial outwash deposits that comprise the buried valley (Great Miami Aquifer). Paddys Run is also in direct contact with these deposits in its lower reaches.

As indicated by a generalized cross section (Figure A-5), the buried valley ranges from about 0.5 to 2 miles wide and is box-shaped, having a broad, relatively flat bottom and steep valley walls. Interbedded fine-grained fluvial and lacustrine deposits occur within the outwash deposits but, in most cases, are of limited lateral extent. In the study area, the thickness of the Great Miami Aquifer varies from 120 to 200 feet in the valley and tributary valley centers to only a few feet along the valley walls. Although the glaciofluvial deposits are heterogeneous, they are typically well-sorted sand and gravel with only minor amounts of silt and clay.

Within the coarse-grained sediment of the Great Miami Aquifer lies a clay layer that underlies most of the FEMP and parts of the area to the west. Figure A-25 is a map showing the zonation of glacial overburden based on thickness of the gray clay; Figure A-26 shows a general cross section through each of the glacial overburden zones. The generalized cross sections depict the minimum thicknesses of materials encountered in these zones.

The clay interbed layer is uniform in texture and contains only a small amount of silt and sand. It was deposited in a lacustrine or low-energy fluvial environment and in some samples displays thin light and dark layers called varves. The clay interbed lies about 100 to 125 feet below the surface and generally about 60 to 80 feet below the water table. Because of this interbed, which may act as an aquitard, the aquifer beneath the FEMP is divided into upper and lower halves. The interbed pinches out to the south and east, extends an unknown distance to the west, and grades into other lacustrine, glaciofluvial, and glacial till deposits to the north in the Shandon Tributary.

In summary, the FEMP is built upon a sequence of Wisconsin Age till, lacustrine, and loess strata that overlies a buried valley sand and gravel aquifer. To distinguish the Wisconsin Age lacustrine, loess, and till strata from the Illinoian valley fill deposits, the former is collectively referred to as glacial overburden. The glacial overburden beneath the FEMP is predominantly clay-rich till that contains interbeds of coarser grained sediment. The glacial overburden is saturated; saturation begins approximately 3 to 5 feet below the ground surface. The dominance of fine-grained particles makes the till at the base of the glacial overburden an effective barrier to vertical migration of contaminants

to the underlying Great Miami Aquifer. The following is a detailed description of the stratigraphy of the glacial overburden presented in the context of depositional environments.

Due to the large number of borings available from the RI, extensive correlation of the geologic units is possible within the FEMP area. Three cross sections that best represent general FEMP geology appear in this FS. Figure A-27 shows cross-section locations and Figures A-28, A-29, and A-30 are cross sections derived from bedrock maps, topographic maps, RI borings, and pre-RI wells.

Figure A-28 (cross section I-I') is a typical cross section obliquely cutting the bedrock valley. Glacial overburden is seen on the western half of the section; on the eastern half, the glacial overburden has been eroded away by the Great Miami River. The Great Miami Aquifer is fairly constant in thickness throughout the section, averaging about 150 to 200 feet thick, with the clay interbed occurring in the western area beneath the FEMP. Bedrock erosional topography is shown in this cross section. Cross sections I-I' and II-II' (Figures A-28 and A-29) illustrate the geology underlying the FEMP. Deposits of glacial overburden overlie the Great Miami Aquifer. The clay interbed underlies the northwestern half of the FEMP, dividing the aquifer almost equally into upper and lower halves. Cross section III-III' (Figure A-30) shows a longitudinal view of the southern portion of the New Haven Trough. A topographic expression of the moraine which dammed a glacial lake in Paddys Run Valley appears on either side of Paddys Run. It should also be noted that the clay interbed is not present this far to the south of the FEMP.

Additional cross sections are included in Section 3.0, Appendix Q, and the Plates of the Operable Unit 5 RI Report.

A.4.0 HISTORY OF FEMP OPERATIONS

The primary mission of the FEMP site during its 37 years of operation was the processing of "feed" materials to produce high-purity uranium metal, thus the derivation of the site's original title, the Feed Materials Production Center. These high-purity uranium metal products were shipped to other DOE facilities. Figure A-31 shows how the FEMP was integrated with other DOE facilities in the defense programs. The Atomic Energy Commission (AEC), predecessor to the DOE, established the FMPC in conformance with AEC orders in the early 1950s. In 1951, NLO, a wholly-owned subsidiary of the National Lead Company, entered into a contract with the AEC as the operations and management contractor for the facility. This contractual relationship lasted, first with the AEC and finally with DOE, until January 1, 1986. Westinghouse Management Company of Ohio (WMCO), a wholly-owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities for the site operations and facilities. In 1991, Westinghouse renamed this subsidiary the Westinghouse Environmental Management Company of Ohio (WEMCO) to correspond with the site name change of FMPC to FEMP to signify the transition of responsibility from defense to environmental restoration programs. On December 1, 1992, the Fernald Environmental Restoration Management Corporation (FERMCO) assumed responsibility for the site as the first environmental restoration management contractor (ERMC) for the DOE.

The FEMP began limited operations in 1951 upon completion of the pilot plant. Figure A-32 is a schematic of the uranium metal process. The pilot plant converted uranium hexafluoride (UF_6) to uranium tetrafluoride (UF_4). The UF_4 was used as feed material for Plant 5 (metals production plant). Also in 1951, Plant 1 (sampling plant) began operation for the sampling of impure uranium feed materials for analysis of uranium assay and isotopic enrichment.

In 1952, Plant 6 operations (metals fabrication plant) were initiated for the fabrication of finished cores. Later, the ingots were shipped off site for extrusion into tubes after they were machined, cored, and heat treated in Plant 6. These slightly enriched uranium ingots were shipped to the Hanford site in Richland, Washington. The extruded tubes of depleted uranium were shipped back to Plant 6 where they were cut, machined, and shipped to the Savannah River Plant in South Carolina. All reject cores were recycled through Plant 5 remelt operations.

Four plants became operational in 1953: Plant 2/3 (refinery), Plant 4 (green salt plant), Plant 5 (metals production), and Plant 8 (scrap recovery plant). Plant 2/3 converted impure feed materials (ore concentrates and recycled residues) from Plant 1 into pure uranium trioxide (UO_3). Beginning in 1962, this plant processed recycled tails containing trace quantities of fission products (technetium-99) and transuranics (plutonium-239). These tails were received from several DOE facilities (including the Hanford site). Plant 4 converted pure UO_3 from Plant 2/3 to pure UF_4 (green salt). Plant 5

converted pure UF_4 from Plant 4 into uranium metal derbies. The derbies weighed between 300 and 375 pounds and consisted of pure uranium metal and a by-product [magnesium fluoride (MgF_2) slag]. Plant 8 processed residues such as off-specification UO_3 and UF_4, MgF_2 slag, ingots and cuts, sump cakes, and chips. Low-grade metal scrap was oxidized to uranium oxide (U_3O_8); fine material became feed for Plant 2/3 and coarse material was further oxidized in a muffle furnace.

With the initiation of operations in 1954 of Plant 7 (hex reduction plant) and Plant 9 (special products plant), all production plants were in full operation from 1954 to 1956. Plant 7 converted UF_6 to UF_4; Plant 9 originally conducted casting and cropping of Plant 5 ingots. Beginning in 1961, the Zirnlo process was conducted at Plant 9 using dilute nitric acid to remove copper from uranium cores which were then recycled for remelt. The Zirnlo process was also used to remove zirconium, copper, nickel, or aluminum from rejected cores by digesting the cladding in hydrofluoric acid, nitric acid, or caustic. This process also dissolves uranium. As operations at DOE sites changed during the 1960s, the FEMP also modified its production streams to meet product specifications. Enriched and depleted uranium production were introduced in the chemical processing operations. Modified billet configurations were produced for Rocky Flats and high purity derby metal was shipped to both Rocky Flats and Oak Ridge.

Production peaked at the FEMP in 1960 at approximately 12,000 metric tons of uranium (MTU) per year; this equates to 13,228 U.S. tons per year. A product decline began in 1964, and reached a low in 1975 of about 1230 MTU (1356 tons). The staffing level, which peaked at 2891 personnel in 1956, slowly declined to 538 personnel in 1979. In 1981, the FMPC began planning to accommodate increased production requirements in support of defense programs. Production levels significantly increased and there was a rapid staff buildup for several years. When production ceased in the summer of 1989, plant resources were focused on regulatory compliance and environmental cleanup activities. In June 1991, the site was officially closed as a federal production facility.

Thorium metal was produced in Plant 9 (1954-1955) and the pilot plant (1969-1971). In Plant 9, solid thorium nitrate tetrahydrate was reacted to form a zinc-thorium derby, which was dezinced and remelted in a vacuum furnace. The resulting thorium metal ingot was machined to produce the final product. The thorium chips and turnings from this operation were processed and returned to the production process for remelting. Thorium oxalate from Plant 4 was also calcined in Plant 9 to thoria and returned to Plant 4.

The pilot plant produced thorium metal from 1969 to 1971. Thorium tetrafluoride was precipitated from hydrofluoric acid added to thorium nitrate tetrahydrate solution. The dried thorium tetrafluoride was milled and blended with calcium metal and zinc fluoride to form a zinc-thorium derby. Thorium

oxalate was produced in the pilot plant from 1971 to 1976 while thoria gel was produced from 1964-1970 and again from 1977-1979.

Thorium hydroxide was produced in Plant 8 for six months in 1966.

A.5.0 NATURE AND EXTENT OF CONTAMINATION

A brief discussion of the nature and extent of contamination for Operable Unit 5 is provided in Section 1.0 of this FS. A more detailed two-part description is given in this appendix and consists of the following information: historical FEMP environmental releases/discharges and a summarization of the Operable Unit 5 RI Report findings.

A.5.1 Historical

A variety of primary release mechanisms including air, wastewater discharge, spills, leaks, and land disposal provided the vehicle for transport of contaminants to environmental media, and subsequently, to potential human and ecological receptors. Secondary releases, such as air resuspension of contaminated soil, contributed to further migration and transport to other media; this migration is discussed further in the Operable Unit 5 RI Report. The cessation of production reduced or eliminated many of the primary sources of contaminant release to environmental media; the remaining primary sources of contamination attributable to the former production area are being addressed under Operable Unit 3 response actions. The following paragraphs briefly discuss airborne, waterborne, and nonroutine releases.

A.5.1.1 Airborne Releases

Airborne particles and gases, radioactive and nonradioactive, were generated by production, storage, and handling operations at the FEMP. Much of the historical information summarized below is excerpted from the following documents and will not be specifically referenced in all instances:

- "A Closer Look at Uranium Metal Production, A Technical Overview" (FMPC 1988)
- "Historical Process Descriptions" (WMCO 1989)
- "History of FMPC Radionuclide Discharges" (Boback 1987, Clark 1989)
- Historical Airborne Release of Uranium and Geochemical Concepts of the Subsurface Uranium Distribution at the Fernald site (Appendix F.3.I of the RI Report for Operable Unit 5).

Current storage and remediation activities are also a source of airborne releases. Airborne particles eventually settle to the ground in the general vicinity of the source, creating a potential for resuspension, as well as a potential for introduction to the human food chain through soil, grass, produce, and milk. Airborne releases and subsequent deposition on the ground also create exposure routes to flora and fauna through several secondary pathways.

The principal sources of past airborne emissions from FEMP processing operations included the following:

- Primary discharges from production operations
  - Dust collector discharges
  - Wet scrubber discharges
  - Acid-pickling fume stacks

- Secondary releases from nonproduction sources
  - Nonproduction sources including the old solid waste incinerator at the sewage treatment plant, the oil burner, the graphite burner, and the new solid waste incinerator
  - Particulate and gaseous emissions during temporary storage of process by-product materials
  - Other sources including building exhaust, laboratory emissions, fugitive emissions from waste pits, radon emissions from the K-65 silos, and nonroutine events.

Since process operations at the FEMP ceased in 1989, airborne emissions have decreased significantly. The total airborne emissions were determined by summing the estimated and measured uranium emissions from a number of stacks, vents, and processes on site. Uranium discharges from monitored stacks were the only measured emissions. Table A-2 summarizes the annual airborne emissions from all known sources at the FEMP since operations began in the 1950s.

Wet scrubber discharges were primarily released from Plant 2/3 gulping operations and Plant 8 wet scrubbers. Acid-pickling operations in Plant 6 and 9 further contributed to uranium emissions. The impact of these emissions to the environmental media is in the discharge of acid vapors which are conducive to promoting solubilization of particulate uranium species released from other sources.

Table A-3 lists estimates of types and time frame of uranium stack discharges during process operations. A summary of total uranium emissions are listed by year and source in Table A-4.

Time characterization is also a significant factor because substantial quantities of uranium discharged during the initial years of operation have had ample opportunity to come into solubility equilibrium with environmental media, undergo slow hydrolysis to other uranium species, or have migrated to other media.

Any analysis of the pathway of uranium releases to environmental media must consider the species transported from the source and the chemical/physical changes it may undergo upon deposition. Routine production operations generally discharged either particulate uranium from dust collectors and the Plant 8 wet scrubbers or vapor forms from Plant 2/3 gulping and Plants 6 and 9 acid pickling processes. The most soluble form of uranium release is UF_6, either from the early days of Plant 7 operation or the pilot plant incident of 1966, because of its hydrolysis to form water soluble uranium

fluoride (UO_2F_2). This form of uranium was rapidly mobilized in the environment. Each of these pathway mechanisms are listed in Table A-5.

Dust collectors and wet scrubbers in Plant 8 were the principal sources of primary airborne emissions at the FEMP and were discharged as either dry particulates from plant stacks or wetted particulates from the Plant 8 scrubbers. The uranium species deposited are listed in Table A-5 and are plant specific. Upon deposition, these species would be expected to undergo chemical/physical changes of solubilization, hydrolysis, or migration of soluble forms. Most uranium compounds have slight solubility in water even over long periods of time (except for uranium fluoride, which is highly soluble). Solubility would be enhanced by soil acidified by FEMP operations or naturally occurring carbonaceous soil; therefore, slow hydrolysis of UF_4 to the soluble UO_2F_2 is expected to occur.

An undetermined amount of uranium was discharged from the Plant 8 metal dissolver. The dissolver, located outdoors, was operated in the 1950s and dissolved uranium metal in hydrochloric acid to produce uranium tetrachloride (UCl_4). An oxidant was added to produce uranyl chloride (UO_2Cl_2) for recovery operation through precipitation and filtration.

Vapor emissions from Plants 6, 8, and 9 operations would be expected to be in transit a moderate distance before depositing on the ground or building surfaces on relatively calm days. Therefore, these emissions are expected to extend beyond the production area but generally remain within the FEMP site boundary. The uranium species deposited are listed in Table A-5 and are expected to migrate after disposition as they are all highly soluble in water.

In November 1993, a draft report, "The Fernald Dosimetry Reconstruction Project - Radionuclide Source Terms and Uncertainties," was issued for review by the Radiological Assessments Corporation (RAC) under contract to the Centers For Disease Control (CDC). The report was prepared to support an initiative being undertaken by the CDC to reconstruct the potential radiological doses received by members of the public residing around the FEMP as a result of environmental discharges during the facility's 38-year operational history.

Within the draft CDC report, RAC evaluated the projected quantities and characteristics of radiological contaminants released to the environment from facility operations. Existing FEMP historical release estimates are presented in the Operable Unit 5 RI Report, were based upon an evaluation of historical stack monitoring data and production records. The RAC estimates employed a probabilistic approach to projecting these same historical release levels.

The probabilistic-based estimates completed by RAC included use of Monte Carlo methods to evaluate the propagation of uncertainty in the estimating process. These Monte Carlo simulations were

completed for total site dust collector emissions, Plant 8 scrubber emissions, Plant 2/3 scrubber discharges and radon releases from the site. In general, the best estimate of the mass of releases from these sources, as projected by RAC, were, on average, approximately 250 percent higher than similar estimates completed by the FEMP. The primary differences reside in the estimation of releases from the Plant 8 scrubbers (385 percent higher release estimates by RAC) and the site-wide dust collection systems (265 percent higher emission estimates by RAC).

No attempt has been made to reconcile the differences between the two estimates of total mass of historical site emissions. For the purposes of this report, it is the forms of uranium chemical (species) that are of significance to the report's findings, not the total mass of contaminants released. The differences in projected total quantities of emissions is not considered significant to the identification of geochemical parameters for fate and transport modeling, which is dependent on the species of uranium forms historically released.

A.5.1.2 Waterborne Releases

Releases of radiological and nonradiological contaminants to environmental media have occurred as the result of FEMP processes involving the generation, storage, and disposal of wastewater. In some instances the discharges were and are regulated under a National Pollution Discharge Elimination System permit. Process wastewaters were produced in virtually all the plants. Within the plants, individual treatment facilities were capable of pretreating the process liquid wastes. In these plant treatment units, a large amount of the uranium compounds dissolved in the liquid wastes were precipitated and removed as sludge or filter cake which, in turn, was recycled through the facilities for uranium recovery or, after August 1986, dried in Plant 8, drummed, and shipped off site for disposal. The filtrate from each plant was sent to the general sump. The Operable Unit 5 RI Report discusses the configuration and function of the general sump in detail. The possibility of effluent line leakage along the outfall line (Figure A-33) to the Great Miami River was the subject of several investigations. Pressure-testing of the line identified one potentially leaking line segment. An entirely new outfall line was constructed in 1992 as part of the South Plume Removal Action.

Currently, liquid effluents from the FEMP (12 basic sources) are monitored and, if necessary, treated before they leave the site. The FEMP effluents eventually enter Manhole 175 where they combine to form a single liquid from which a representative sample can be taken before discharge of the effluent to the Great Miami River.

Surface water runoff has been and is a significant pathway for the migration of contaminants in environmental media. Soil contaminated through air deposition, waste storage areas, and the waste pits are all sources that have released contaminants to storm water runoff. The runoff subsequently became surface water, groundwater, or wastewater effluent. The major pathways for contaminant

migration were from the perimeter of the waste pits directly into Paddys Run at the northwestern corner of the FEMP and through the storm water drains in the production area and a series of drainage ditches which form the SSOD. The SSOD historically has conveyed surface water runoff from the former production area directly into Paddys Run during periods of heavy precipitation when the capacity of the storm sewer lift station (which diverted low-flow storm water to Manhole 175) had been exceeded. Due to their highly permeable channel bottoms, both Paddys Run and the SSOD lose water to the underlying Great Miami Aquifer, providing a mechanism for contaminants to enter the aquifer.

Surface water runoff from the production area is now conveyed to the SWRB; the two chambers were constructed in October 1986 and December 1989 at the head of the SSOD. After a minimum retention period of 24 hours to allow settling of suspended solids, the water is pumped out of the SWRB into the Great Miami River through the main effluent line. The basin is designed to retain the runoff from a 10-year, 24-hour rainfall event; only in the event of an overflow would storm water from the production area enter the SSOD.

During 1992, the Waste Pit Area Storm Water Runoff Control project was completed as an Operable Unit 1 CERCLA removal action. This project involved the installation of ditches, curbs, and storm sewers to collect storm water runoff that previously flowed to Paddys Run from the waste pit perimeter areas. The collected runoff is now directed to a sump and then pumped to the existing 8.5 million gallon biodenitrification surge lagoon (BSL). At the BSL, the storm water is combined with other wastewaters and processed through the biodenitrification and effluent treatment systems.

Production operations contributed significantly to contaminant release to groundwater. The following characteristics of the FEMP production cycle, facilities, and equipment contributed to these unmonitored releases:

- Plants 2/3, 6, 8, and 9 used large quantities of acids to digest, extract, and treat uranium materials; the spilled or leaked soluble uranium then migrated into the groundwater

- Former process operations involved the use of floor sumps, piping, drums, and other containers to collect, store, and transport materials within the plant or to other plants or waste handling areas; materials were contained in floor sumps that were leaking or were not designed to accommodate the part of the process for which they were used

- The process facilities and equipment continued to be used in production operations far beyond their design lives

- The plants in the former production area are situated in a portion of the FEMP site that has a number of perched water-bearing zones interspersed in the glacial till, close to the ground surface.

A.5.1.3 Nonroutine Releases

Due to the nature of activities historically conducted at the FEMP, spills, leaks, and nonprocess discharges to the air, storm sewers, and soil have occurred. Details of these discharges are discussed in "History of FMPC Radionuclide Discharges," (Boback et al. 1987) and an addendum (Clark et al. 1989). These documents discuss only one nonroutine release: an airborne release in the pilot plant area. These documents state the release was not monitored by a sampling system. The incident occurred on February 14, 1966, when the inadvertent removal of a valve from a heated cylinder of uranium hexafluoride resulted in a release of 1195 kg of uranium as UF_6. The cylinder vented for one hour before the valve opening could be plugged.

The reports mentioned above primarily detail the historic discharge of uranium to the air through on-site dust collectors and various incinerators. Wastewater and groundwater are very briefly mentioned but no detailed discussion of nonroutine releases to these areas are presented.

Additional nonroutine releases are reported as "significant or unusual events" in the Environmental Monitoring Annual Reports for 1986, 1987, and 1988 (WMCO 1987, 1988, 1989, 1990). Those events are summarized below by calendar year.

- January 19, 1986: Reaction vessel No. 2 in the pilot plant facility cracked, releasing 21.6 pounds of UF_6 gas to the atmosphere. The maximum amount of uranium in the UF_6 gas was calculated to be 14.5 pounds.

- November 11, 1986: A release of approximately 230 pounds of UO_3 containing 26 parts per billion (ppb) of plutonium occurred from the Plant 4 Bank 9 fluid bed reactor system used to convert UO_3 to UF_4. The primary cause of the incident was the stopping of the feed conveyor screw in a position that allowed an open path for the UO_3 to flow through freely. No estimate was provided on the amount of uranium and/or plutonium released.

- 1987: Although eight unusual events were reported during 1987, only one spill and one release are described (detailed below). The events not described included two magnesium fluoride spills, three UF_4 or UF_4/magnesium blend spills, and one small uranium fire; no additional details on these events are available.

- August 18, 1987: UF_4 escaped from a processing feed hopper in Plant 4 when a gas seal failed as a routine nitrogen purge was introduced into the fluid bed reactors. This resulted in a spill of approximately 200 pounds of uranium oxide.

- September 29, 1987: Anhydrous hydrogen fluoride was released at the pilot plant when a rupture disc on an anhydrous hydrogen fluoride transfer line overpressure protection system was activated. The calculated maximum amount of anhydrous hydrogen fluoride released was 270 pounds.

- January 18, 1988: An area of the Plant 2/3 roof and nearby soil northeast of Plant 2/3 was found contaminated with uranyl nitrate. The amount of uranium released over a number of years was calculated to be approximately 40 pounds.

- June 1988: An undersized exhaust scrubber, designed to remove traces of UO_3 from the Plant 2/3 gulping operations exhaust gases, allowed a release of approximately 145 pounds of uranium to the atmosphere.

- October 4, 1988: A uranium chip fire occurred in Plant 6 when a saw tooth on a milling machine broke off and ignited a drum of depleted uranium chips. The fire spread to four other drums. No estimate of uranium release was completed.

- Spring 1989: Sometime in the spring of 1989 a black material (thought to be fly ash) fell from a dump truck in the area south of Plant 7 routinely used as a parking lot. In July 1989, the material (1356 pounds) was placed in three drums; a sample was collected for analysis and revealed an uranium concentration of 1 percent. The release was calculated to be approximately 0.004 pounds of uranium.

- June 1, 1989, Plant 6: A uranium fire occurred on the southeast storage pad of Plant 6 resulting in a release calculated to be 0.84 pounds of uranium.

In interviews with former and current employees, it has been determined that throughout production operations numerous significant releases have occurred within the FEMP plants and other support facilities. Many of these incidents occurred in areas where "wet" processes took place (especially those involving the use of acids); i.e., uranium-containing liquids came in contact with acid brick that was often cracked or chipped, allowing migration of the uranium-containing liquids to the underlying soil and perched groundwater.

Another source of nonroutine releases to the environment originated from drums staged on noncontrolled pads such as the Plant 1 pad (i.e., no secondary containment, no dedicated sumps, no runoff control). Through the years, improvements have been made through best management practices, spill prevention and control configuration actions, and drum management actions.

A.5.1.4 Leaching and Transport of Uranium

The concepts of leaching and subsequent transport of uranium must be understood for predicting the environmental impact uranium-contaminated soil could potentially have on the underlying groundwater quality in the Great Miami Aquifer. A paper, the "Historical Release of Uranium and Geochemical Concepts of the Subsurface Uranium Distribution at the Fernald Site" (Attachment I to Appendix F.3, Operable Unit 5 RI Report, June 1994) was prepared to provide this understanding in support of the Operable Unit 5 RI fate and transport modeling and also to support the Operable Unit 5 FS modeling used to assist in the selection of uranium preliminary remediation levels (PRLs) for soil. The paper summarized historical uranium releases, type of deposition, form of uranium, and the geochemical conditions which have and will affect uranium migration through the soil column. The paper also

relates these concepts to the leaching and distribution coefficients (K_l and K_d) used in the uranium fate and transport modelling for the Operable Unit 5 RI Report. The following paragraphs provide a brief summary of this paper.

Uranium Release History

As discussed in Section 1.5.4.1 of this document, historical releases of uranium from process plants in general, have occurred in the past either as repetitive emissions or as singular, and in some instances, episodic, well-documented events. An example of a singular airborne release is the 1966 UF_6 tank leak at the pilot plant. Episodic UF_6 releases occurred at Plant 7 in the mid-1950s and repetitive airborne releases of various forms of uranium oxide have been emitted from Plants 2/3, 4, and 5. Examples of former repetitive point source releases to the soil are acid bath spills at Plants 2/3, 6, and 8. Approximately 90 percent of the airborne uranium releases at the site had occurred by the end of 1970. Of all the airborne uranium releases from the site, approximately 25 percent were in the form of relatively soluble uranium compounds and approximately 75 percent were in the form of relatively insoluble compounds.

Geochemical Processes Influencing the Uranium Distribution

Rainwater will leach the various uranium forms and both dissolved and particulate forms will migrate downward through the soil column with infiltrating rainwater. The surface of the water table in the glacial overburden is about 3 to 5 feet below land surface. In general, the soil column is dominated by carbonate minerals in the glacial overburden which is fractured and weathered (brown) glacial overburden in the upper 8 to 15 feet of the column underlain by dense gray glacial overburden to a depth of 20 to 50 feet across most of the site. Fractured glacial overburden has a brown appearance due to the oxidation of iron, as this sediment and groundwater are in contact with oxygen in the atmosphere. The gray glacial overburden has not been oxidized.

Dissolution reactions between rainwater and carbonate minerals are the primary control on the porewater and groundwater compositions, resulting in carbonate-rich water that is effective at complexing and transporting uranium. Adsorption of uranium by the weathered and unweathered glacial overburden is not significantly different, as the aqueous form of uranium is homogenous throughout the glacial overburden.

It is important to highlight the contrast between the heterogeneous uranium forms in the source area and the homogeneous uranium forms in the perched groundwater/glacial overburden system. The heterogeneity of uranium forms in the different source areas results in a wide range of release concentrations to porewater and groundwater. However, once the uranium has been released to the porewater and groundwater, the uranium is homogenized as uranyl carbonate species. This

conceptual picture is important to recall throughout the discussion presented in the following paragraphs.

Below the glacial overburden is the highly permeable sand and gravel that contains the Great Miami Aquifer. Due to the high hydraulic conductivity contrast between the glacial overburden and the sediments comprising the Great Miami Aquifer, the upper portion of the sand and gravel is unsaturated and the Great Miami Aquifer exists as a second unconfined water table as much as 45 feet below the bottom of the glacial overburden. The composition of groundwater in the Great Miami Aquifer is very similar to groundwater in the glacial overburden. Therefore, the nature and mobility of uranium species in these groundwaters is similar.

Distribution of Uranium in the Glacial Overburden

Airborne releases of uranium particles have been deposited site-wide on the surface of the soil as both highly soluble uranium fluorides and less soluble uranium oxides. Over the 1951 to 1989 period of operation, the uranium fluoride forms in this air-deposited source have been leached and transported into the soil column by infiltrating rainfall. Additionally, uranium oxide particles may have been suspended and carried into the subsurface by infiltrating rainwater. The aqueous uranium derived primarily from dissolution of the uranium fluoride forms migrated into the soil first and the less soluble uranium oxide particles remained at or near the surface. As time progressed, the uranium fluoride forms were depleted from the source and uranium concentrations in the infiltrating rainfall begin to decrease, as the less soluble uranium oxide particles become the primary source for leaching. The nature and extent of these migrating fronts with respect to past, present, and future distribution of uranium is evaluated in Appendix F of the Operable Unit 5 RI Report.

Geochemical Parameters For Fate and Transport Modeling

Appendix F of the Operable Unit 5 RI Report relates the historical releases and geochemical concepts to the leaching and distribution coefficients (K_l and K_d) used in the uranium fate and transport model for the Operable Unit 5 RI Report. These same values are to be used in the FS modeling to assist in the selection of soil preliminary remediation levels for uranium-contaminated soils, pending confirmation of the K_l and K_d values through a presently ongoing study. Leaching coefficients are used to determine the input uranium loading as a function of time, and the large range in observed and calculated values (about 1 to 3500 L/kg) reflects the heterogeneity of uranium forms in the source. In contrast, the large range in distribution coefficients (about 1 to 2400 L/kg) reflects the kinetics of adsorption versus desorption, rather than a variety of uranium forms. Adsorption distribution coefficients are well constrained to the range of 11 to 40 L/kg, while desorption coefficients vary from 75 to 2433 L/kg. The lower adsorption values are used to model uranium migration when the source is present, and desorption coefficients are applicable once the source has been removed.

A.5.2 Operable Unit 5 RI Report Summarization

This section summarizes the nature and extent of contamination as defined in the Operable Unit 5 RI Report. To aid in determination of site-related contamination, constituent concentrations in various media were compared to background concentrations. These background data provide points of comparison that aid in understanding the significance of data collected during the RI. The background data can be used to identify constituents present in Operable Unit 5 at concentrations statistically elevated above those levels which occur naturally in soil, surface water, sediment, and groundwater. The following sections discuss the nature and extent of contamination in various media within and outside the FEMP boundaries.

A.5.2.1 Surface and Subsurface Soil

Within the boundaries of the FEMP, much of the soil sampling was conducted in areas where contamination would most likely be present because of activities known to have been conducted in the vicinity. This was supplemented with systematic sampling designed to evaluate potential contamination from airborne releases and point-source releases. The Operable Unit 5 RI Report summarizes the results of this investigation in Tables 7-2 and 7-3. These tables list the surface and subsurface soil areas where parameters were detailed at levels greater than five times the background concentrations and indicate the geographic areas where these parameters were expected to be found (based on process history).

A.5.2.1.1 On-Site Radiological Parameters

Radiological contamination is predominantly characterized by total uranium, radium-226, and total thorium. Other radiological parameters were found within the bounds of these three parameters. The radiological contamination of surface soil is widespread throughout the former production and waste storage areas as well as the areas adjacent to the former production area. Subsurface soil contamination is limited to smaller areas and fewer parameters. Of the radiological contamination detected, uranium and its progeny were generally the only radionuclides found at significantly elevated levels at the FEMP. The uranium contamination, as expected, is widespread, whereas the occurrence of the other radiological constituents is localized and generally limited to the surface soil. With few exceptions, on-property radiological contamination is located within the 20 mg/kg contour for total uranium which is referred to as the uranium envelope in the Operable Unit 5 RI Report.

Total Uranium

Concentrations of uranium in excess of background are found consistently throughout the former production area and in portions of the administrative and laboratory areas. The pervasive uranium contamination is a result of processing uranium, which was the original mission of the FEMP. It has been estimated that during the 38-year production life of the FEMP, more than 179,000 kilograms of

uranium and nearly 6500 kilograms of thorium were released to the atmosphere from the production facilities.

Above-background levels of uranium are found throughout the FEMP at depths as great as 20 feet. The highest concentrations of uranium in the surface soil (greater than 10,000 mg/kg) were found in the Plant 1, Plant 6, laboratory, and former scrap metal pile areas. Total uranium contamination in the subsurface soil can be characterized as isolated occurrences beneath process and waste areas. The areas of highest subsurface uranium contamination, those with concentrations greater than 100 mg/kg, were found localized near former processing facilities and in-ground sumps where acid-solutions of uranium and liquid wastes were handled in large volumes. Total uranium concentrations in surface soil within the FEMP boundary typically ranged from 10 to 100 mg/kg.

Radium-226

Radium-226 contamination is limited to process areas and storage areas where elevated levels were expected. The Plant 1 area and former scrap metal pile are two areas where radium-226 activity was detected at levels greater than 1000 pCi/g. The only area of significant radium-226 contamination in the subsurface soil is the area west of the K-65 silos. The source of this contamination is likely the K-65 decant tank or spills associated with the filling of the silos.

Total Thorium

Elevated levels of thorium and its decay products were generally found in localized areas near former processing and storage locations. All thorium detections were within the uranium envelope. The highest concentrations of total thorium (exceeding 1000 mg/kg) were within the former scrap metal pile and laboratory areas. These occurrences were not pervasive, but isolated areas of major contamination. Thorium contamination was detected primarily in the surface soil and was limited to a depth of less than 10.0 feet in the subsurface soil.

Fission and Uranium Activation Products

Fission and uranium activation products present are associated with recycled uranium that was processed at the FEMP (uranium that has been irradiated in a nuclear reactor for the production of energy, weapons material, or synthetic radionuclides). Irradiated uranium was chemically processed to remove fission and activation products prior to its shipment to the FEMP, but some residual levels remained. These fission and activation products are found sporadically in soil samples, but are generally located within the uranium envelope.

A.5.2.1.2 On-Property Inorganic and Organic Parameters

The majority of inorganic contamination is located in the surface soil. The primary inorganic contaminants at the FEMP are beryllium and cadmium. The only known source of cadmium is as an

impurity in the uranium ore feed material, while the primary source of beryllium is not known. Silver was detected sporadically in both the surface and subsurface soils at low levels across the site. Selenium was found in low concentrations in the subsurface soil; no background level is available for selenium. Volatile and semivolatile organic compounds and PCBs were detected in scattered samples in the vicinity of all major processing and support facilities. With few exceptions, the organic detections were located within the uranium envelope.

A.5.2.1.3 Off-Property Radiological Parameters

Total uranium concentrations were observed at levels slightly above background on the property surrounding the FEMP. Uranium detections exceeding background were mainly located east, northeast, and southwest of the FEMP; the levels generally ranged from 5 to 6 mg/kg in these areas. The probable source of these elevated levels of uranium is airborne releases from the FEMP. However, such low analyte levels as those stated above might be considered to be typical minor variations in analytical results. Although the levels of uranium and its isotopes do exceed background, the exceedance is minor and may be attributable to the accuracy of analytical measurement. There were also isolated areas of significant contamination located along the outfall line and along the eastern boundary adjacent to the sewage treatment plant.

A.5.2.2 Groundwater

Two types of groundwater are discussed in this section: perched groundwater and Great Miami Aquifer groundwater. The nature and extent of contamination in these two groundwater types is described in the following two subsections. Figure A-34 shows the well types, screened intervals, and approximate completion depths of monitoring wells used to characterize groundwater contamination at the FEMP.

A.5.2.2.1 Perched Groundwater

Seven broad areas where uranium and other contaminants are present at above-background concentrations in the perched groundwater are discussed below. The generalized dimensions of these seven areas of contamination are displayed in Figure A-35.

Area I Plume: Production Area

The contaminants detected in Area I resulted from a variety of process-area spills and leaks that occurred over the 38-year operating history of the FEMP. Other probable mechanisms by which the perched groundwater in Area I became contaminated are infiltration of surface water through contaminated surface soil and leaks from the storm sewer network and subgrade piping. At the outer fringes of the Area I plume, where concentrations grade to background levels, uranium is generally present as a result of air deposition onto surface soils and subsequent infiltration to the perched groundwater.

A total of 48 constituents [16 radionuclides, 25 inorganics, volatile organic compounds (VOCs), semivolatiles organic compounds (SVOCs), and 5 general chemistry parameters] were detected at above-background concentrations in Area I. Seven inorganics have been released to groundwater in sufficient quantity to be discernable as plumes in the monitoring well network: calcium, iron, magnesium, manganese, sodium, vanadium, and zinc. Organic compounds were detected infrequently in perched groundwater and are generally minor contaminants relative to the volume of uranium and inorganics released to perched groundwater. Twenty-four VOCs were detected in perched groundwater. Seven VOCs were detected in six or more wells: 1,1,1-trichlororoethane (maximum 310 μg/L), 1,1-dichloroethane (maximum 800 μg/L), 1,2-dichloroethene (maximum 270 μg/L), 1,2-dichloroethane (maximum 72 μg/L), and trichloroethene (maximum 10,000 μg/L). The SVOCs were only rarely detected, and then only at low concentrations. The most frequently detected SVOC was tributyl phosphate, which was detected in 5 of 28 wells tested (maximum 410 μg/L). Tributyl phosphate was used at the FEMP in the uranium refining process. Dioxins, pesticides, PCBs, and furans were not detected in groundwater samples.

The distribution of contamination indicates that lateral migration of contaminants from their initial points of entry has not been extensive. Maps contained in the RI Report show that uranium is the major contaminant, with other contaminants having smaller plume dimensions or only isolated, above-background occurrences relative to uranium. The constituents comprising Area I contamination are generally commingled as a result of releases from multiple production area sources and the migration of contaminants away from their initial point of entry over the 38 years of plant operation. The major areas where contaminants are typically detected well above background are located beneath Plants 2/3, 6, 8, and 9.

Area II Plume: Sewage Treatment Plant

The plume in the vicinity of the sewage treatment plant and incinerator complex clearly has its point of origin at the incinerator complex. The individual parameter plumes that originate from the sewage treatment plant do not overlap with Area I, except for low-level uranium contamination which is present throughout most of the eastern side of the site. Air deposition onto the surrounding surface soil from incinerator air emissions and leaks from the sewage treatment plant are the likely means by which the perched groundwater became affected in this area.

A total of 24 constituents or constituent groups (11 radionuclides, 8 inorganics, VOCs, semivolatiles, and 3 general chemistry parameters) were detected at above-background concentrations in the Area II Plume. Next to uranium, VOCs were the most frequently detected parameter above background. Four VOCs were detected in perched groundwater: 1,1-dichloroethane (maximum 3 μg/L), 1,2-dichloroethene (maximum 89 μg/L), tetrachloroethene (maximum 39 μg/L), and trichloroethene (maximum 13 μg/L). Two semivolatile organic compounds were detected at

concentrations only slightly above the method detection limit: diethyl phthalate (a common laboratory and sampling cross-contaminant) and phenol.

Area III Plume: Operable Unit 2 South Field/Flyash Pile Area

Plumes of individual parameters in Area III are commingled releases from sources within the Operable Unit 2 South Field and active and inactive flyash pile areas (according to individual contaminant concentration contour maps shown in the RI Report. At the outer fringes of the plume, where uranium and other parameter concentrations approach background levels, the contaminants may be present as a result of air deposition onto the surrounding surface soil and subsequent infiltration to the perched groundwater, rather than resulting from releases from the South Field/flyash pile source areas. Along the northern fringe of the plume, where uranium levels approach background, the Area III and Area I plumes may grade into each other at levels approaching background.

A total of 22 constituents or constituent groups (12 radionuclides, 8 inorganics, VOCs, semivolatiles, and 2 general chemistry parameters) were detected at above-background concentrations in Area III. The principal contaminant detected was uranium, which occurs as a distinct plume in the area; other radionuclides occur as isolated detections. Two VOCs, 2-butanone and acetone, were detected in one sample each at concentrations of 1 μg/L and 6 μg/L, respectively. Two semivolatiles, diethyl phthalate and tributyl phosphate were detected in one sample each at a concentration of 1 μg/L. Eight inorganics were only detected at above-background concentrations in isolated wells. The two general chemistry parameters, nitrate and sulfate, were isolated, low-concentration detections.

Area IV Plume: Operable Unit 4 K-65 Silos Area

The Area IV plumes are a result of contaminant migration from the Operable Unit 4 K-65 silos area. To the north of the K-65 silos, as uranium levels grade to background, the Area IV plumes and the southern margin of the Area V plumes may be commingled at levels approaching background. The Area V plume extends into the northern boundaries of the Operable Unit 4 area as far south as Silos 3 and 4.

A total of 29 constituents or constituent groups (7 radionuclides, 17 inorganics, VOCs, SVOCs, and 3 general chemistry parameters) were detected at above-background concentrations in Area IV. The principal contaminant detected was uranium; other radionuclides occurred as isolated detections. Seven inorganics have been released to groundwater in sufficient quantity to be discernable as plumes in the monitoring well network: calcium, magnesium, manganese, sodium, vanadium, and zinc. VOCs were detected very infrequently and at low concentrations: 1,1,2,2-tetrachloroethane (maximum 5 μg/L), 1,1,2-trichloroethane (maximum 2 μg/L), 2-hexanone (maximum 6 μg/L), 4-methyl-2-pentanone (maximum 7 μg/L), acetone (maximum 41 μg/L), bromoform (maximum 2 μg/L), carbon disulfide (maximum 9 μg/L), methylene chloride (maximum 2 μg/L), and toluene

(maximum 1 μg/L). Three isolated detections of semivolatiles were observed: bis(2-ethylhexyl) phthalate (maximum 350 μg/L), diethyl phthalate (maximum 3 μg/L), and n-nitroso-di-n-propylamine (maximum 8 μg/L). There was a single detection of 4,4-DDT at a concentration of 8 μg/L.

Area V Plume: Operable Unit 1 Waste Pits and Operable Unit 2 Solid Waste Landfill Area

The Area V plumes envelop the Operable Unit 1 waste pits and the Operable Unit 2 solid waste landfill. Based on the RI Report, the waste pits appear to be the major contributor to the Area V plumes. In the northeast portion, however, contributions from the solid waste landfill may be present, and these plumes become commingled with plumes originating from the waste pits.

A total of 43 constituents or constituent groups (12 radionuclides, 24 inorganics, VOCs, semivolatiles, and 5 general chemistry parameters) were detected at above-background concentrations in Contamination Area V. Uranium is the principal groundwater contaminant; other radionuclides were detected in isolated wells. Five inorganics have been released to groundwater in sufficient quantity to be discernable as plumes in the monitoring well network: calcium, iron, magnesium, manganese, and sodium. Seven VOCs were detected in multiple wells: 1,1,1-trichloroethane (maximum 8 μg/L), 1,1-dichloroethane (maximum 48 μg/L) 1,1-dichloroethene (maximum 5 μg/L), 1,2-dichloroethene (maximum 60 μg/L), 4-methyl-2-pentanone (maximum 18 μg/L), benzene (maximum 4 μg/L), and trichloroethane (maximum 290 μg/L). Eight SVOCs were detected in perched groundwater. Three of the compounds were phthalates, a common laboratory and sampling cross-contaminant. The other five SVOCs were each detected once: 2,3,4,6-tetrachlorophenol (4.2 μg/L), 4-nitrophenol (4 μg/L), benzoic acid (4 μg/L), pentachlorophenol (7 μg/L), and tributyl phosphate (320 μg/L). Three furans were each detected once: hexachlorodibenzofurans (0.32 μg/L), pentachlorodibenzofurans (0.32 μg/L), and tetrachlorodibenzofurans (0.12 μg/L).

Five general chemistry parameters occur as discernable plumes over Area V with the highest concentrations and greatest number of detections above background being chloride and nitrate. Chloride was detected at above-background concentrations in 15 of 34 wells tested, with a maximum concentration 140 times background (6300 mg/L). Sulfate was detected at above-background concentrations in 21 of 34 wells tested. Elevated concentrations of fluoride were detected in 5 of 34 wells and elevated concentrations of ammonia were detected in 3 of 33 wells.

To the south, the Area V plumes extend into the Operable Unit 4 area approximately as far south as Silos 3 and 4, where uranium concentrations approaching background are observed. Silo 4 is empty and thus is not a contributing source to the Area V plumes. The degree to which Silo 3 contributes to the above-background levels observed in this portion of the Area V cannot be distinguished; however, the Operable Unit 4 RI concluded that, based on process knowledge, potential contributions from Silo 3 would be expected to be considerably less than those anticipated from the K-65 Silos

(Silos 1 and 2). Infiltration of rainwater through uranium-contaminated soil (air fallout) is the likely source of perched groundwater contamination in this overlapping area.

Area VI Plume: Fire Training Area

The fire training area includes the training building, burn pond and drain pit, and the burn tough. The Area VI plumes in the vicinity of the fire training area clearly originate at the training complex. The bulk of the contamination appears to originate at the burn pond, drain pit, and burn trough, rather than from the burnhouse. Because the activities that took place in the burn areas included the ignition of radiologically contaminated combustible organic liquids, the mix of groundwater contaminants includes a mix of organic and radiological constituents. The plume is not commingled with any of the other perched groundwater plumes, with the exception of low-level total uranium concentrations.

A total of 23 constituents or constituent groups (15 radionuclides, 7 inorganics, VOCs, and semivolatiles) were detected at above-background concentrations in Area VI. Uranium and volatile organic compounds are the primary contaminants in the fire training area groundwater data with other radionuclides and inorganic parameters generally detected in isolated wells. Thirteen VOCs were detected in perched groundwater. Seven VOCs were detected in multiple wells: 1,1,1-trichloroethane (maximum 82 μg/L), 1,2-dichloroethene (maximum 520 μg/L), 1,1-dichloroethene (maximum 14 μg/L), 1,2-dichloroethene (maximum 150 μg/L), chloroethane (maximum 24 μg/L), methylene chloride (maximum 19 μg.L), and trichloroethene (maximum 1 μg/L). With respect to SVOCs, only three were detected; and all three were phthalates, which are common laboratory and sampling cross contaminants.

Area VII Plume: Operable Unit 2 Lime Sludge Ponds Area

The pattern of total uranium contamination as shown in the RI Report, does not distinctly separate the lime sludge ponds area from the production area. The lime sludge ponds area and production area do not appear to be separated by an area with less-than-20 μg/L total uranium contamination. However, the lime sludge ponds are physically separated from the production area by open space, and they are administratively separated from the production area contamination by the site division into operable units. Source area investigations, conducted as part of the Operable Unit 2 RI, concluded that perched groundwater contaminants detected in the vicinity of the lime sludge ponds may be attributed to the K-65 trench that traverses through this area, rather than releases from the ponds.

A total of 18 constituents or constituent groups (11 radionuclides, 4 inorganics, semivolatiles and 2 general chemistry parameters) were detected at above-background concentrations in Area VI. Uranium is the most extensive contaminant in groundwater. Other radionuclides and inorganics occur at above-background concentrations only in isolated wells.

As determined in the Operable Unit 5 RI Report, the greatest number of constituents and the highest reported concentrations above background occur in perched groundwater beneath the production area (Figure A-36). The least number of constituents and the lowest reported concentrations occur in perched groundwater near the lime sludge ponds. The results of RI characterization of perched groundwater provide sufficient information to characterize risk and to determine appropriate response actions in the FS.

A.5.2.2.2 Great Miami Aquifer Groundwater

Uranium is the principal groundwater contaminant in the Great Miami Aquifer. The extent of every other contaminant, except sulfate, falls within the limits of uranium contamination as defined by the 5 μg/L contour line of total uranium based on unfiltered samples. Figure A-37 shows the extent of on- and off-property total uranium concentrations in the upper Great Miami Aquifer groundwater.

The uranium contamination observed in the Great Miami Aquifer can be divided into the following six separate plumes, which have six distinctly different point or line sources. Samples from Type 2 wells define the maximum lateral extent for the uranium component of the six plumes. The data for Type 3 and 4 wells show that each of the distinct plumes described above is present as less concentrated and areally extensive plumes at depth.

The approximate edge of each uranium plume is defined by the 5 μg/L contour line shown on the total uranium isoconcentration maps for Type 2 wells in the RI Report. It is reasonable to assume that each plume began forming by the middle-1950s; therefore, the extent of each plume represents the distribution of uranium after approximately 38 years of travel time.

Waste Storage Area A Plume

The Waste Storage Area A plume originates primarily as waste pit leachate that enters the Great Miami Aquifer as a result of leaks from one or more of the six waste pits. In the waste storage area, the glacial overburden is up to 30 feet thick. However, all of the waste pits, with the exception of Pit 5, are excavated deeply into the glacial overburden. Each of these pits can potentially leak to the Great Miami Aquifer because they are underlain by only a thin, protective barrier. Waste Pit 3, the burn pit, and the Clearwell were excavated to such a depth that in places little or no glacial overburden separates their liners from the underlying sand and gravel of the Great Miami Aquifer.

Waste Pits 1, 2, 4, 5, and 6 and the solid waste landfill are underlain by approximately 30 feet of glacial overburden. The Operable Unit 1 FS Report (DOE 1994b) contains a detailed description of waste pit construction details, and the RI Report for Operable Unit 2 (DOE 1995) contains a detailed description of the solid waste landfill. The Operable Unit 1 RI Report concluded that uranium and other contaminants have entered the Great Miami Aquifer as a result of vertical leaks from the waste

pits to the Great Miami Aquifer. The Operable Unit 2 RI Report concluded that the solid waste landfill has not yielded a detectable release to the Great Miami Aquifer. Consequently, Waste Pit 3, the Clearwell, and the Burn Pit may be the largest contributors of contamination to the Waste Storage Area A plume, because they are the only pits not underlain by glacial overburden.

Concentrations of total uranium greater than 5 μg/L in the Waste Storage Area A plume extend laterally across the entire waste pit area in Type 2 wells. The highest total uranium value at this interval was 64.7 μg/L. Deeper in the aquifer at the level of the Type 3 wells, the 5 μg/L contour for total uranium extends laterally across an area of similar size, as was observed in Type 2 wells; the highest total uranium value at the Type 3 depth interval was 28.4 μg/L. No detections above background were noted in Type 4 wells. This is to be expected, since the waste pit area is underlain by the blue clay layer between the Type 3 and Type 4 well depth interval which acts as an aquitard to downward plume migration.

Waste Storage Area B Plume

The Waste Storage Area B plume originates as contaminated surface water in Paddys Run that infiltrates into the Great Miami Aquifer, where Paddys Run flows directly on top of the sand and gravel of the Great Miami Aquifer. Surface water from the waste storage area and north buffer zone has historically drained directly to Paddys Run by way of several unnamed drainages and the pilot plant drainage ditch. High concentrations of uranium have been historically documented in the surface water flow that leaves the waste storage area. Surface water flow in the waste storage area has been controlled since 1992 as a result of a removal action to control storm water runoff in the waste pit area. Consequently, the waste storage area is no longer a contributing source to the Waste Storage Area B plume. However, potentially contaminated surface water flow continues to enter the Paddys Run drainage by way of the pilot plant drainage ditch and drainage from the north buffer zone.

Concentrations of total uranium greater than 5 μg/L in the Waste Storage Area B plume extend laterally away from the line source. The highest total uranium value at this interval was 27.2 μg/L. Deeper in the aquifer at the level of Type 3 wells, the 5μg/L contour for total uranium extends laterally over a smaller area than was observed in Type 2 wells than is observed at the Type 2 well depth (Figure 4-93). The highest total uranium value at the Type 3 depth interval was 31.5 μg/L. No detections above background were noted in Type 4 wells. This is to be expected because the area is underlain by the blue clay layer between the Type 3 and Type 4 well depth interval.

Plant 6 Plume

The Plant 6 plume is believed to originate as perched groundwater that infiltrates into the Great Miami Aquifer, where a deep basement underlies the west half of Plant 6, and where the sewage lift

station is excavated deeply into the glacial overburden. The western portion of Plant 6 is a rolling mill, which has a basement extending more than 20 feet below grade; glacial overburden in the Plant 6 area is approximately 25 feet thick. Total uranium occurs in perched groundwater beneath Plant 6 at concentrations ranging to 146,000 μg/L. Concentration contours of total uranium indicate that the highest concentrations in the Plant 6 plume directly underlie the Plant 6 area. It is believed that the Great Miami Aquifer contamination is primarily the result of contaminated perched groundwater that migrated downward along the Plant 6 basement walls or migrated downward within backfill adjacent to the walls.

Concentrations of total uranium greater than 5 μg/L in the Plant 6 plume extend laterally downgradient from the Plant 6 source area; the highest total uranium value at this interval was 37 μg/L. The highest total uranium value at the Type 3 depth interval was 13.1 μg/L.

South Plume

Contaminated groundwater in the southern portion of the FEMP has historically been referred to as the South Plume. Monitoring wells installed in 1992 and 1993 provide data that show the South Plume is a composite of three separate plumes (A, B, and C) with each plume having a distinctly different source of contamination.

South Plume A

South Plume A originates as infiltration that occurs where the glacial overburden is thin or absent adjacent to and beneath the southern Operable Unit 2 waste units (inactive flyash pile, South Field, and active flyash pile). The RI Report for Operable Unit 2 (DOE 1994c) concluded that the inactive flyash pile, South Field, and active flyash pile were all sources of uranium contamination in the Great Miami Aquifer. Each of these units is constructed such that they lie partly on glacial overburden and partly on the sand and gravel of the Great Miami Aquifer. Releases from these units may potentially reach the Great Miami Aquifer by leachate leaking downward from the waste unit, leachate leaking to perched groundwater, which in turn is transmitted through the glacial overburden to the Great Miami Aquifer, and surface water runoff that flows southward from the waste units onto areas where the glacial overburden is absent and infiltration into the Great Miami Aquifer can readily occur.

Concentrations of total uranium greater than 5 μg/L in the Waste Storage Area A plume extend laterally to the east where they commingle with South Plume B. The highest total uranium value at the interval was 2070 μg/L. The highest total uranium value at the Type 3 depth interval was 3.0 μg/L. No detections above background were noted in Type 4 wells.

South Plume B

South Plume B originated as contaminated surface water runoff that infiltrated into the Great Miami Aquifer through the bed of the SSOD, Paddys Run, and the area immediately southeast of the South Field. Prior to 1986, a significant portion of the storm water runoff from the production area flowed down the SSOD to Paddys Run and eventually to the Great Miami River. Surface water in the SSOD and Paddys Run can potentially infiltrate into the sand and gravel of the Great Miami Aquifer because no glacial overburden underlies the streambed.

The southern edge of South Plume B is commingled with inorganic and organic plumes that originate from the Paddys Run Road Site (PRRS). Uranium exists in groundwater at above-background concentrations beneath and downgradient of the PRRS and could be a byproduct of manufacturing processes at the Albright & Wilson/Ruetgers-Nease phosphoric acid and sodium tripolyphosphate manufacturing plant.

South Plume C

South Plume C originated as contaminated surface water flow in Paddys Run that infiltrated into the Great Miami Aquifer through the bed of Paddys Run along the losing stretch of stream between New Haven Road and the Great Miami River.

South Plume C has low total uranium concentrations relative to South Plumes A and B. The maximum value detected in the 1993 data set was 11.4 μg/L. No Type 4 wells were completed in the South Plume C area.

Other Uranium Plumes and Sources

Slightly elevated total uranium concentrations ranging from approximately 2 to 5 μg/L with isolated concentrations as high as 14 μg/L are observed in wells outside the plume edges defined by the 5 μg/L isoconcentration contours. Uranium contamination on the surface of the glacial overburden has in places been transported through the glacial overburden, resulting in slightly elevated uranium concentrations in the unsaturated sand and gravel above the Great Miami Aquifer. It is believed that this process of slow transport through the glacial overburden is responsible for many of the isolated, above-background, total uranium detections in wells outside the six well-defined plumes of the Great Miami Aquifer.

Low levels of uranium contamination also exist in groundwater along the east bank of the Great Miami River, south of the confluence of Paddys Run. The low levels of uranium contamination in the area were identified through sampling of private wells; results up to 9.9 μg/L total uranium were observed and is believed to have resulted from infiltration of Great Miami River water into the riverbank. It is believed that uranium-bearing surface water flowed down Paddys Run and entered the

Great Miami River; subsequently, the Paddys Run water may have flowed along the west bank of the Great Miami River without mixing completely with the Great Miami River water, thus allowing migration of river water into the soil of the bank.

Radionuclides from Uranium Raffinates

Thorium-230 and radium-226 are progenies of uranium-238 and are found as a natural constituent in uranium ores. Because large quantities of ore were processed through the site and raffinate was disposed in on-property units, thorium-230 and radium-226 are potential contaminants in the Great Miami Aquifer. Thorium-230 and radium-226 are considered minor groundwater contaminants because they are detected only in isolated wells (i.e., their pattern of occurrence does not define a plume), and the above-background concentrations are typically elevated only slightly above background.

Based on unfiltered samples from Type 2 wells, thorium-230 was detected at above-background concentrations in only 10 of 158 wells sampled. The maximum concentration of thorium-230 was 2.5 μg/L, relative to a background concentration of 0.89 μg/L.

Based on unfiltered samples from Type 2 wells, radium-226 was detected at above-background concentrations in only 22 of 158 wells sampled. The maximum concentration of radium-226 was 14.9 μg/L, relative to a background concentration of 1.5 μg/L.

Total Thorium and Thorium-232

Analysis for total thorium is a measurement of the quantity of thorium in a sample without distinguishing between thorium's three principal isotopes (thorium-232, -230, and -228). Thorium-232 was briefly processed at the FEMP. The decay progeny of thorium-232 are radium-228 and thorium-228. Thorium-230 is unrelated to thorium-232 and thorium-228 because it is a progeny of uranium-238. Thorium-232 is much more prevalent in nature, by weight, than are thorium-230 and thorium-228. Additionally, activities of the three thorium isotopes observed at the site, when converted to weight percent, show that thorium-232 is always the most abundant isotope in total thorium results. Consequently, measurement of total thorium in samples is largely a measurement of thorium-232.

Thorium-232 was detected at above-background concentrations in 13 of 185 wells, ranging from 0.3 to 2.7 μg/L, relative to a background concentration of 0.23 μg/L. There is no mechanism that can easily explain the above-background detections of thorium-232 at distances far removed from known sources; consequently, the above-background detections are thought to represent natural variations in the thorium-232 concentration of groundwater.

Radionuclides from Thorium Raffinates

Radium-228 and thorium-228 are progeny of thorium-232 and are found as a natural constituent in thorium materials brought to the site for refining. Thus, radium-228 and thorium-228 are potential contaminants to the Great Miami Aquifer. Radium-228 and thorium-228 are considered minor groundwater contaminants because they are only detected in isolated wells (i.e., their pattern of occurrence does not define a plume), and the above-background concentrations are typically only slightly elevated above background.

Based on unfiltered samples from Type 2 wells, thorium-228 was detected at above-background concentrations in only 18 of 158 wells sampled. The maximum concentration of thorium-228 was 1.97 μg/L, relative to a background concentration of 0.77 μg/L.

Based on unfiltered samples from Type 2 wells, radium-228 was detected at above-background concentrations in only 8 of 158 wells sampled. The maximum concentration of radium-228 was 5.3 μg/L, relative to a background concentration of 3.6 μg/L.

Activation and Fission Product from Returned Uranium Fuels

Fission products and activation products are isotopes that are created in controlled nuclear reactors (activation products: neptunium-237, plutonium-239/240, and plutonium-238; fission products: strontium-90, technetium-99, ruthenium-106, and cesium-137). They can be found in minor quantities in uranium fuel rods that have been used as reactor fuel. Fission products and activation products entered the FEMP as constituents in uranium fuel rods returned to the FEMP for recovery and recycling of uranium. All fission and activation products are considered minor groundwater contaminants because they are generally detected only in isolated wells (i.e., their pattern of occurrence does not define a plume), and the above-background concentrations are typically only slightly elevated above background. Technetium-99 is an exception; it is detected in multiple adjacent wells in the Waste Storage Area A plume (i.e., it can be defined as a plume).

Though technetium-99 can be defined as a plume on the basis of analytical results, it is important to note that the volume of technetium released is minimal. For instance, the maximum detected activity of technetium-99 (34.3 pCi/L) corresponds to a weight concentration of 0.0022 μg/L (i.e., 2.2 parts per trillion).

Inorganic Contamination

The FEMP groundwater samples were typically tested for a suite of 26 inorganic parameters. Fourteen inorganics were present in the Great Miami Aquifer at above-background concentrations but they were not found with trends indicative of plumes or widespread contamination. These inorganics are potentially attributable to FEMP site activities and include aluminum, antimony, copper, cyanide,

lead, manganese, magnesium, molybdenum, nickel, selenium, silicon, silver, thallium, vanadium, and zinc. Detection of these constituents at above-background concentrations are minimal. Many above-background occurrences may represent detection of naturally occurring concentrations.

Characteristic patterns of contamination attributable to FEMP site activities were observed for the following eight inorganics: cadmium, calcium, chromium, cobalt, iron, magnesium, potassium, and sodium. Typical of these patterns are increased concentrations in the vicinity of waste sources and detection of above-background concentrations in multiple adjacent wells; the data and contours imply the presence of plumes.

Cadmium and cobalt were detected at above-background concentrations only in the Plant 6 plume. The lateral extent of the identified plumes is small, localized beneath the Plant 6 source, and limited to the confines of the total uranium component of the Plant 6 plume. On the basis of unfiltered samples from Type 2 wells in the Plant 6 plume, cadmium was detected at a maximum concentration of 0.0459 mg/L, relative to a background concentration of 0.0135 mg/L. On the basis of unfiltered samples from Type 2 wells, cobalt was detected at a maximum concentration of 0.0114 mg/L, relative to a background concentration of 0.0086 mg/L.

Chromium was detected in patterns indicative of a plume only within South Plume A. The lateral extent of the identified plumes is small, localized immediately downgradient of the Operable Unit 2 source, and limited to the confines of the total uranium component of South Plume A. On the basis of unfiltered samples from Type 2 wells in South Plume A, chromium was detected at a maximum concentration of 0.0436 mg/L, relative to a background concentration of 0.0211 mg/L.

Organic Contamination

Detections of VOCs were noted in each of the six FEMP Great Miami Aquifer plumes; the detections of individual VOCs were isolated and of low concentration. The VOCs were noted at their highest concentrations beneath and downgradient of the PRRS. The PRRS has extensive organic contamination in groundwater that is attributable only to the PRRS (ERM 1992).

The extent of VOC contamination in the Waste Storage Area A plume is a good example of the minimal VOC contamination present in FEMP plumes. Based on Type 2 wells in the Waste Storage Area A plume, nine individual VOCs were detected. No individual VOC was detected in more than one well. The nine VOCs and their observed concentrations were 1,1,1-trichloroethane (10 μg/L), 1,1-dichloroethane (5 μg/L), 1,2-dichloroethene (5 μg/L), 2-butanone (34 μg/L), acetone (2 μg/L), chloroform (1 μg/L), toluene (0.8 μg/L), trichloroethene (120 μg/L), and trichlorofluoromethane (66 μg/L).

Semivolatile Organic Compounds

Detections of SVOCs (phthalates and phenols) were noted in each of the six FEMP plumes; the detections of individual SVOCs were isolated and of low concentration. Phthalates are common laboratory and/or sampling contaminants with most detections of phthalates attributed to sample cross-contamination. Phenols were detected in the Waste Storage Area A plume only, where the maximum detected concentration was 50 μg/L.

Other Organics

Pesticides were detected in three wells in the Waste Storage Area A plume and in one well in South Plume B. All detections of pesticides were in isolated wells and detectable concentrations were low. Pesticides detected in the Waste Storage Area A plume were endosulfan-II (0.15 μg/L), endosulfan sulfate (2.6 μg/L), and heptachlor (0.07 μg/L). Pesticides detected in South Plume A were dieldrin (0.016 μg/L) and endosulfan-I (0.025 μg/L).

Isolated detections of dioxins and furans were detected in two isolated wells in the Waste Storage Area A plume and one well in South Plume C. Constituents detected in the Waste Storage Area A plume were hexachlorodibenzofurans (0.38 ng/L), octachlorodibenzo-p-dioxins (0.7 ng/L), pentachlorodibenzofurans (0.31 ng/L), and tetrachlorodibenzofurans (0.22 ng/L). Constituents detected in South Plume C were 2,3,7,8-tetrachlorodibenzo-p-dioxin (1.7 ng/L) and 2,3,7,8-tetrachlorodibenzofuran (1.2 ng/L). The constituents detected in South Plume C were detected in Well 2094, located in a farm field. The positive detections are not attributed to site activities.

General Water Quality Parameters in the Great Miami Aquifer

General water-quality parameters are typically not important contributors to risk calculations; however, water quality parameters are indicators of affected groundwater. Site activities have adversely affected the Great Miami Aquifer in the form of plumes of ammonia, chloride, nitrate, sulfate, and total organic carbon. Isolated above-background detections were observed for alkalinity, fluoride, pH, total phenols, phosphorus, specific conductivity, total organic halogens, total organic nitrogen, and total Kjeldahl nitrogen. Next to uranium, sulfate and nitrate form the most areally extensive FEMP contaminant plumes in the Great Miami Aquifer.

Above-background concentrations of nitrate are present beneath the waste pits. The occurrence of above-background concentrations indicates that the waste pits have been the major source of nitrate to the Great Miami Aquifer, and infiltration of nitrate along the losing stretches of Paddy Run and the SSOD has resulted in isolated above-background concentrations in the Great Miami Aquifer.

Above-background concentrations of sulfate are present beneath the waste pits and the southern portion of the production area. The sulfate plume beneath the waste storage area is attributed to leaks of leachate from the waste pits. The sulfate plume beneath the production area has its highest concentration beneath the Plant 6 area, suggesting that the source of contamination is the same as the uranium which defines the Plant 6 plume. However, the sulfate plume beneath the production area extends upgradient (west) from the Plant 6 source. The westward extension of the sulfate plume is anomalous relative to all other parameters that occur above-background in the Plant 6 plume, suggesting that there may a source of sulfate in the Plant 2/3 area. No other parameters show concentration trends that would indicate the Plant 2/3 area as a source of contamination to the Great Miami Aquifer.

Contamination of the Great Miami Aquifer is largely confined to the uppermost portion of the aquifer. In general, each plume is most laterally extensive at the top of the aquifer (i.e., Type 2 well locations - a total of 340 acres based on the 5 μg/L total uranium contour), less laterally extensive with lesser concentrations at the middle of the aquifer (i.e., Type 3 well locations - a total of 120 acres), and essentially nonexistent at the bottom of the aquifer (i.e., Type 4 well locations).

Isolated occurrences of uranium and other contaminants have been detected at low concentrations at select locations outside the six FEMP plumes. The uranium is primarily a result of deposition of FEMP air emissions on surface soils. In most other cases, there is no evidence the low-level, above-background detections are site related; there is a strong possibility the occurrences are due to natural variation of the constituents, agricultural activities, cross-contamination, or analytical error.

Low levels of uranium contamination also exist in groundwater along the west bank of the Great Miami River, south of the confluence of Paddys Run. The low levels of uranium contamination in this area were identified through sampling of private wells. The contamination is believed to have resulted from infiltration of Great Miami River water into the bank of the river. This contamination is limited to a 100- to 200-foot-wide strip of land along the river bank.

A.5.2.3 Surface Water and Sediment

The RI/FS surface water and sediment sampling program provided for collection of samples at locations within and around the FEMP during the years 1988 to 1993. Complementing RI sampling events are data from the FEMP Environmental Monitoring Program; surface water and sediment samples were collected and analyzed for this program for total uranium from 1986 to the present. In addition, several additional environmental studies have been performed during the past five years. Where pertinent in establishing a historical baseline or for illustration of temporal trends, data from these studies were included in the Operable Unit 5 RI Report.

A.5.2.3.1 Surface Water

The primary drainageways on the FEMP property are Paddys Run and the SSOD (Figure A-13). Paddys Run traverses the western portion of the FEMP from north to south and the Great Miami River is located approximately 1 mile east of FEMP property. Surface water and sediment samples collected from the SSOD, Paddys Run, and the Great Miami River have, in general, been analyzed for a wider range of analytes than the smaller, intermittent drainageways which feed them.

Storm Sewer Outfall Ditch

Currently, the SSOD carries all surface water flow from the open areas east and south of the production area. However, from the beginning of production at the FEMP through 1986, when the SWRB was installed, the SSOD served as the primary receptor of storm water runoff from the production area storm sewer collection system.

As part of the RI program, surface water samples were collected from the SSOD in 1988, 1989, and 1993. Total uranium was detected in all samples with concentrations ranging from 2 to 51.8 μg/L. One sample also exhibited above-background concentrations of magnesium and sodium. The only other notable constituent present was the semivolatile bis(2-ethylhexyl)phthalate with concentrations ranging from 16 to 58 μg/L.

Paddys Run

Paddys Run is an intermittent stream that flows south along the western edge of the FEMP to the confluence with the Great Miami River approximately 2.5 miles south of the FEMP. Historically, Paddys Run received both uncontrolled FEMP sheet runoff and runoff from drainage ditches within the FEMP boundaries. Numerous storm water runoff control projects and removal actions in the waste storage area and production area have nearly eliminated the primary sources of contamination to Paddys Run. Currently, all uncontrolled drainages except the northeast drainage ditch (which flows to the Great Miami River) discharge into Paddys Run or one of its tributaries. These uncontrolled drainage ditches continue to be pathways for contaminants to reach Paddys Run, the Great Miami River, and the Great Miami Aquifer.

For surface water samples collected as part of the RI program from the on-property portion of Paddys Run during the period 1988 to 1993, constituents exceeded background concentrations for uranium-238, uranium-234, and strontium-90. In addition, the average on-property total uranium concentration, 15.5 μg/L, exceeded average Paddys Run background values by an order of magnitude. The average on-property concentrations of aluminum and silicon in Paddys Run were also determined to be above the average surface water background concentrations in Paddys Run.

Surface water samples collected from off-property locations in Paddys Run to the south of the FEMP contained concentrations slightly above the Paddys Run background levels for thorium-230, uranium-234, uranium-238, and total uranium. The maximum detected concentrations for each of these constituents occurred at different locations. The filtered concentrations for calcium, manganese, and silicon also slightly exceeded the Paddys Run background concentrations for these constituents.

Great Miami River

The Great Miami River is the principal surface water feature in the FEMP area and the ultimate receptor of surface water discharged from the FEMP. The two principal pathways for FEMP discharges to enter the river are effluent from the outfall line and surface water flow from Paddys Run.

Numerous sampling programs have investigated discharges to the Great Miami River by sampling upstream locations to establish background concentration values, and comparing background values to sampling points downstream of the outfall line and the mouth of Paddys Run. Environmental monitoring data is also used to illustrate temporal trends in total uranium concentrations.

Using results from the FEMP Environmental Monitoring Program, the Great Miami River surface water sampling data show that during the period from 1986 to 1993, the highest annual average concentration of total uranium was 2.5 μg/L, detected downstream of the confluence of Paddys Run with the Great Miami River. The data indicate that since 1991, annual average concentrations at both sampling locations have been below 2 μg/L.

The RI/FS program consisted of data collected during 1988/1989 and 1993. This data is representative of conditions in the river before and after production activities were halted at the site. As part of the 1988/1989 RI/FS sampling program, total uranium was detected in Great Miami River surface water samples at concentrations ranging from 1 to 7 μg/L. The highest concentrations were detected in samples collected between the FEMP outfall line and the confluence of Paddys Run with the Great Miami River. Thorium-228 was detected at levels ranging from 1.5 to 2.6 pCi/L; thorium-230 was detected in one sample at 1.3 pCi/L at a location immediately downstream of the confluence of Paddys Run with the Great Miami River. Technetium-99 was detected in 19 samples at concentrations ranging from 30 to 95.9 pCi/L. Radium-228 was detected in one sample at 5 pCi/L. Metals were detected at concentrations comparable to background and phenols were detected at concentrations ranging from 0.01 to 0.03 μg/L.

One round of surface water was collected as part of 1993 RI/FS activities. All samples were analyzed for Hazardous Substance List volatile, semivolatile, and inorganic parameters, total and isotopic uranium and thorium, and isotopic radium. Surface water samples were also analyzed for general

water chemistry parameters. Total uranium was detected in all surface water samples at concentrations ranging from 0.4 to 2.8 μg/L. Isotopic uranium was not detected above background concentrations. The highest isotopic thorium activity detected was 0.7 pCi/L. Radium-226 was detected at activity levels ranging from 0.6 to 2.8 pCi/L. One organic constituent (trichloroethane) was detected in one sample; two semivolatiles [bis(2-ethylhexyl)phthalate and di-n-butyl phthalate] were also detected in the same sample.

A.5.2.3.2 Sediment

Sediment samples were collected from the SSOD, Paddys Run, and the Great Miami River. The analytical results are discussed below.

Storm Sewer Outfall Ditch

Sediment samples collected from the SSOD showed that uranium and technetium-99 were the most abundant radionuclides. Total uranium concentrations ranged from 3.3 to 12 mg/kg. Metals detected at above-background concentrations included beryllium, calcium, magnesium, sodium, and zinc. Methylene chloride (a volatile) was detected at 6 mg/kg; six semivolatiles were also detected at low concentrations.

Paddys Run

Radium-226, thorium-230, and total uranium were detected in sediment from the on-property portion of Paddys Run at slightly above-background concentrations. The maximums for these radionuclides occurred downstream of the pilot plant drainage ditch and upstream of the flyash piles. Although thorium-230 was detected in one sample collected from Paddys Run, there is no background concentration available for comparison.

In addition to radionuclides, volatile organics, semivolatiles, and inorganics were detected in on-property Paddys Run sediment. During the 1993 RI/FS sediment sampling, several volatile organics not previously detected were identified: acetone, chloroform, carbon tetrachloride, methylene chloride, and toluene. All constituents were detected at on-property locations at a concentration at or below 3 μg/kg. Semivolatiles not previously detected were also identified; PAHs ranged from 100 to 350 μg/kg in the sediments taken from the last sampling point on Paddys Run (before the stream exits FEMP property). The following inorganic concentrations were detected at levels above-background concentrations: aluminum, barium, calcium, magnesium, manganese, nickel, potassium, vanadium, and zinc.

Off-property sediment locations in Paddys Run were sampled for inorganics and, although all metals were detected, only calcium, magnesium, and zinc exceeded the sediment background concentrations.

One sediment sample was analyzed for HSL organics with only methylene chloride detected at a concentration of 6 μg/kg.

Great Miami River

With regard to sediment samples collected during the FEMP Environmental Monitoring Program, the data shows no discernable difference between total uranium concentrations in sediment from locations upstream and downstream of the FEMP outfall line.

Sediment samples collected in 1988/1989 for the RI/FS sampling effort showed no discernable increase in levels of radionuclides downstream of the effluent line or downstream of Paddys Run. Total uranium was detected at concentrations ranging from 1 to 3 μg/kg. The average activity levels for the uranium isotopes was at or less than background concentrations. Radium-226 was detected at twice background concentrations and thorium-230 was detected at three times background concentrations at a location downstream of the confluence of Paddys Run with the Great Miami River.

One round of Great Miami River sediment samples was collected as part of 1993 RI/FS activities. All samples were analyzed for HSL volatile, semivolatile, and inorganic parameters, total and isotopic uranium and thorium, and isotopic radium. Total uranium was detected at concentrations ranging from 2 to 11 μg/kg. Interestingly, the highest total uranium value was detected at the sampling location farthest from the outfall line. The only other radionuclide detected above-background concentrations was radium-226; activity levels ranged from 0.4 to 0.8 pCi/g. Metals detected at concentrations above-background included barium, beryllium, calcium, chromium, cobalt, copper, lead, magnesium, nickel, potassium, selenium, sodium, and zinc. Volatiles (chlorobenzene, carbon disulfide, and toluene) were detected in only one sample. Semivolatiles detected included acenapthene, chrysene, dibenzofuran, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indo(1,2,3-cd)pyrene, phenanthrene, pyrene, and benzoic acid.

A.5.2.4 Air and Direct Radiation

There are 21 on-property fence line locations for radon detection, two background locations, and nine other locations around the FEMP. Each location has either two, three, or six alpha-track-type radon detectors for measuring radon concentrations in the air. The detectors are changed each calendar quarter and sent to the supplier for analysis.

The average quarterly radon level at each location was computed from the results of all detectors at that location. The annual average radon level at each location was then calculated from the quarterly

averages. The average annual radon level at the fence line ranged from 0.57 pCi/L (1992) to 1.16 pCi/L (1988).

The maximum fence line radon level recorded during this period was 2.9 pCi/L in 1988 at Location K, along the western perimeter immediately west of the southwestern corner of the former production area. Since production ceased in 1989, the highest fence line radon level recorded was 1.7 pCi/L in 1993 at Location P, at the northwestern corner of the site. None of the observed levels exceeded either the DOE guideline of 3.30 pCi/L above background (DOE Order 5400.5) or the EPA guidance of 4.0 pCi/L for indoor radon levels.

The end of the FEMP's production mission has resulted in a measurable reduction in the concentration of air particulates. At present, the largest sources of air emissions are the boiler plant cooling tower mists, fugitive dust from the waste pit area, and other areas where environmental cleanup activities are underway.

The FEMP operates nine on-property air monitoring stations to measure the concentration of total suspended particulates, uranium, and other airborne radionuclides.

The average annual concentration of airborne uranium at each fence line monitoring station for the years 1988 through 1993 was well below the DOE Derived Concentration Guide of $1.0 \times 10^{13} \mu Ci/mL$. Even the highest average at Location 9 in 1991 was only 2 percent of the standard. Stations 8 and 9 recorded notably higher values than the other stations due to their location near the former production area in the northeast (prevailing downwind direction) portion of the FEMP.

The FEMP periodically measures doses from direct radiation at a total of 32 locations. Measurements are normally made on a quarterly basis using thermoluminescent dosimeters.

The maximum incremental annual dose from all sources to the person living closest to the K-65 silos was estimated to range from 1.0 mrem (1993) to 19.3 mrem (1988). The reduction from 1991 to 1992 is the result of a bentonite layer added to the K-65 silos in late 1991, which effectively shields and reduces the levels of direct radiation from the silos. For comparison, the annual dose due to background radiation is approximately 100 mrem per year (excluding radon), and DOE's limit for exposure to all sources and all pathways is 100 mrem per year.

A.5.2.5 Biological Resources

Radiochemical analysis was performed on samples of aquatic and terrestrial vegetation, benthic macroinvertebrates, fish, and small mammals from on and off the FEMP property to examine potential bioaccumulation. Additionally, chemical analysis was performed on samples of grass leaves,

roots, and two small mammals. The reader is referred to the results of the biota sampling program presented in the Operable Unit 5 RI Report. In general, isotopes of uranium were detected in some samples at low concentrations from all sample groups. Comparison of these values to background or statistical analysis of the results is not appropriate due to lack of control values and the small data set. The fission products examined (i.e., strontium-90 and cesium-137) were generally not detected above laboratory detection limits. Some samples of grass roots and a single cucumber sample did indicate cesium-137 levels above detection limits. The significance of these occurrences cannot be ascertained due to lack of control samples.

Limited analysis of samples was completed for inorganics, including metals and sulfates, and organics. These constituents were detected in collected samples of grass roots and leaves and small mammals. Background values for these constituents have not been established.

TABLE A-1

SOIL SERIES, SLOPES, AND PRIME AGRICULTURAL SOIL CLASSIFICATIONS

Symbol	Soil Series	Slopes (%)	Prime/Non-Prime Agricultural
DaB	Dana silt loam	2-6	Prime
EcE2	Eden silty clay loam	15-25	Non-Prime
EcF2	Eden silty clay loam	25-50	Non-Prime
FcA	Fincastle silt loam	0-2	Non-Prime
FdA	Fincastle silt loam	0-2	Non-Prime
FeA	Fincastle-urban land complex	0-2	Non-Prime
FoA	Fox loam	0-2	Prime
Gn	Genesee loam	0-2	Prime
HeF	Hennepin silt loam	35-60	Non-Prime
HoA	Henshaw silt loam	0-2	Prime
MaB	Markland silty clay loam	2-6	Prime
MaC2	Markland silty clay loam	6-12	Non-Prime
McA	Martinsville silt loam	0-2	Prime
MnC2	Miamian silt loams	8-15, eroded	Non-Prime
MoE2	Miamian-Hennepin silt loams	25-35, eroded	Non-Prime
MsC2	Miamian-Russel silt loams	2-6	Non-Prime
MsD2	Miamian-Russel silt loams	12-18, eroded	Non-Prime
Ra	Ragsdale silty clay loam	level	Non-Prime
RdA	Raub silt loam	0-2	Non-Prime
RvB	Russell-Miamian silt loam	0-2	Non-Prime
RwB2	Russell silt loam	3-8, eroded	Non-Prime
UnA	Uniontown silt loam	0-2	Non-Prime
UnB	Uniontown silt loam	2-6	Non-Prime
XeB	Xenia silt loam	2-6	Non-Prime
XeB2	Xenia silt loam	2-6	Non-Prime
XfA	Xenia silt loam	0-2	Prime
XfB2	Xenia silt loam	0-2, eroded	Prime

Source: SCS/USDA

TABLE A-2

URANIUM EMISSIONS FROM FEMP AIRBORNE RELEASES (kg)

Calendar Year[a]	Dust Collectors[b] Plant 1	Plant 2/3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Pilot Plant	Plant 8 Wet Scrubbers	Non-Production Sources[c]	Other Sources[d]	Total Emissions	Percent of Total 1951-1984
1951	--	--	--	--	--	--	--	--	123	--	--	2	125	0.1
1952	--	--	--	--	6	--	--	--	493	--	--	44	543	0.3
1953	3.8	6	1,473	90	12	--	--	--	493	--	--	105	2,182.8	1.2
1954	46.2	281	5,890	4,119	28	4,261	201	0	271	217	15	157	15,486.2	8.7
1955	46.2	1,113	12,450	10,410	53	7,268	877	0	443	948	118	167	33,893.2	19.0
1956	43.4	1,978	5,145	3,501	27	1,743	1,316	0	32	1,442	118	174	15,519.4	8.7
1957	49.4	3,730	814	3,664.4	35	--	791	0.4	18	1,575	118	230	11,025.2	6.2
1958	407.4	3,520	661	715	161	--	875	679	27	1,650	118	242	9,055.4	5.1
1959	46	3,929	1,428	478.4	127	--	260	417	34	2,100	118	240	9,177.4	5.2
1960	20	4,233	212	202.8	268	--	298	219	718	2,604	118	260	9,152.8	5.1
1961	52.8	3,707	262	76.2	119	--	209	67.4	174	2,271	118	271	7,427.4	4.2
1962	14	2,137	703	356	59	--	618	135	174	2,304	138	304	6,942	3.9
1963	82.6	0	1,469	783	181	--	994	159	51.8	2,171	145	339	6,375.4	3.6
1964	18	0	545	330.4	34	--	1,051	252	13	2,865	145	330	5,583.4	3.1
1965	4.1	192.7	334.7	226.5	42.6	--	390	68	10	5,810	146.2	269	7,493.8	4.2
1966	12.2	514	227.7	76.7	11.3	--	327	48.5	18.1+ 1,195[e]	926	152	222	3,730.5	2.1
1967	20.4	646.8	279.9	147.9	2.7	--	417	76.2	11.8	1,790	152	181	3,725.7	2.1
1968	0.5	1,119.5	267.2	88	30.4	--	901	121.0	3.6	3,082	152	120	5,885.2	3.3
1969	27.2	698.2	49.4	119.3	2.7	--	424	12.7	3.6	3,123	128	120	4,708.1	2.6

TABLE A-2 (Continued)

Calendar Year[a]	Dust Collectors[b] Plant 1	Plant 2/3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Pilot Plant	Plant 8 Wet Scrubbers	Non-Production Sources[c]	Other Sources[d]	Total Emissions	Percent of Total 1951-1984
1970	4.5	356.7	29.9	53.1	0	--	569	13.6	0	666	105	185	1,982.8	1.1
1971	9	306	0	0	0	--	91	0	0	541	105	40	1,092	0.6
1972	28.4	1,360	9	33	0	--	5	24	0	--	105	37	1,601.4	0.9
1973	1	1,396	57	79	0	--	14	15	0	39	105	33	1,739	1.0
1974	1.4	2,445	24.4	40	0	--	11	38	0	--	105	32	2,696.8	1.5
1975	5.6	2,844.7	119.8	19	0	--	3.5	0	0.4	--	105	40	3,138	1.8
1976	2.7	3,339.2	26.1	13.7	2.4	--	7.2	2.8	0	--	105	40	3,539.1	2.0
1977	0.6	756.2	11.8	53.3	0	--	4.6	0	10.4	--	105	36	977.9	0.5
1978	1.8	0	11.9	29.1	0	--	0	72	2.2	--	105	39	261.0	0.1
1979	0.8	0	46.3	12.3	0	--	0	2.3	0	--	93	45	199.7	0.1
1980	13.4	2.7	133.8	89.5	0	--	5.1	0	3.3	11	7.7	50	316.5	0.2
1981	1.3	30	432.1	135.6	0	--	0	0	0	10	8.2	60	677.2	0.4
1982	2.1	52.3	21	121.8	0.5	--	81.2	5.1	0	37	8.8	65	394.8	0.2
1983	6.4	130	42.9	41.4	0	--	24.7	0	0	58	7.8	65	376.2	0.2
1984	12.1	574.3	39.6	83.9	1.0	--	8.1	170.9	2.8	38	16.8	66	1,013.5	0.6
Total 1951-1984	985.3	41,398.3	33,216.5	26,189.3	1,203.6	13,272	10,773.4	2,598.9	4,326.0	36,378	3,086.5	4,610	178,037.8	100.0
% of Total	0.6	23.3	18.7	14.7	0.7	7.5	6.1	1.5	2.4	20.4	1.7	2.6	100	

TABLE A-2 (Continued)

Calendar Year[a]	Dust Collectors[b] Plant 1	Plant 2/3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Pilot Plant	Plant 8 Wet Scrubbers	Non-Production Sources[c]	Other Sources[d]	Total Emissions	Percent of Total 1951-1984
1985												64	315.3	
1986												68	130.2	
1987											--	60	302.3	
Total 1951-1987												5,074[f]	179,057.6	

aData are on a fiscal year basis:
- 1952-1976, July 1-June 30
- 1976 transition
- 1977 and after, October 1-September 30

bIncludes gulping emissions for Plant 2/3.

cConsists of:
- Old solid waste incinerator (1954-1979) 2474.7 kg
- Old burner (1962-1979) 462.9 kg
- Graphite burner (1965-1984) 124.6 kg
- New solid waste incinerator (1980-1984) <20 kg
- Liquid organic waste incinerator (1983-1984) <20 kg

3086.5 kg

dIncludes other process emissions, buildings exhausts, laboratory emissions, fugitive emissions from waste pits, and nonroutine events.

eUnmonitored UF_6 release on Februry 14, 1966.

fIncludes an additional 272 kg from nonroutine events (concentrated liquid uranyl nitrate hexahydrate releases).

Sources: Boback, et al., 1987, "History of FMPC Radionuclide Discharges," FMPC-2082, prepared for DOE, Oak Ridge Operations Office, Oak Ridge, TN.
Clark, et al., 1989, "History of FMPC Radionuclide Discharges - Revised Estimates of Uranium and Thorium Air Emissions from 1951-1987," Addendum to FMPC-2082, prepared for DOE, Oak Ridge Operations Office, Oak Ridge, TN.

TABLE A-3

ESTIMATE OF FORM OF URANIUM STACK DISCHARGES BY DECADE (kg)

Plant	Species[a]	1950s	1960s	1970s	1980s	Species Total	Plant Total
1	Ores	642	149	0	0	791	985
2/3	Ores	1788	414	597	0	2799	3219
	U_3O_8	199	45	105	6	355	
	UO_3	0	0	62	3	65	
4	UO_3	0	75	0	8	83	33,217
	U_3O_8	21,349	3468	29	18	24,864	
	UF_4	6382	791	301	631	8105	
	UO_2F_2	130	16	6	13	165	
5	U_3O_8	22,185	2230	322	436	25,173	26,188
	UF_4	777	176	10	36	999	
	UO_2F_2	16	0	0	0	16	
6	U_3O_8	449	751	2	2	1204	1204
7	UF_4	13,272	0	0	0	13,272	13,272
8	U_3O_8	4089	5239	706	119	10,153	10,774
	UAP	222	371	0	0	593	
	UCl_4	9	19	0	0	28	
9	U_3O_8	672	696	168	176	1712	2599
	UF_4	416	371	0	0	874	
	UO_2F_2	8	5	0	0	13	
Pilot	U_3O_8	1912	1064	13	5	2994	3132
	UF_4	22	115	0	1	138	
Total		74,537	16,187	2378	1488	94,590	

[a] U_3O_8 = uranium oxide
UO_3 = uranium trioxide
UF_4 = uranium tetrafluoride
UO_2F_2 = uranium fluoride
UAP = uranyl ammonium phosphate
UCl_4 = uranium tetrachloride

TABLE A-4

FEMP URANIUM EMISSIONS SUMMARY (kg)

Year[a]	FMPC-2082 Totals	Gulping Emissions	Other Process Emissions	Building Exhausts Emissions	Estimated Laboratory Emissions	Waste Pits Fugitive Emissions	Non-Routine Events Emissions	Total Emissions
1951	123.0	0	0	0	2	0	0	125
1952	499.0	0	0	0	2	0	42	543
1953	2,077.8	0	3	1	2	0	99	2,183
1954	15,119.2	210	8	5	2	0	142	15,486
1955	32,976.2	750	11	11	2	1	142	33,893
1956	13,595.4	1,750	12	16	2	2	142	15,519
1957	8,045.2	2,750	12	26	2	48	142	11,025
1958	5,513.4	3,300	14	31	2	95	100	9,055
1959	5,127.4	3,810	15	28	2	95	100	9,177
1960	4,872.8	4,020	17	33	2	108	100	9,153
1961	3,516.4	3,640	18	30	2	121	100	7,427
1962	4,568.0	2,070	19	26	2	125	132	6,942
1963	6,036.4	0	19	25	2	125	168	6,375
1964	5,253.4	0	22	20	2	129	157	5,583
1965	7,044.8	180	22	19	2	71	155	7,494
1966	3,048.5	460	12	16	2	49	143	3,731
1967	2,924.7	620	11	16	2	11	141	3,726
1968	4,655.2	1,110	7	14	2	12	85	5,885
1969	3,898.1	690	7	8	2	15	88	4,708
1970	1,487.8	310	6	6	2	16	155	1,983
1971	772.0	280	5	2	2	16	15	1,092
1972	614.4	950	4	3	2	15	13	1,601
1973	496.0	1,210	5	3	2	15	8	1,739
1974	234.8	2,430	4	6	2	14	6	2,697
1975	318.0	2,780	4	7	2	18	9	3,138

TABLE A-4 (Continued)

Year[a]	FMPC-2082 Totals	Gulping Emissions	Other Process Emissions	Building Exhausts Emissions	Estimated Laboratory Emissions	Waste Pits Fugitive Emissions	Non-Routine Events Emissions	Total Emissions
1976	169.1	3,330	5	7	2	20	6	3,539
1977	191.9	750	5	2	2	20	7	978
1978	222.0	0	4	2	2	22	9	261
1979	154.7	0	4	1	2	31	7	200
1980	266.5	0	4	2	2	34	8	317
1981	587.2	30	5	2	2	42	9	677
1982	279.8	50	6	2	2	41	14	395
1983	181.2	130	6	4	2	40	13	376
1984	377.5	570	6	5	2	40	13	1,014
Total[b]	133,165.8	38,180.0	302.0	379.0	68	1,391.0	2,470.0[c]	178,037

[a]The 1985, 1986 and 1987 totals are those reported in the Environmental Monitoring Annual Reports as corrected for dust collector round-off error.

[b]Numbers may not add due to roundoff.

[c]Includes 272 kg uranium from estimated emissions not distributed over production years.

TABLE A-5

CHARACTERIZATION OF URANIUM RELEASE TRANSPORT AND SPECIES CHANGES

Form of Release	Types	Airborne Transport	U Species[a] Deposited	Chemical/Physical Changes
Solid discharges	Particulates from dust collectors and wet scrubbers	Close to source, deposition within production area	U Ores, UO_3, U_3O_8, UO_2, UF_4/UO_2F_2	Solubilization Hydrolysis Migration
Liquid emissions	Vapors from UO_3 gulping and acid-pickling operations	Intermediate distance from source, deposition within FEMP site boundary	UNH/HNO_3, UCl_4/HCl, UO_2Cl_2/HCl	Migration
Gaseous incidents	Episodal plant releases as UF_6	Potentially distant to beyond FEMP, considering reevaporation	UF_6, UO_2F_2	Evaporation Hydrolysis Migration

[a] U_3O_8 = uranium oxide
UO_3 = uranium trioxide
UO_2 = uranium dioxide
UF_4 = uranium tetrafluoride
UO_2F_2 = uranium fluoride
UCl_4 = uranium tetrachloride
UNH = uranyl nitrate
HNO_3 = nitric acid
HCl = hydrochloric acid
UF_6 = uranium hexafluoride

REFERENCE LIST FOR APPENDIX A

Boback, M. W., T. A. Dugan, D. A. Fleming, R. B. Grant and R. W. Keys, 1987, "History of FMPC Radiological Discharges," FMPC-2082, revision to NLCO-2058, Westinghouse Materials Co. of Ohio, Cincinnati, OH, prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Clark, T. R., L. Elikan, C. A. Hill and B. L. Speicher, 1989, "History of FMPC Radionuclide Discharges-Revised Estimates of Uranium and Thorium Air Emissions from 1951-1987," Addendum to FMPC-2082, Westinghouse Materials Co. of Ohio, Cincinnati, OH, prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Dames and Moore, 1985, "Dept. of Energy Feed Materials Production Center, Groundwater Study-Task C Report," Dames & Moore, White Plains, NY, prepared for National Lead of Ohio, Inc., Cincinnati, OH.

Davis, J. G., 1994, "Report on the Status of the Cave Salamander (*Eurycea lucifuga*) at the Fernald Environmental Management Project," FERMCO, Cincinnati, OH.

Dove, G. D., 1961, "A Hydrologic Study of the Valley-Fill Deposits in the Venice Area, Ohio," Technical Report No. 4, Ohio Dept. of Natural Resources, Division of Water, Columbus, OH.

EBASCO Environmental, 1993, "Wetlands Delineation Report of the Fernald Environmental Management Project, Butler and Hamilton Counties, Ohio," prepared for FERMCO, Cincinnati, OH.

ERM-Midwest, Inc., 1992, "Remedial Investigation and Risk Assessment Report, Paddys Run Road Site, Crosby Township, Hamilton, Ohio," ERM-Midwest, Inc., Worthington, OH.

Feed Materials Production Center, March 1988, "A Closer Look at Uranium Metal Production: A Technical Overview," Fernald, OH.

Miami Conservancy District, 1994, "Hydrologic Data for the Hamilton-New Baltimore Area 1992," the Water Conservation Subdistrict of the Miami Conservancy District, Dayton, OH.

Spieker, A. M., 1968, "Groundwater Hydrology and Geology of the Lower Great Miami River Valley, Ohio, "U.S. Geological Survey Professional Paper 605-A, available from U.S. Government Printing Office, Washington, DC.

St. John, F. L., 1993, "Report on the Status of the Sloan's Crayfish (*Orconectes sloanii* Bundy) at the Fernald Environmental Management Project," FERMCO, Cincinnati, OH.

St. John, F. L., 1994, "Addendum to the Report on the Sloan's Crayfish (*Orconectes sloanii* Bundy) at the Fernald Environmental Management Project," Draft, FERMCO, Cincinnati, OH.

U.S. Dept. of Agriculture, Soil Conservation Service, Ohio Dept. of Natural Resources, Division of Lands and Soil, Cooperative Extension Service and Ohio Agricultural Research and Development Center, 1980, "Soil Survey of Butler County, Ohio," USDA, ODNR, and Ohio Agricultural Research and Development Center, n.p.

U.S. Dept. of Agriculture, Soil Conservation Service, Ohio Dept. of Natural Resources, Division of Lands and Soil, Cooperative Extension Service and Ohio Agricultural Research and Development Center, 1982, "Soil Survey of Hamilton County, Ohio," USDA, ODNR, and Ohio Agricultural Research and Development Center, n.p.

U.S. Dept. of Energy, 1993, "Site-Wide Characterization Report," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994a, "Feasibility Study Report for Operable Unit 4," Fernald Environmental Management Project, Final, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994b, "Feasibility Study/Proposed Plan for Operable Unit 1, "Fernald Environmental Management Project, Final, DOE, Fernald Area Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994c, "Remedial Investigation Report for Operable Unit 2," Fernald Environmental Management Project, Draft, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994d, "SWIFT Great Miami Aquifer Model - Summary of Improvements Report," Fernald Environmental Management Project, DOE, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1995, "Remedial Investigation Report for Operable Unit 2," Final, Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH.

Westinghouse Materials Co. of Ohio, 1987, "Feed Materials Production Center Environmental Monitoring Annual Report for 1986," FMPC-2076, prepared for U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Westinghouse Materials Co. of Ohio, 1988, "Feed Materials Production Center Environmental Monitoring Annual Report for 1987," FMPC-2135, prepared for the U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Westinghouse Materials Co. of Ohio, 1989, "Feed Materials Production Center Environmental Monitoring Annual Report for 1988," FMPC-2173, prepared for the U.S. Dept. of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Westinghouse Materials Co. of Ohio, 1990, "Feed Materials Production Center Annual Environmental Monitoring Report for 1989," prepared for the U.S. Dept. of Energy, Fernald Office, Cincinnati, OH.

Whitaker, J. O., Jr., 1994, "Survey of Bats and Search for Endangered Bat Species, Particularly the Indiana Bat (*Myotic sodialis*) at the Fernald Environmental Project (FERMCO), Hamilton and Butler Counties, Ohio," FERMCO, Cincinnati, OH.

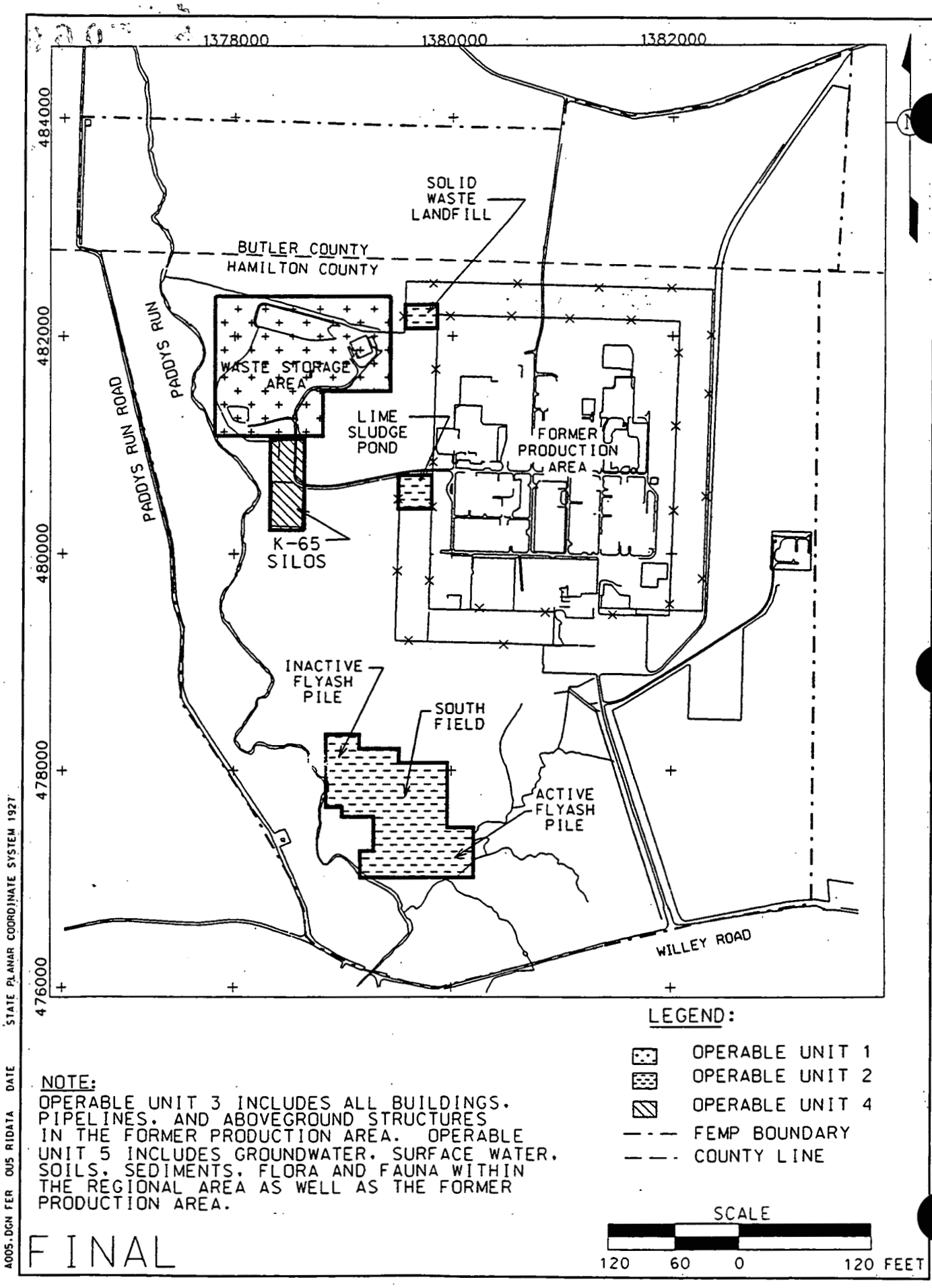
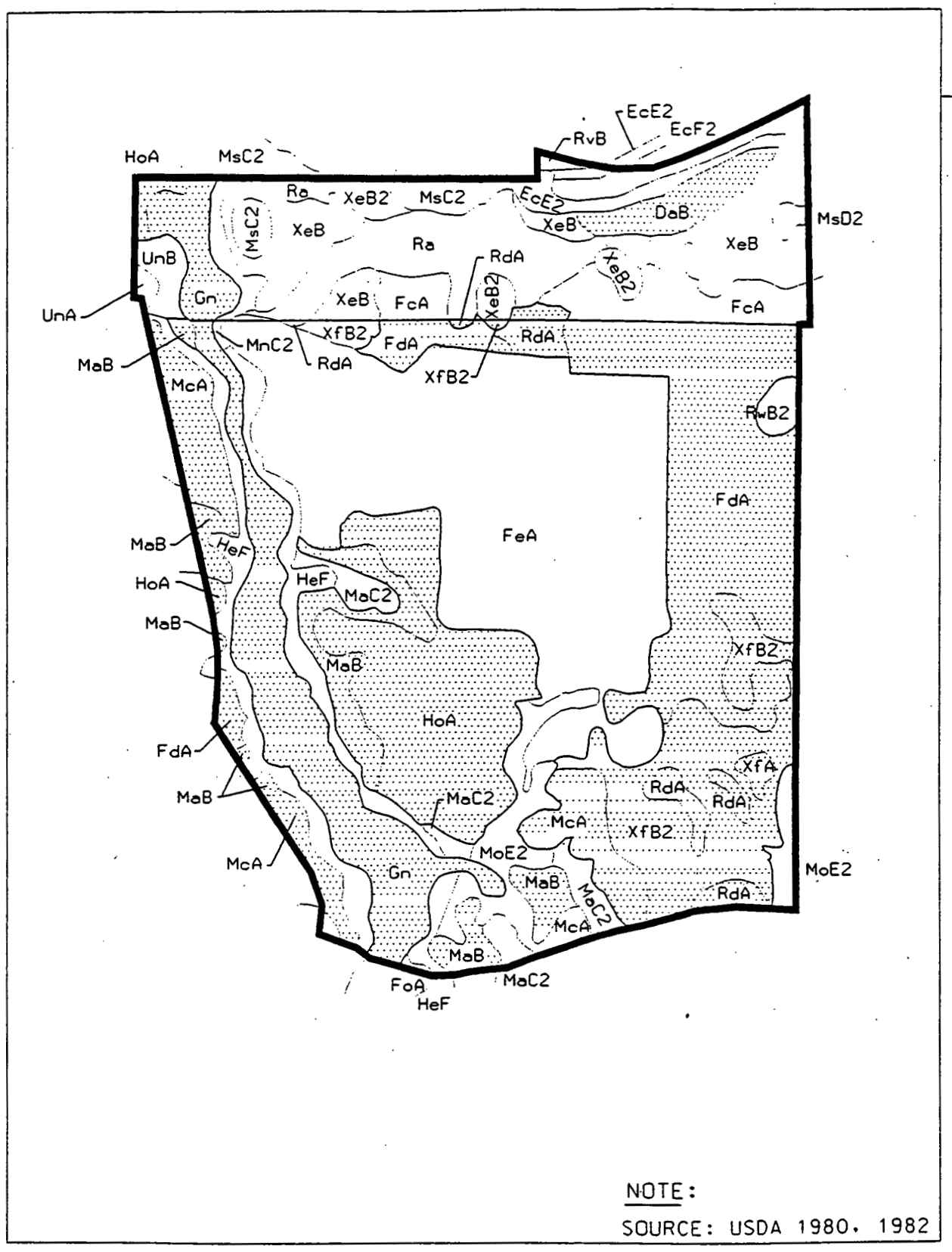


FIGURE A-1. RI/FS OPERABLE UNITS

Source	Release Mechanism	Affected Media/Pathways
Process Operations (OU3):		
• Dust collectors • Scrubbers • Fugitive emissions • Wastewater discharges • Stormwater discharges • Process material handling • Underground storage tanks • Process piping • Sewage treatment plant	• Air	• Soil → Direct radiation Air resuspension → Groundwater via leaching → Storm water runoff ↓ Surface water/sediment ↓ Groundwater recharge
	• Wastewater/stormwater discharge	• Surface water/sediment ↓ Groundwater recharge
	• Spills/Leaks - Process materials - Wastewater	• Soil → Groundwater via leaching
Waste Management:		
• OU1 • OU2 • OU4 • Regulated units • Soil/debris piles • Scrap metal piles	• Land disposal/storage practices	• Soil → Air resuspension → Groundwater via leaching → Stormwater runoff ↓ Surface water/sediment ↓ Groundwater recharge
	• Air	• Radon gas • Direct radiation

FINAL

FIGURE A-2. OPERABLE UNIT 5 ENVIRONMENTAL MEDIA CONTAMINATION PATHWAYS



NOTE:

SOURCE: USDA 1980, 1982

LEGEND:

PRIME AGRICULTURAL LAND

FEMP BOUNDARY

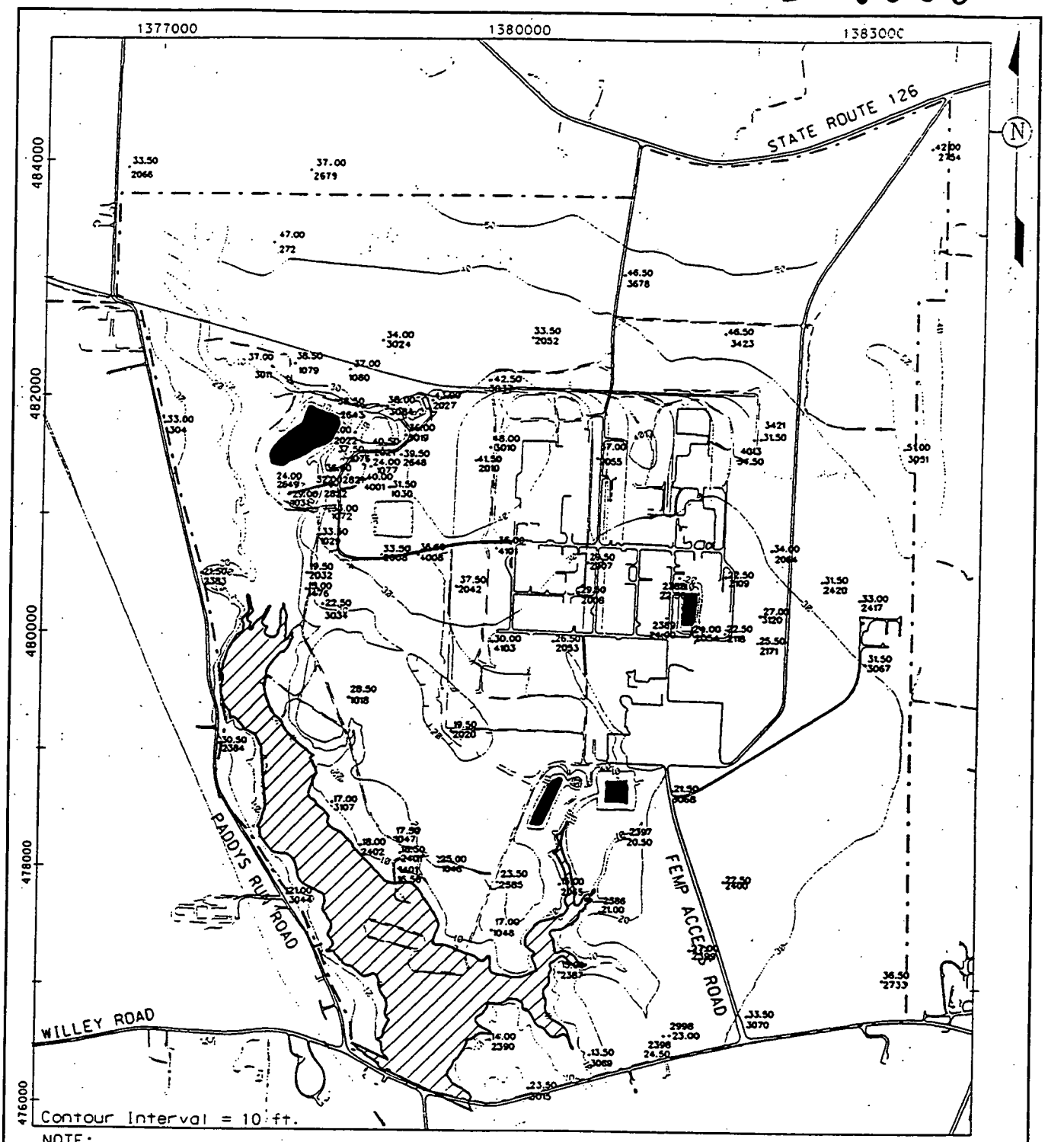
SCALE

1800 900 0 1800 FEET

FINAL

/USR/ERMA3/FMPC/IDX/A89.DGN FER OU5 RIDATA 6-11-94

FIGURE A-3. SOIL TYPES MAPPED WITHIN FEMP SITE BOUNDARIES



NOTE:

THIS MAP PORTRAYS THE THICKNESS OF UNDISTURBED GLACIAL OVERBURDEN. UNDISTURBED GLACIAL OVERBURDEN IS SEDIMENT THAT HAS REMAINED IN SITU SINCE ITS DEPOSITION BY NATURAL PROCESSES. THE MAP WAS CONSTRUCTED. FIRST. BY DETERMINING THE THICKNESS OF STRATA BETWEEN THE BASE OF GLACIAL OVERBURDEN STRUCTURE MAP AND THE PRESENT SITE TOPOGRAPHY (E.G. THE 1987 TOPOGRAPHIC MAP) AND SECOND. BY SUBTRACTING FROM THE FIRST THICKNESS ANY SIGNIFICANT AREAS OF FILL OR EXCAVATION.

LEGEND:

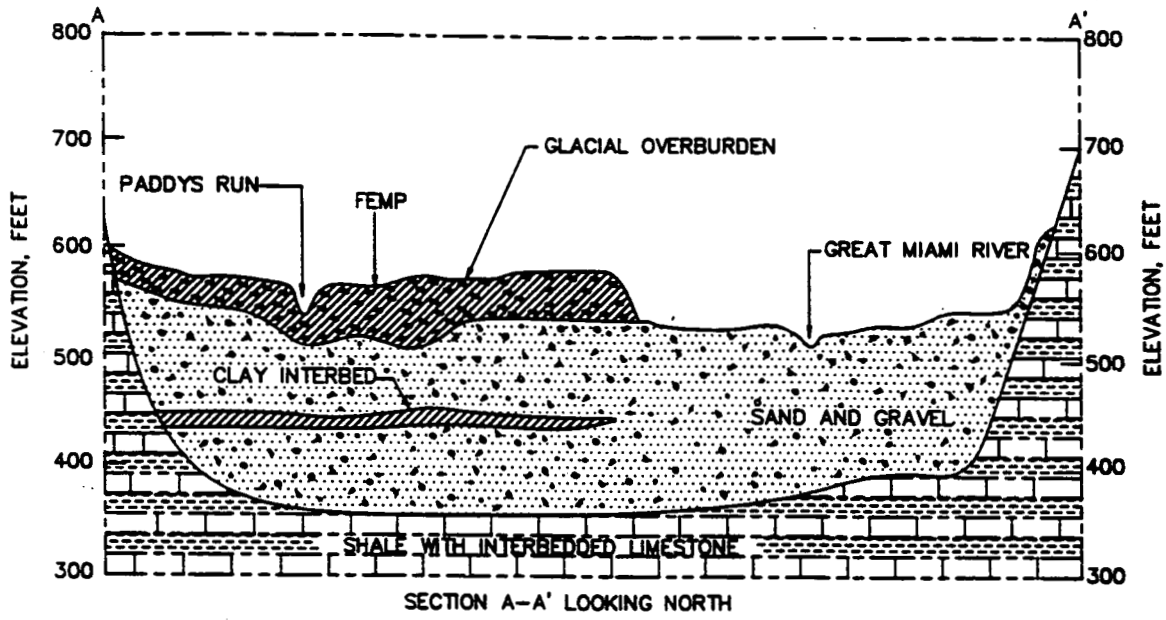
- GLACIAL OVERBURDEN REMOVED AND REPLACED DURING CONSTRUCTION
- GLACIAL OVERBURDEN REMOVED BY EROSION
- 33.50 OVERBURDEN THICKNESS IN FEET
- °3093 BORING NO.
- — - — FEMP BOUNDARY

FINAL

SCALE

1250 625 0 1250 FEET

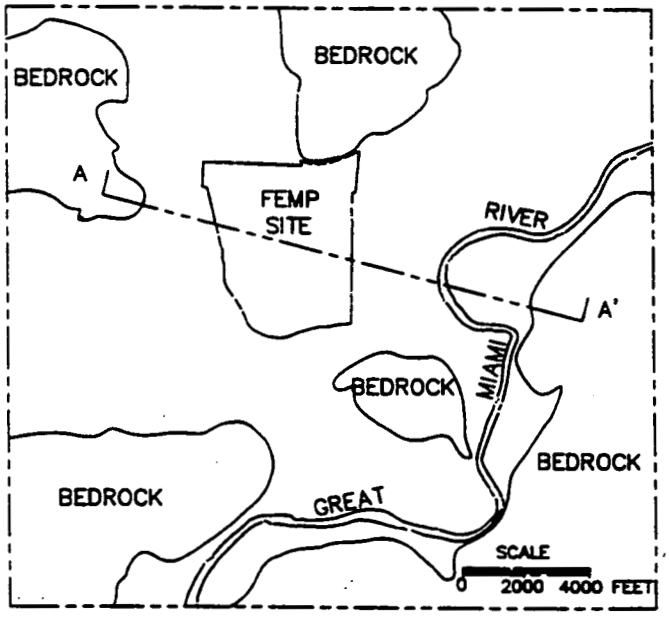
FIGURE A-4. ON-PROPERTY AREAS WHERE CONSTRUCTION HAS BREACHED GLACIAL OVERBURDEN



SECTION A–A' LOOKING NORTH

NOTES:

HORIZONTAL SCALE IS APPROXIMATELY 1" = 2500'

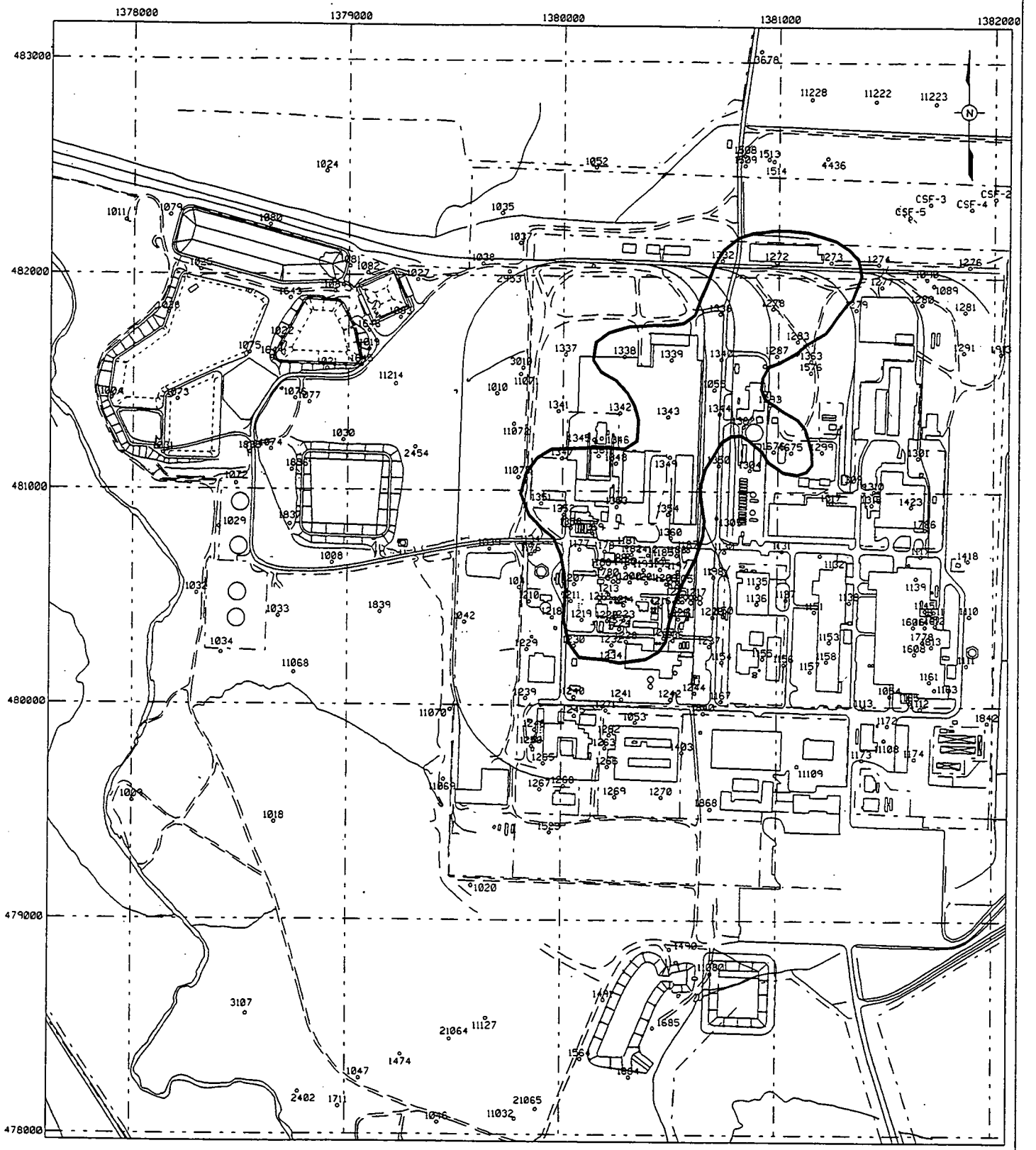


LOCATION OF CROSS SECTION

FINAL

FIGURE A-5. GENERALIZED CROSS SECTION OF BURIED CHANNEL AQUIFER AT FEMP AND SURROUNDING AREA

FILE NAME /wo /fs-fig01.dgn 8x11 cru5 3-9-95 GES STATE PLANAR COORDINATE SYSTEM 1927



LEGEND:

1047 WELL/BORING LOCATION

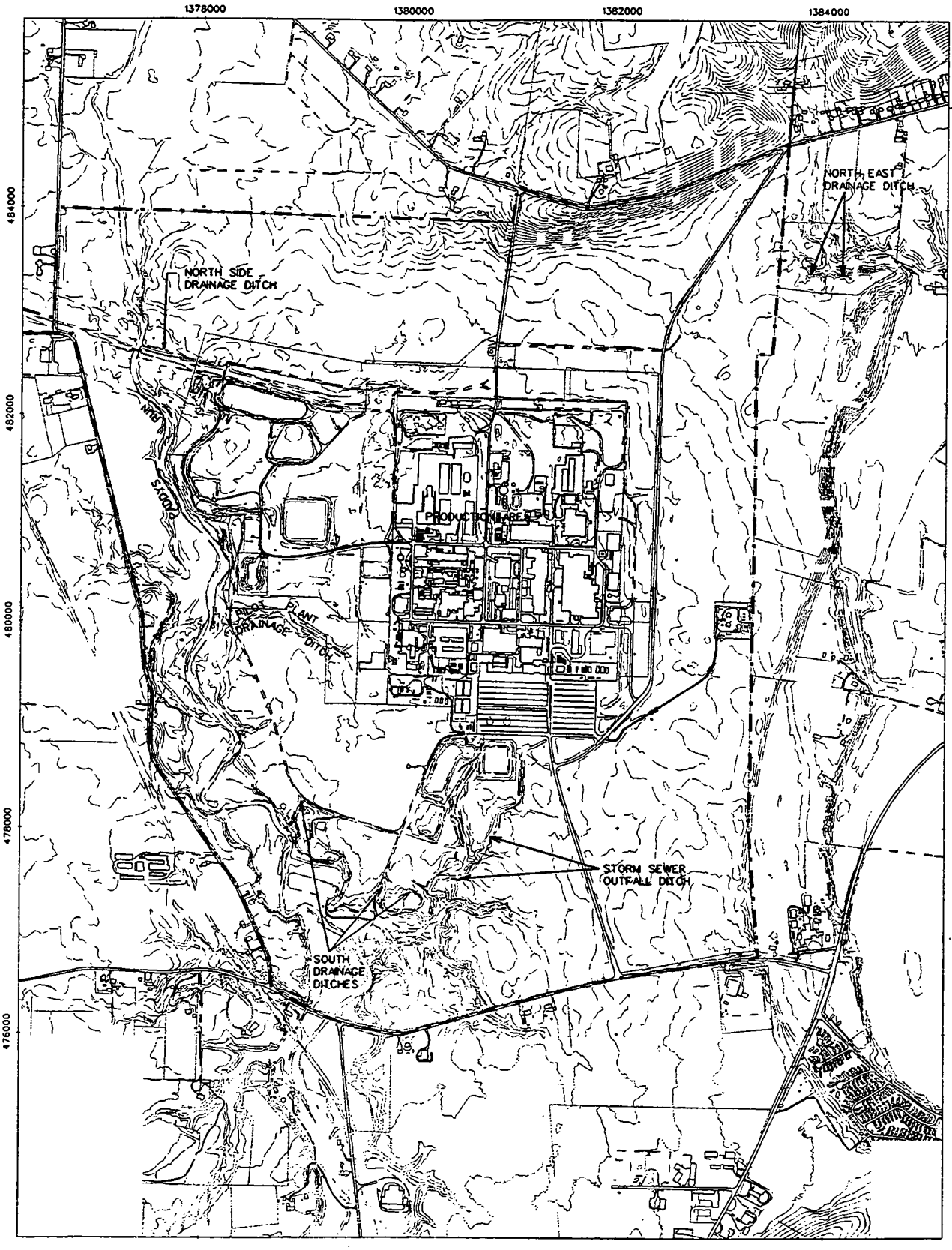
WELLS/BORINGS LOCATED WITHIN DARK CONTOUR HAVE > 1 GALLON PER MINUTE FLOW RATE

SCALE

0 400 800 FEET

FINAL

FIGURE A-6. ON-PROPERTY WELLS EXHIBITING GREATER THAN ONE GALLON PER MINUTE FLOW RATE



LEGEND:

------ FEMP BOUNDARY

SCALE

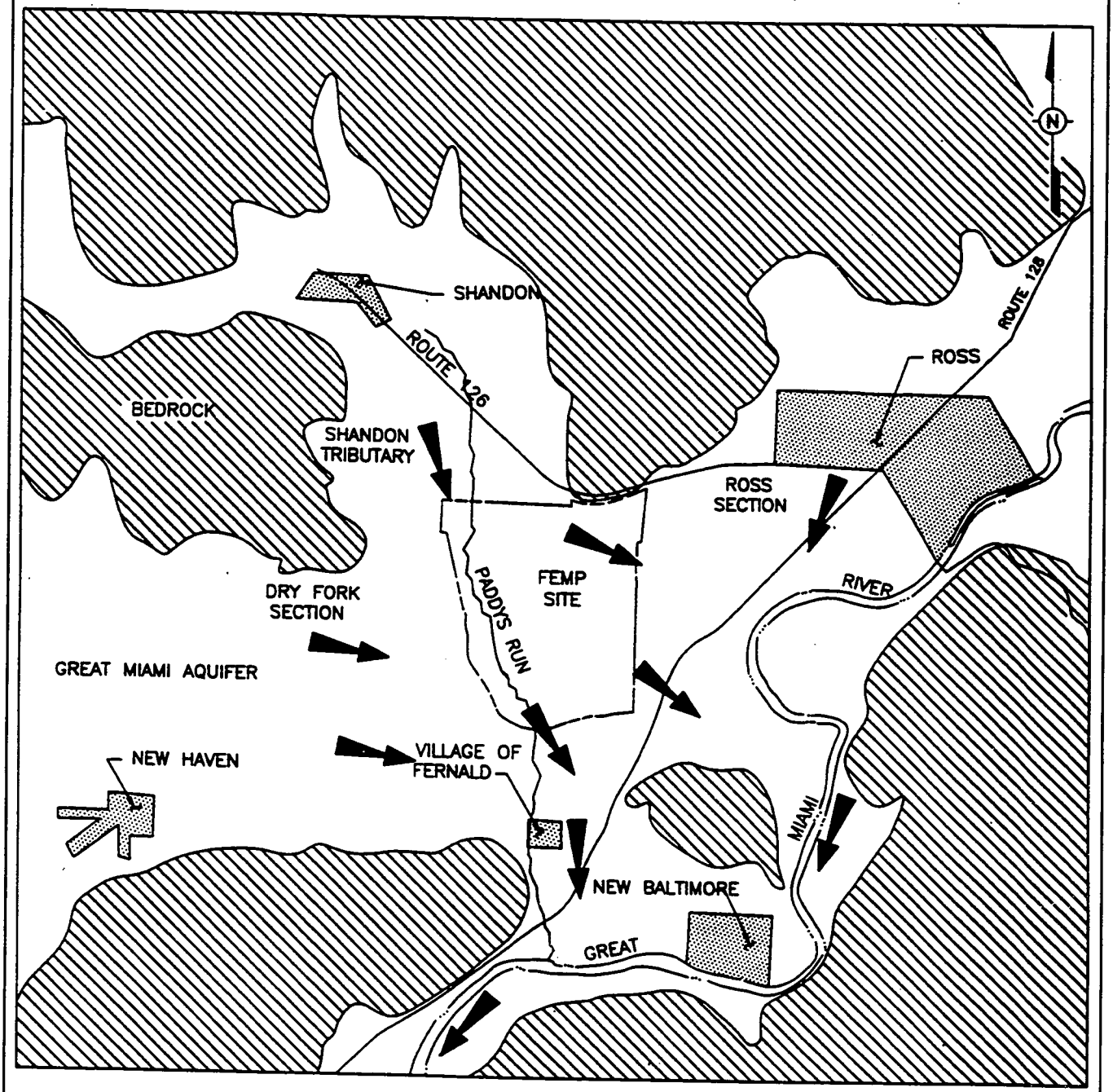
1400 700 0 1400 FEET

FINAL

FIGURE A-6A. TRIBUTARIES TO PADDYS RUN AND THE STORM SEWER OUTFALL DITCH THAT RECEIVE PERCHED GROUNDWATER FLOW

/USR/ERMA3/5ARN1/DGN/BMP/FSDRAIN.DGN FER OU5 FS 3/06/95 STATE PLANAR COORDINATE SYSTEM 1927

000658



SCALE
0 2500 5000 FEET

NOTE:
DIRECTION OF GROUNDWATER FLOW BASED ON APRIL 1986 WATER LEVEL CONTOURS AND GROUNDWATER MODELING OUTPUT (3DPART07.OUT)

LEGEND:
GENERALIZED GROUNDWATER FLOW DIRECTION.
BEDROCK OUTSIDE GREAT MIAMI AQUIFER

FINAL

FIGURE A-7. GREAT MIAMI AQUIFER GENERALIZED GROUNDWATER FLOW

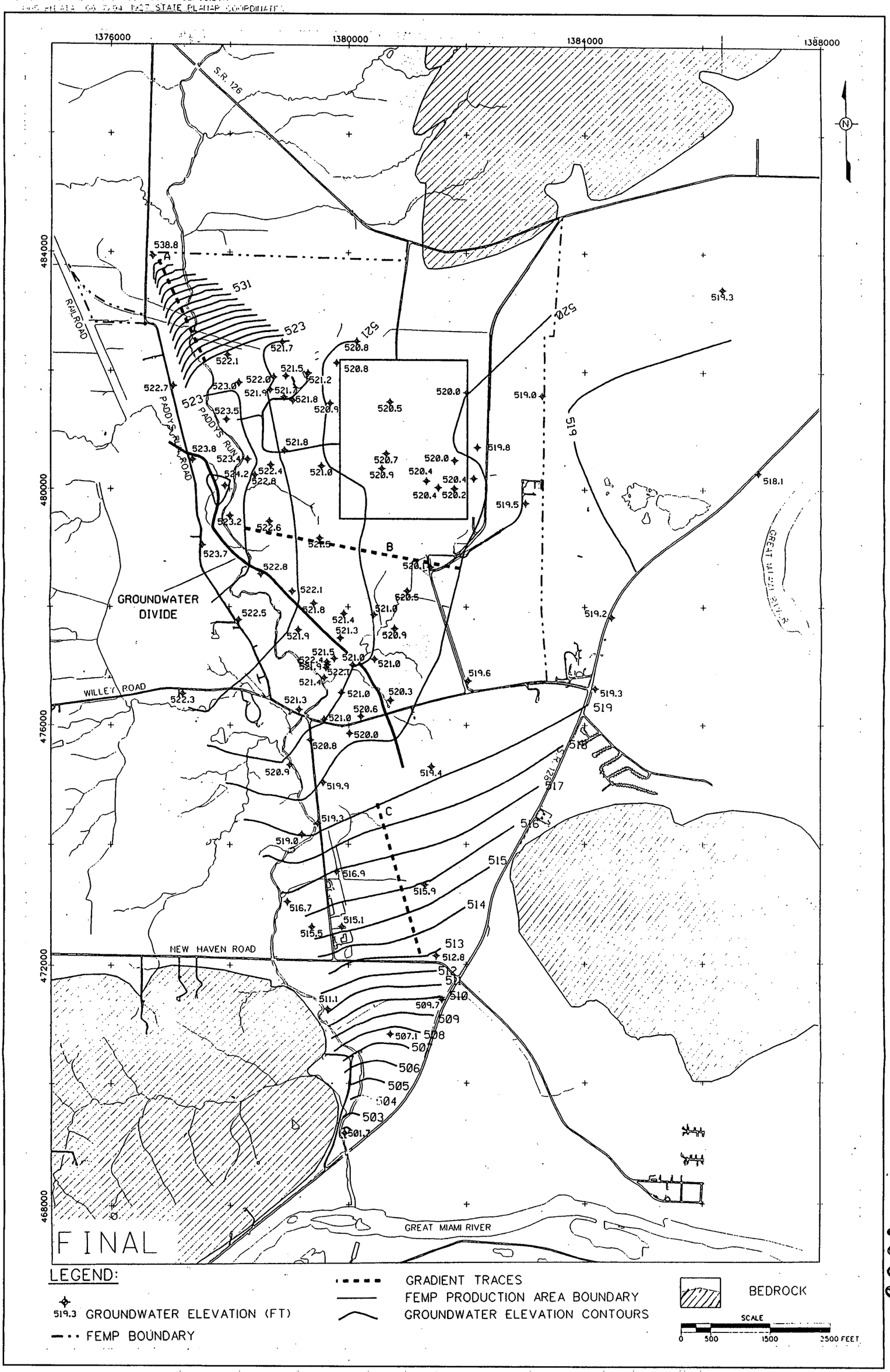


FIGURE A-8. AVERAGE GROUNDWATER ELEVATIONS IN THE GREAT MIAMI AQUIFER (1988 THRU 1993)

002000

6902 2069

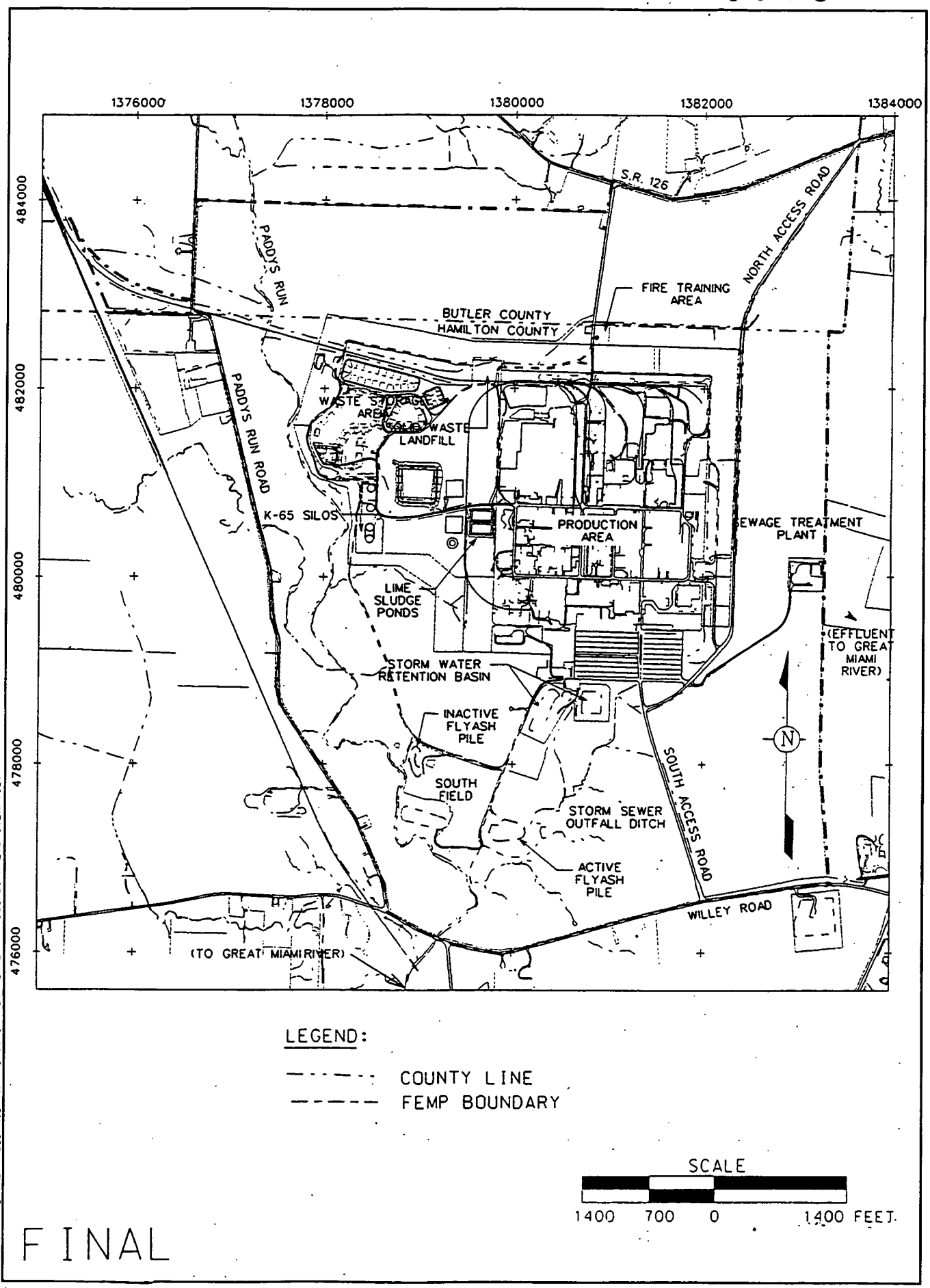


FIGURE A-9. MAJOR FEATURES OF THE FEMP

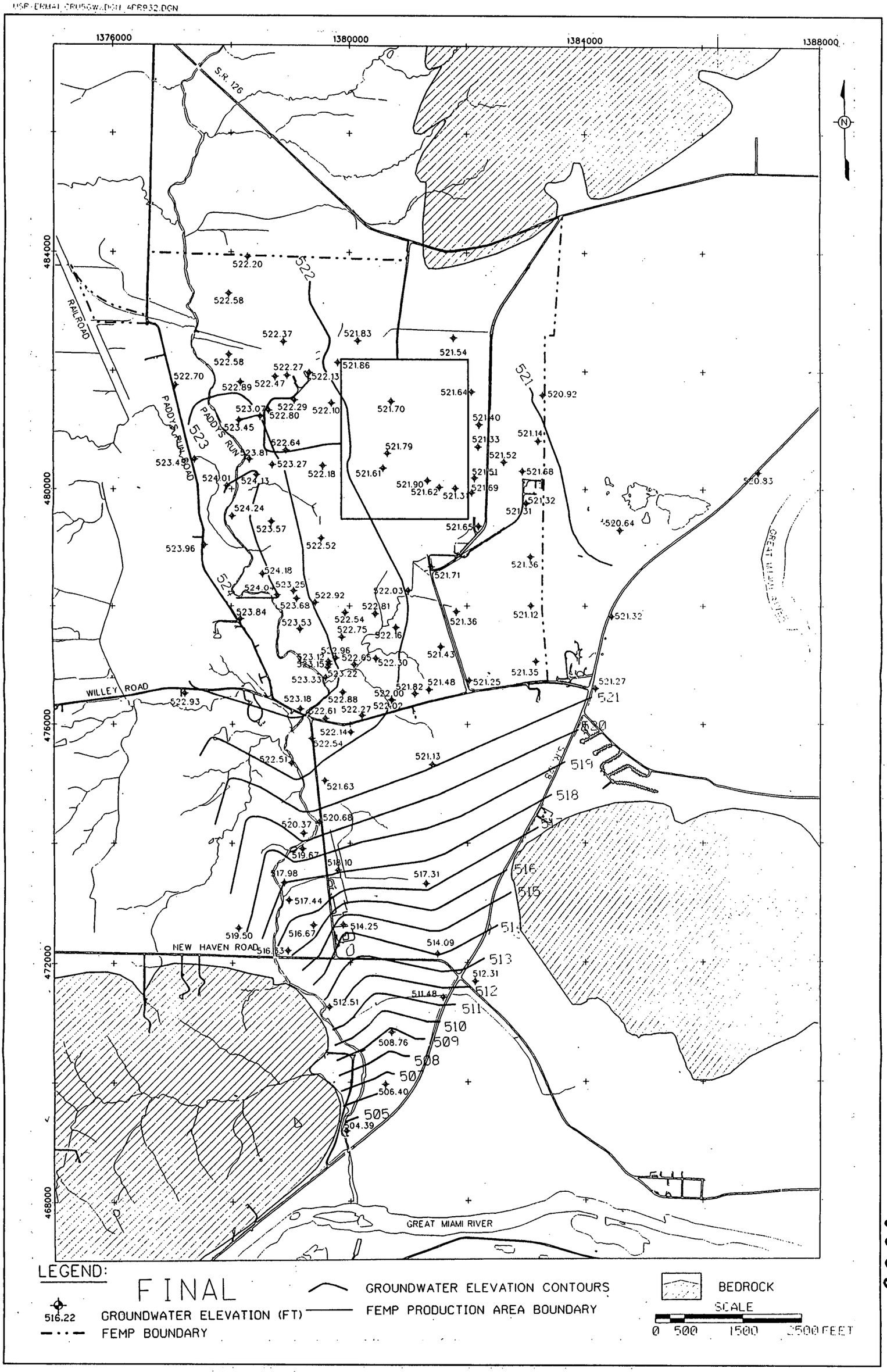
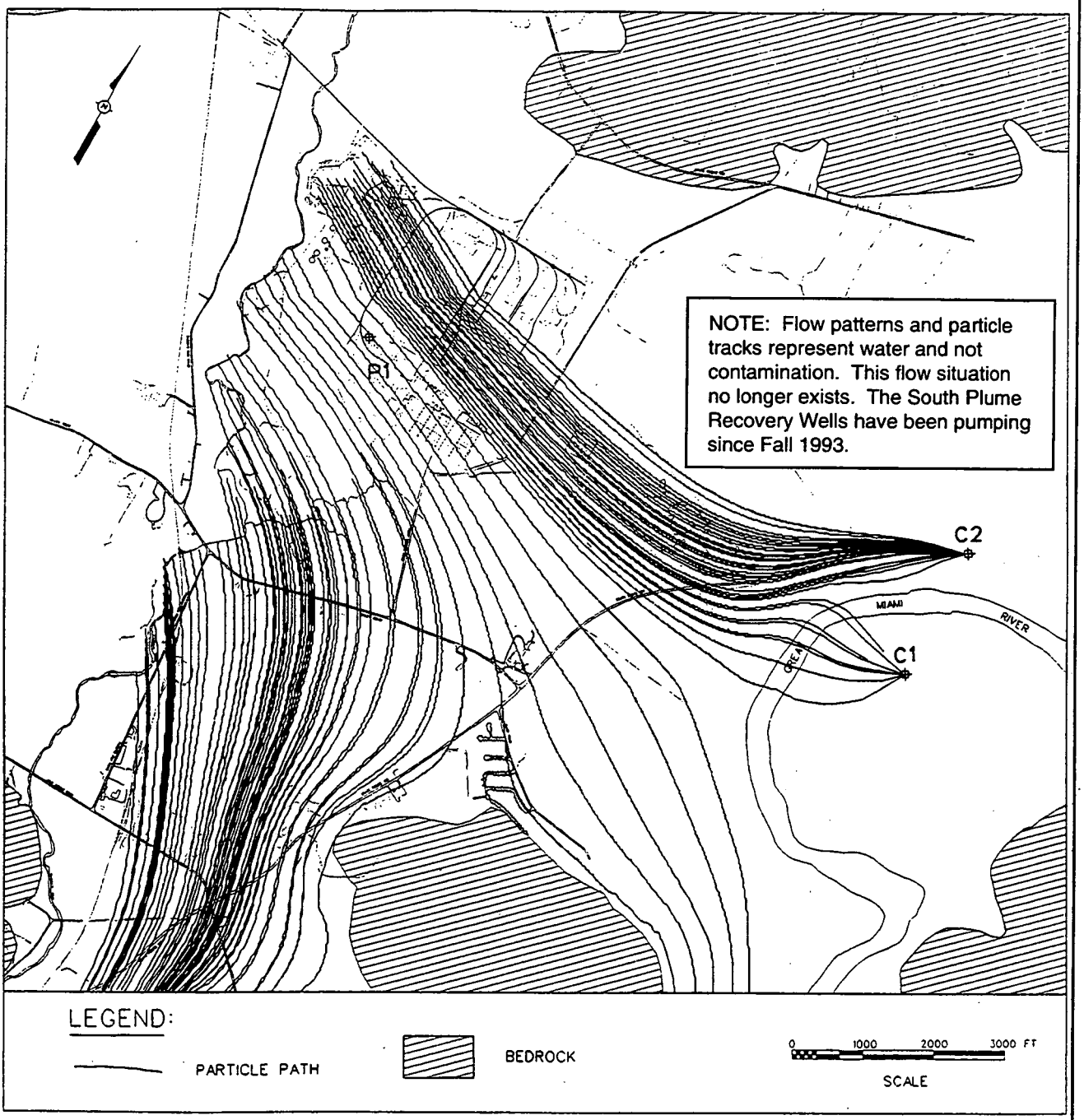


FIGURE A-10. GROUNDWATER ELEVATIONS, TYPE 2 WELLS, APRIL 1993

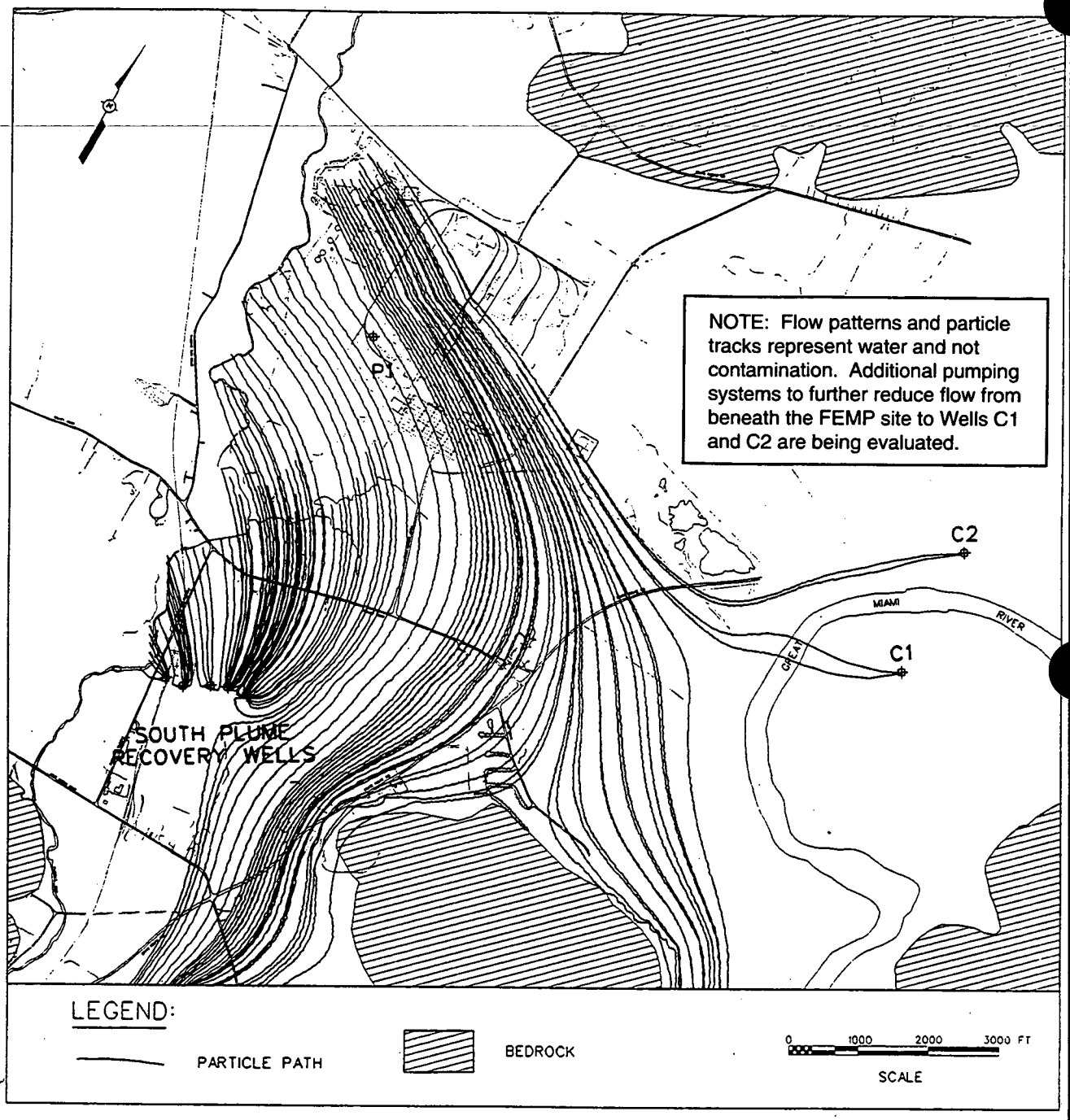


sk x02824.dgn

FINAL

ERAFS1\VOL1:RSAPPS\RSDATA\
OU-5\PO-37\MSR1.RVB\VOLUME2\END-ILLS

FIGURE A-11. BASELINE SCENARIO WATER PARTICLE TRACKING (PUMPING AT THE SOWC WELLS AND FEMP PRODUCTION WELL)



FINAL

ERAFS1\VOL1:RSAPPS\RSDATA\
OU-5\PO-37\MSR1.RVB\VOLUME2\END-ILLS

FIGURE A-12. PUMPING SCENARIO WATER PARTICLE TRACKING (PUMPING AT THE SOWC WELLS, FEMP PRODUCTION WELL, AND SOUTH PLUME RECOVERY WELLS)

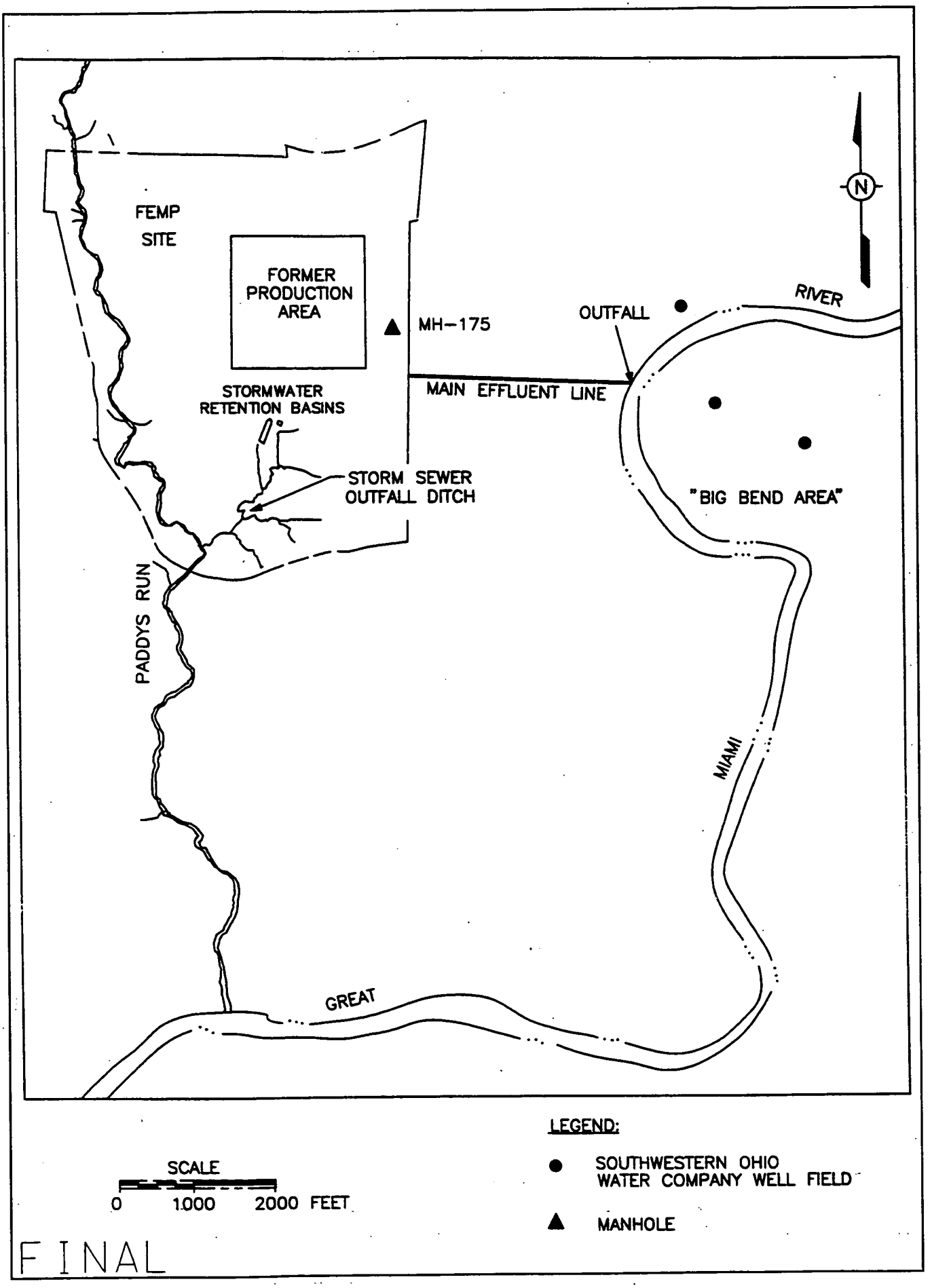
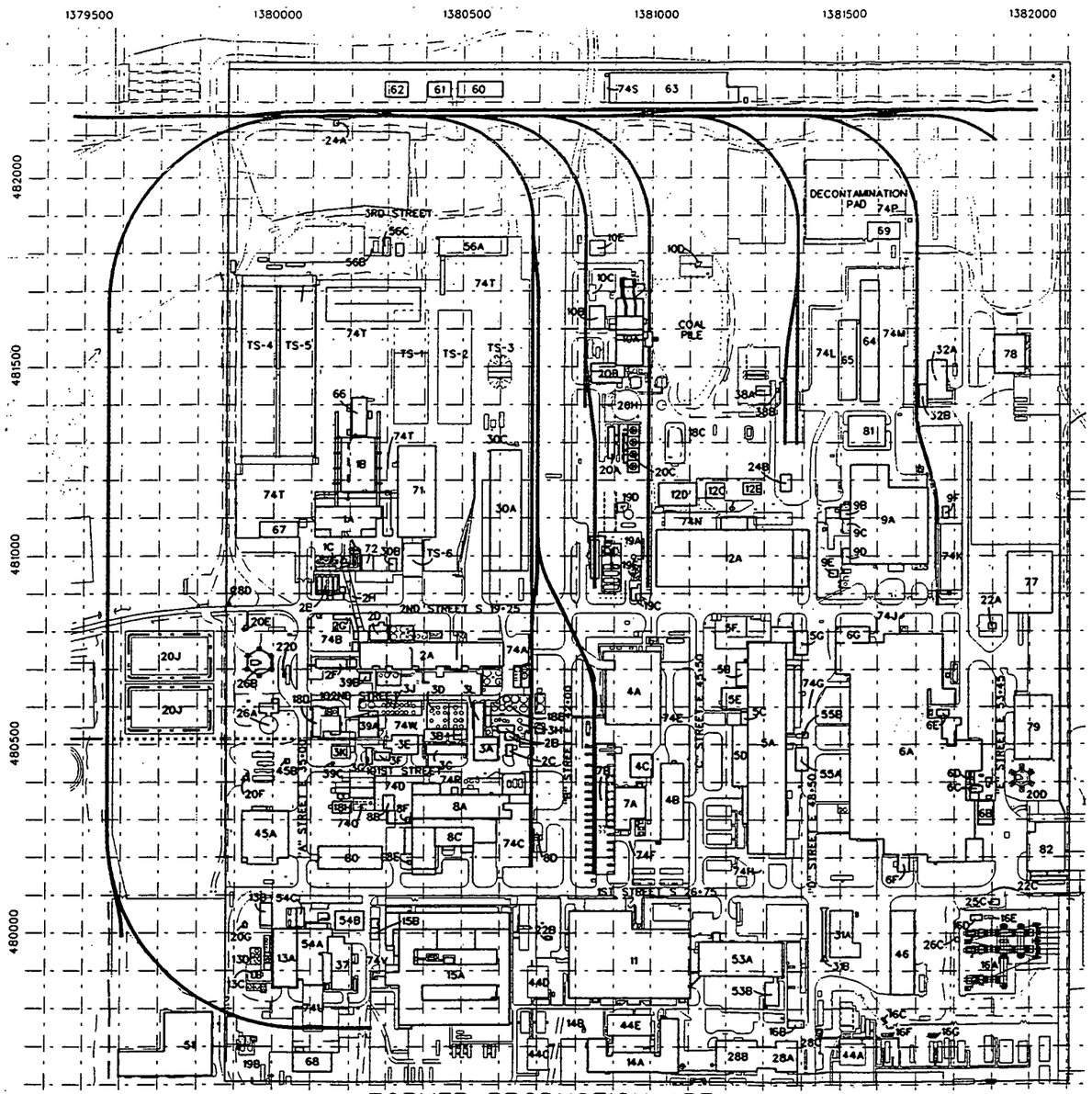


FIGURE A-13. SURFACE WATER HYDROLOGY



FEMP SITE INDEX

TS-1 TENSION SUPPORT STRUCTURE *1
TS-2 TENSION SUPPORT STRUCTURE *2
TS-3 TENSION SUPPORT STRUCTURE *3
TS-4 TENSION SUPPORT STRUCTURE *4
TS-5 TENSION SUPPORT STRUCTURE *5
TS-6 TENSION SUPPORT STRUCTURE *6
1A PREPARATION PLANT
1B PLANT 1 STORAGE BLDG.
1C PLANT 1 ORE SILOS
2A ORE REFINERY PLANT
2B GENERAL/REFINERY SUMP CONTROL BLDG.
2C BULK LIME HANDLING BLDG.
2D METAL DISSOLVER BLDG.
2E NFS STORAGE AREA & PUMP HOUSE
2F COLD SIDE ORE CONVEYOR
2G HOT SIDE ORE CONVEYOR
2H CONVEYOR TUNNEL (FROM PLANT 1)
3A MAINTENANCE BLDG.
3B OZONE BLDG.
3C NAR CONTROL HOUSE
3D NAR TOWERS
3E HOT RAFFINATE BLDG.
3F HARSHAW SYSTEM
3G REFRIGERATION BLDG.
3H REFINERY SUMP
3J COMBINED RAFFINATE TANKS
3K OLD COOLING WATER TOWER
3L ELECTRICAL POWER CENTER BLDG.
4A GREEN SALT PLANT
4B PLANT 4 WAREHOUSE
4C PLANT 4 MAINTENANCE BLDG.
5A METALS PRODUCTION PLANT
5B PLANT 5 INGOT PICKLING
5C PLANT 5 ELECTRICAL SUBSTATION
5D WEST DERBY BREAKOUT/SLAG MILLING
5E PLANT 5 FILTER BLDG.
5F PLANT 5 COVERED STORAGE PAD
5G PLANT 5 INGOT STORAGE SHELTER
6A METALS FABRICATION PLANT
6B PLANT 6 COVERED STORAGE AREA
6C PLANT 6 ELECTROSTATIC PRECIPITATOR (SOUTH)
6D PLANT 6 ELECTROSTATIC PRECIPITATOR (CENTRAL)
6E PLANT 6 ELECTROSTATIC PRECIPITATOR (NORTH)
6F PLANT 6 SALT OIL HEAT TREAT BLDG.
6G PLANT 6 SUMP BLDG.
7A PLANT 7
7B PLANT 7 OVERHEAD CRANE
8A RECOVERY PLANT
8B PLANT 8 MAINTENANCE BLDG.
8C ROTARY KILN/DRUM RECONDITIONING
8D PLANT 8 RAILROAD FILTER BLDG.
8E DRUM CONVEYOR SHELTER
8F PLANT 8 OLD DRUM WASHER
9A SPECIAL PRODUCTS PLANT
9B PLANT 9 SUMP TREATMENT FACILITY
9C PLANT 9 DUST COLLECTOR
9D PLANT 9 SUBSTATION
9E PLANT 9 CYLINDER SHED
9F PLANT 9 ELECTROSTATIC PRECIPITATOR
10A BOILER PLANT
10B BOILER PLANT MAINTENANCE BLDG.
10C WET SALT STORAGE BIN
10D CONTAMINATED OIL/GRAPHITE BURN PAD
10E UTILITIES HEAVY EQUIP. BLDG. (PROPOSED)
11 SERVICE BLDG.
12A MAIN MAINTENANCE BLDG.
12B CYLINDER STORAGE BLDG.
12C LUMBER STORAGE BLDG.
12D MAINTENANCE BLDG. WAREHOUSE (PROPOSED)
13A PILOT PLANT WET SIDE
13B PILOT PLANT MAINTENANCE BLDG.
13C SUMP PUMP HOUSE
13D PILOT PLANT THORIUM TANK FARM
14A ADMINISTRATION BLDG.
14B BLDG. 14 EOC GENERATOR SET
15A LABORATORY
15B LABORATORY CHEMICAL STORAGE BLDG.
16A MAIN ELECTRICAL STATION
16B ELECTRICAL SUBSTATION
16C ELECTRICAL PANELS & TRANSFORMER
16D MAIN ELECTRICAL SWITCH HOUSE
16E MAIN ELECTRICAL TRANSFORMERS
16F TRAILER SUBSTATION *1
16G TRAILER SUBSTATION *2
16H 10 PLEXS NORTH SUBSTATION
16J 10 PLEXS SOUTH SUBSTATION
18A BDN SURGE LAGOON
18B GENERAL SUMP
18C COAL PILE RUNOFF BASIN
18D BIODENITRIFICATION TOWERS
18E STORM WATER RETENTION BASINS
18F PIT *5 SLUICE GATE
18G CLEARWELL PUMP HOUSE
18H BDN EFFLUENT TREATMENT FACILITY
18J METHANOL TANK
18K LOW NITRATE TANK
18L HIGH NITRATE TANK
18M HIGH NITRATE STORAGE TANK
18N WASTE PIT AREA STORM WATER RUNOFF CONTROL
18P DISSOLVED OXYGEN BLDG.
18Q IAWWT VALVE HOUSE
19A MAIN TANK FARM
19B PILOT PLANT AMMONIA TANK FARM
19C TANK FARM CONTROL HOUSE
19D OLD NORTH TANK FARM
19E TANK FARM LIME SLITTER BLDG.
20A PUMP STATION & POWER CENTER
20B WATER PLANT
20C COOLING TOWERS
20D ELEVATED POTABLE STORAGE TANK
20E WELL HOUSE *1
20F WELL HOUSE *2
20G WELL HOUSE *3
20H PROCESS WATER STORAGE TANK
20J LIME SLURRY PITS
22A GAS METER BLDG.
22B STORM SEWER LIFT STATION
22C TRUCK SCALE
22D SCALE HOUSE & WEIGH SCALE
22E UTILITY TRENCH TO PIT AREA
23 METEOROLOGICAL TOWER
24A RAILROAD SCALE HOUSE
24B RAILROAD ENGINE HOUSE
25A CHLORINATION BLDG.
25B M.H. *175/EFF. LINE/SAMPLING BLDG.
25C SEWAGE LIFT STATION BLDG.
25D U.V. DISINFECTION BLDG.
25E DIGESTER & CONTROL BLDG.
25F SLUDGE DRYING BEDS
25G PRIMARY SETTLING BASINS
25H TRICKLING FILTERS
25J 10 PLEXS SEWAGE LIFT STATION
26A PUMP HOUSE-HP FIRE PROTECTION
26B ELEVATED WATER STORAGE TANK
26C MAIN ELECTRICAL STRAINER HOUSE
28A SECURITY BLDG.
28B HUMAN RESOURCES BLDG.
28C GUARD POST ON SOUTH END OF "D" STR.
28D GUARD POST ON WEST END OF "2ND" STR.
30A CHEMICAL WAREHOUSE
30B DRUM STORAGE WAREHOUSE
30C OLD TEN TON SCALE
31A ENGINE HOUSE/GARAGE
31B OLD TRUCK SCALE
32A MAGNESIUM STORAGE BLDG.
32B BLDG. 32 COVERED LOADING DOCK
34A K-65 STORAGE TANK (NORTH)
34B K-65 STORAGE TANK (SOUTH)
34C RTS BLDG.
35A METAL OXIDE STORAGE TANK (NORTH)
35B METAL OXIDE STORAGE TANK (SOUTH)
37 PILOT PLANT ANNEX
38A PROPANE STORAGE
38B CYLINDER FILLING STATION
39A INCINERATOR BLDG.
39B WASTE OIL DECANT SHELTER
39C INCINERATOR SPRINKLER RISER HOUSE
39D SEWAGE TREATMENT PLANT INCINERATOR
44A TRAILER COMPLEX (6-PLEX)
44C TRAILER COMPLEX (7-PLEX S.)
44D TRAILER COMPLEX (7-PLEX N.)
44E TRAILER COMPLEX (10 PLEX)
45A RUST ENGINEERING BLDG.
45B UTILITY SHED EAST OF RUST TRAILERS
46 HEAVY EQUIPMENT BLDG.
51 SIX TO FOUR REDUCTION FACILITY *2
53A HEALTH & SAFETY BLDG.
53B IN-VIVO BLDG.
54A SIX TO FOUR REDUCTION FACILITY *1
54B PILOT PLANT SHELTER
54C PILOT PLANT DISSOCIATOR SHELTER
55A SLAG RECYCLING BLDG.
55B SLAG RECYCLING PIT/ELEVATOR
56A CP STORAGE WAREHOUSE
56B STORAGE SHED (WEST)
56C STORAGE SHED (EAST)
60 QUONSET HUT *1
61 QUONSET HUT *2
62 QUONSET HUT *3
63 KC-2 WAREHOUSE
64 THORIUM WAREHOUSE
65 (OLD) PLANT 5 WAREHOUSE
66 DRUM RECONDITIONING BLDG.
67 PLANT 1 THORIUM WAREHOUSE
68 PILOT PLANT WAREHOUSE
69 DECONTAMINATION BLDG.
71 GENERAL IN-PROCESS WAREHOUSE
72 DRUM STORAGE BUILDING
73A FIRE BRIGADE TRAINING CENTER BLDG.
73B FIRE TRAINING POND
73C FIRE TRAINING TANK
73D FIRE TRAINING BURN TROUGH
73E CONFINED SPACE BURN TANK
74A PLANT 2 EAST PAD
74B PLANT 2 WEST PAD
74C PLANT 8 EAST PAD
74D PLANT 8 WEST PAD
74E PLANT 4 PAD
74F PLANT 7 PAD
74G PLANT 5 EAST PAD
74H PLANT 5 SOUTH PAD
74J PLANT 6 PADS
74K PLANT 9 PAD
74L BUILDING 65 WEST PAD
74M BUILDING 64 EAST PAD & R.R. DOCK
74N BUILDING 12 NORTH PAD
74P DECONTAMINATION PAD
74Q PLANT 8 OLD METAL DISSOLVER PAD
74R PLANT 8 NORTH PAD
74S BUILDING 63 WEST PAD
74T PLANT 1 STORAGE PAD
74U PILOT PLANT PAD
74V LABORATORY PAD
74W INCINERATOR BLDG. PAD
77 FINISHED PRODUCTS WAREHOUSE (4A)
78 D & D BUILDING
79 PLANT 6 WAREHOUSE
80 PLANT 8 WAREHOUSE
81 PLANT 9 WAREHOUSE
82 RECEIVING/INCOMING MAT'LS. INSP.
88 CLEARWELL LINE
89 PARKING LOTS
T76 INTERIM OFFICE SPACE
T77 INTERIM OFFICE SPACE
T80 INTERIM OFFICE SPACE
T81 INTERIM OFFICE SPACE

N

LEGEND:

- ROADWAY
- FENCE LINES
- BUILDING OUTLINES
- CSX RAIL LINES
- INDICATES PROPOSED LOCATIONS OF STRUCTURES

SCALE

100 0 100 200 300 FEET

FINAL

FIGURE A-14. FORMER PRODUCTION AREA MAP

/res/res2187/lig1-6.dgn

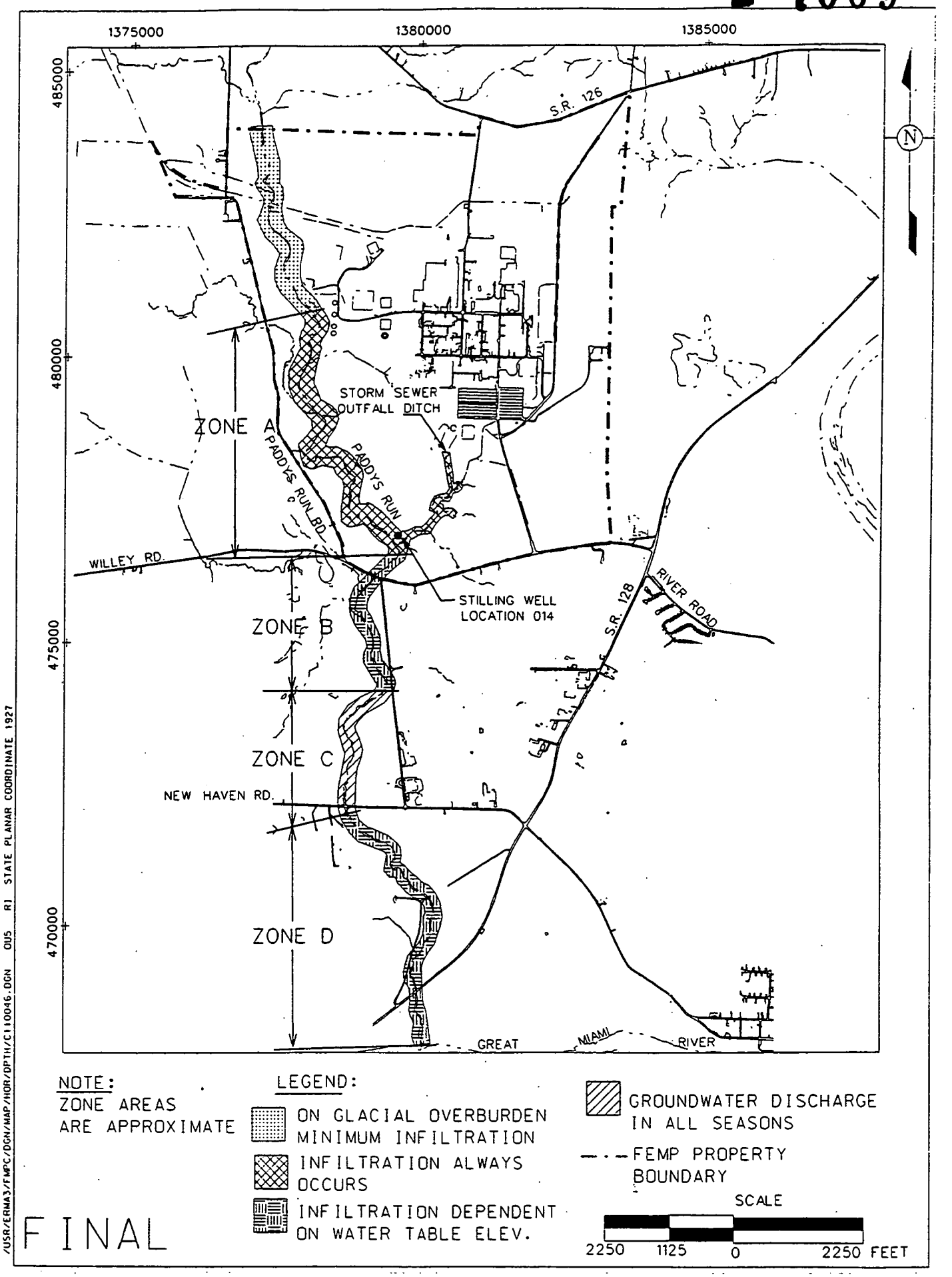
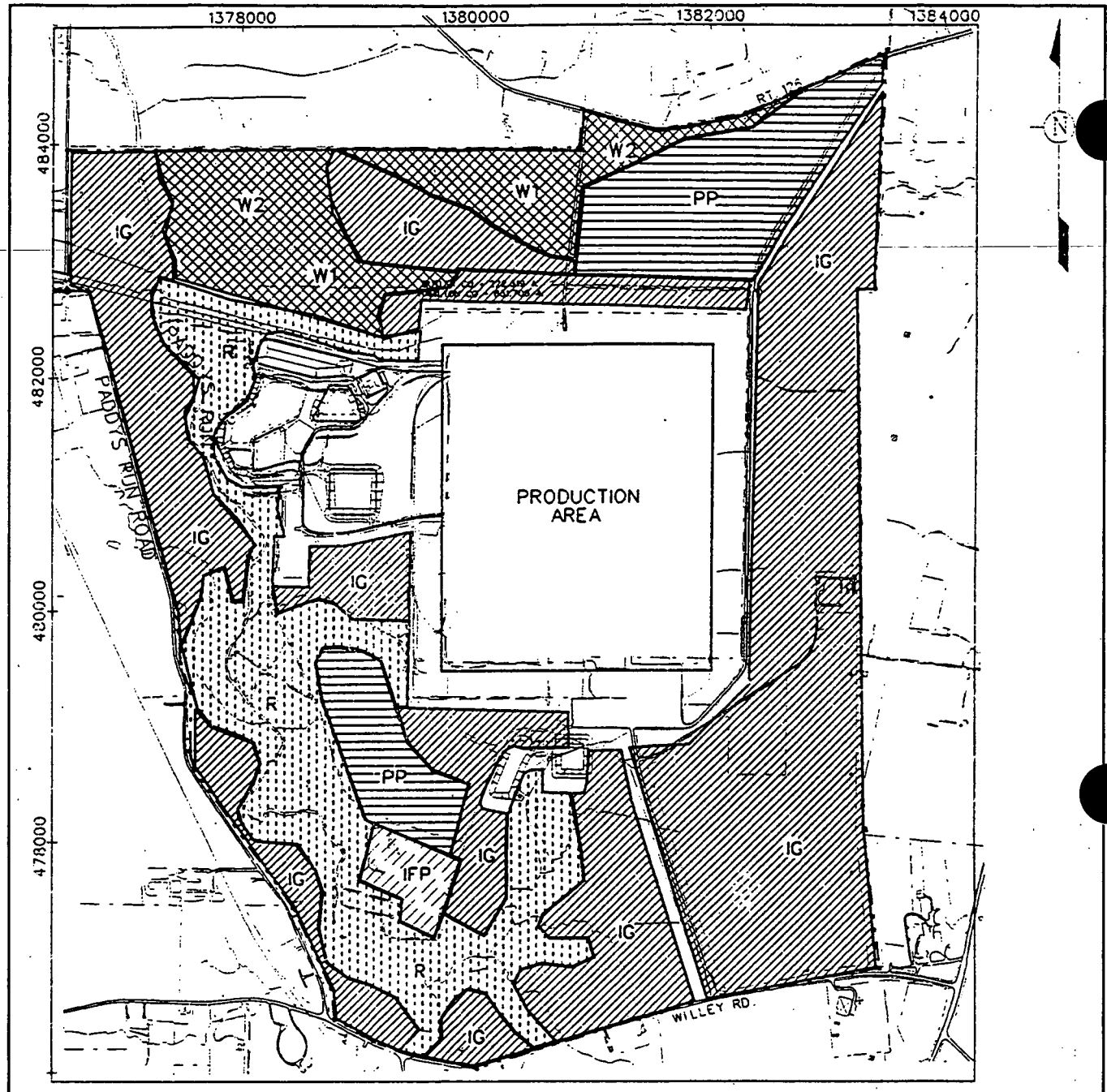


FIGURE A-15. SURFACE WATER INFILTRATION TO THE GREAT MIAMI AQUIFER ALONG PADDYS RUN AND THE STORM SEWER OUTFALL DITCH



LEGEND:

- INTRODUCED GRASSLAND (IG)
- PINE PLANTATION (PP)
- RIPARIAN (R) WOODLANDS
- EARLY SUCCESSION (W1) MID-SUCCESSION (W2)
- INACTIVE FLYASH PILE (IFP)
- FEMP BOUNDARY

NOTE:

HABITAT BOUNDARIES ARE APPROXIMATE.

FINAL

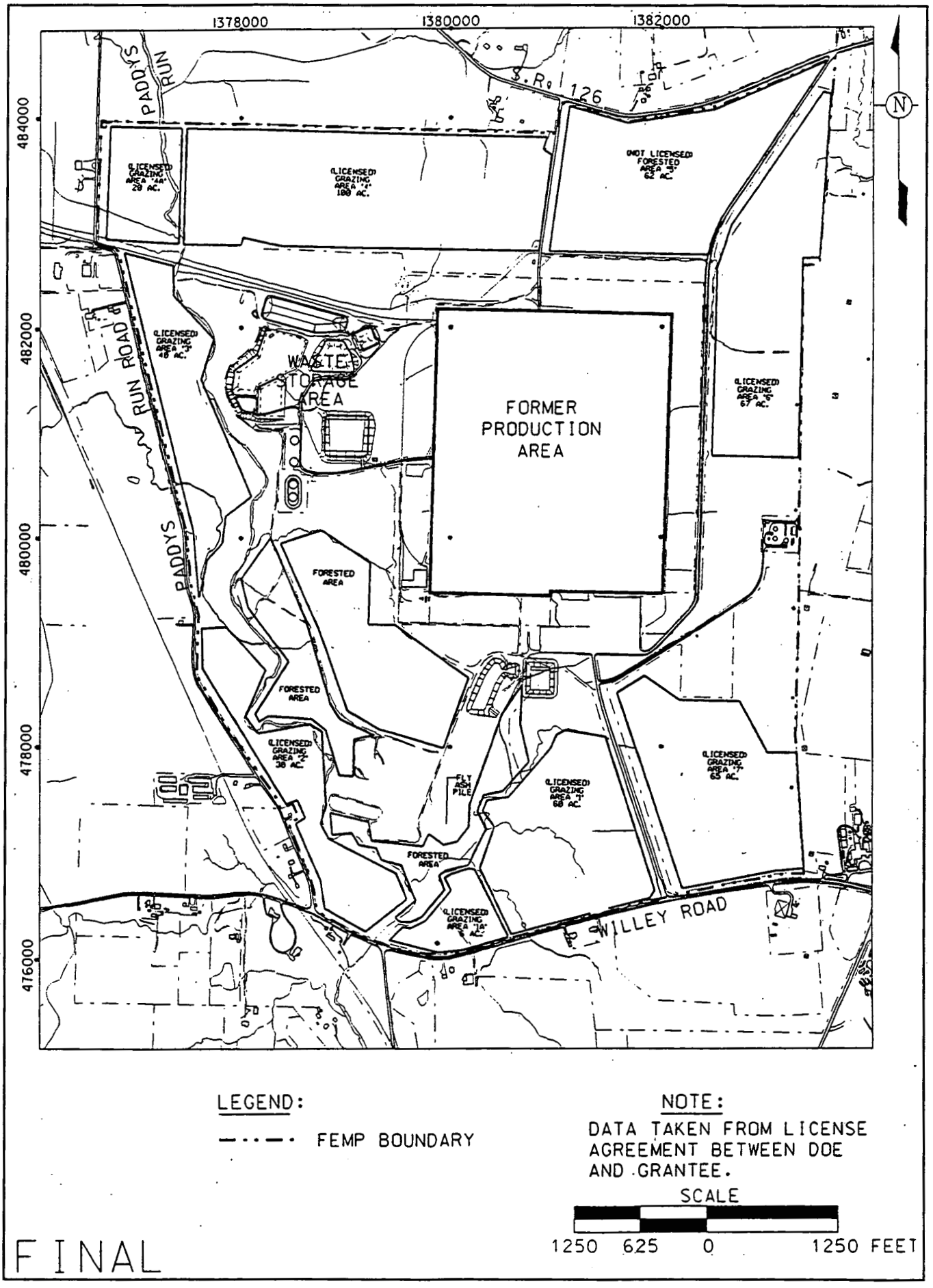
SCALE

1350 675 0 1350 FEET

STATE PLANAR COORDINATE SYSTEM 1927

FIG4-1.DGN OU5 RI

FIGURE A-16. FEMP HABITAT TYPES



STATE PLANAR COORDINATE SYSTEM 1927

A133.DGN OU5 R1

LEGEND:

—·—·— FEMP BOUNDARY

NOTE:

DATA TAKEN FROM LICENSE AGREEMENT BETWEEN DOE AND GRANTEE.

SCALE

1250 625 0 1250 FEET

FINAL

FIGURE A-17. POTENTIAL ON-PROPERTY GRAZING AREAS AND SURROUNDING LAND USE

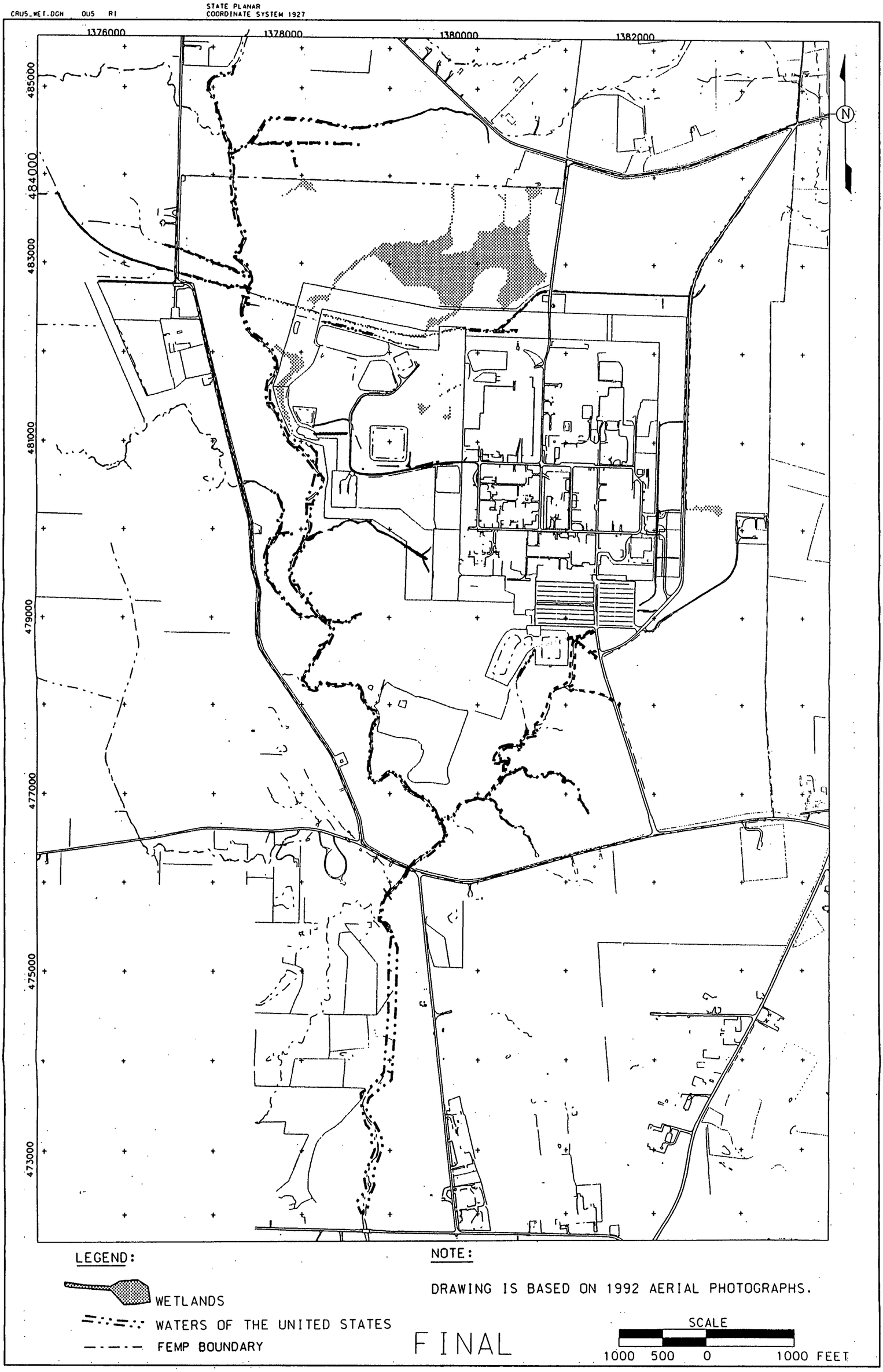


FIGURE A-18. APPROXIMATE BOUNDARIES OF JURISDICTIONAL WETLANDS AT FEMP

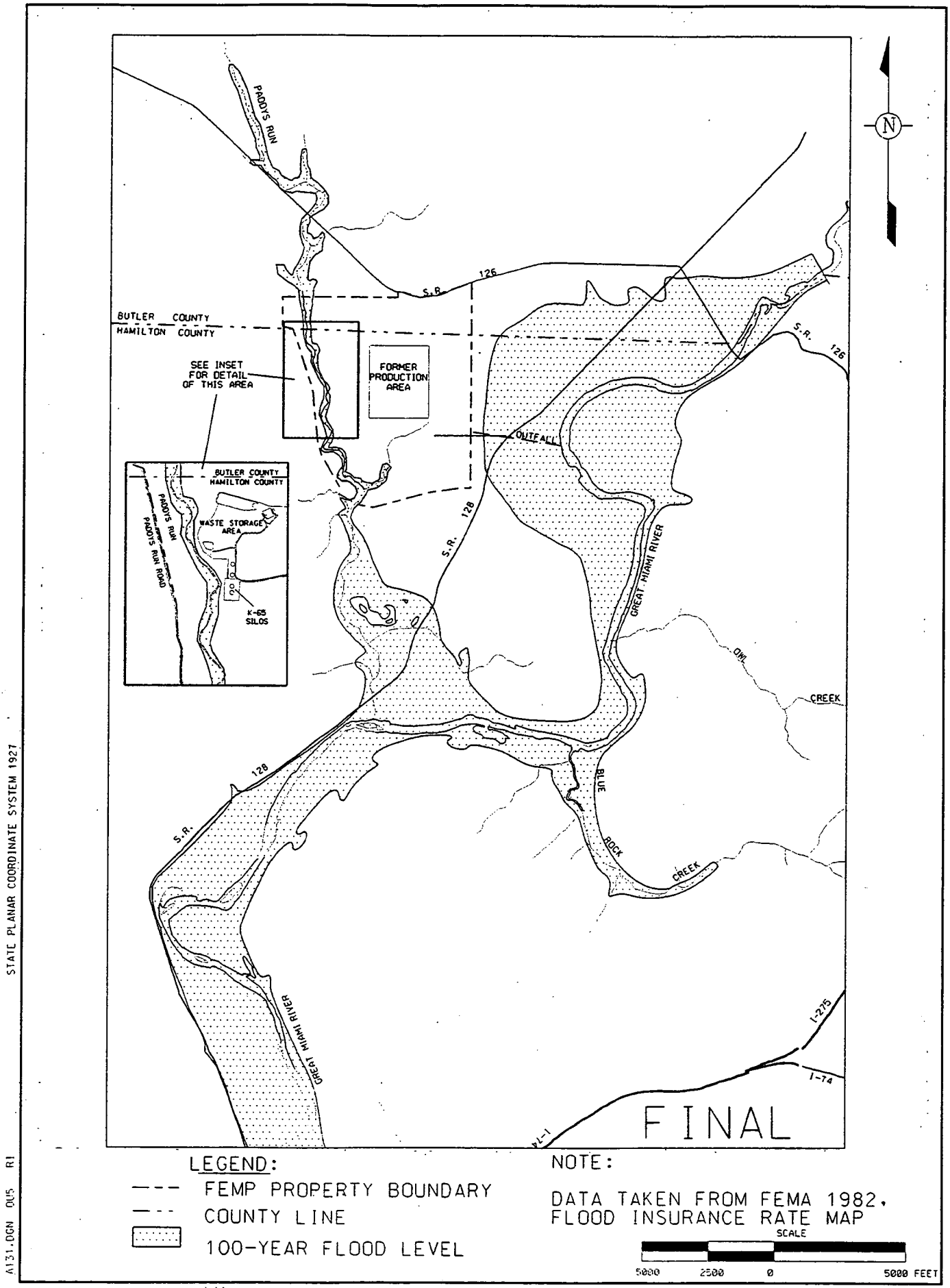


FIGURE A-19. GREAT MIAMI RIVER AND PADDYS RUN 100-YEAR AND 500-YEAR FLOODPLAIN

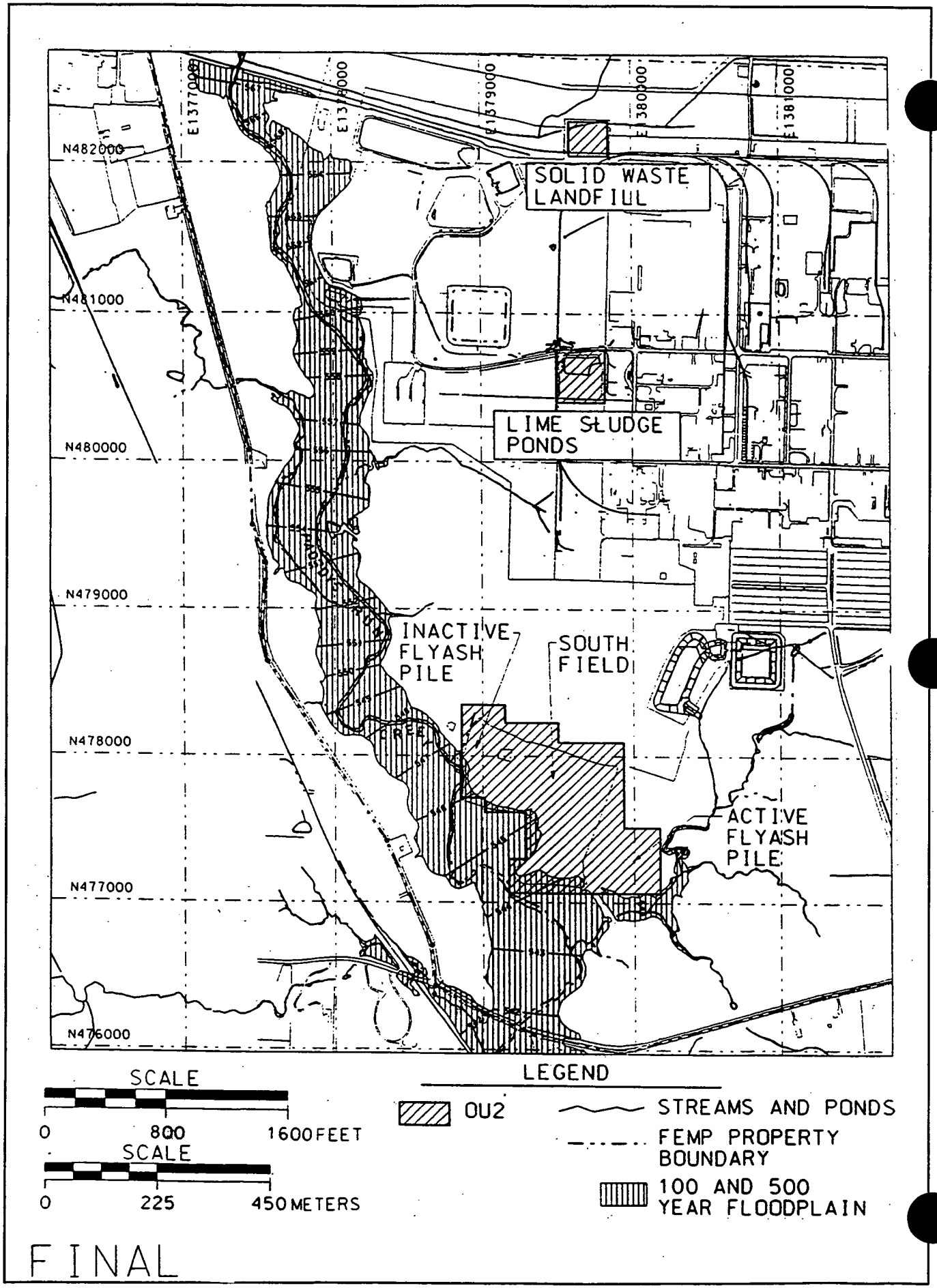
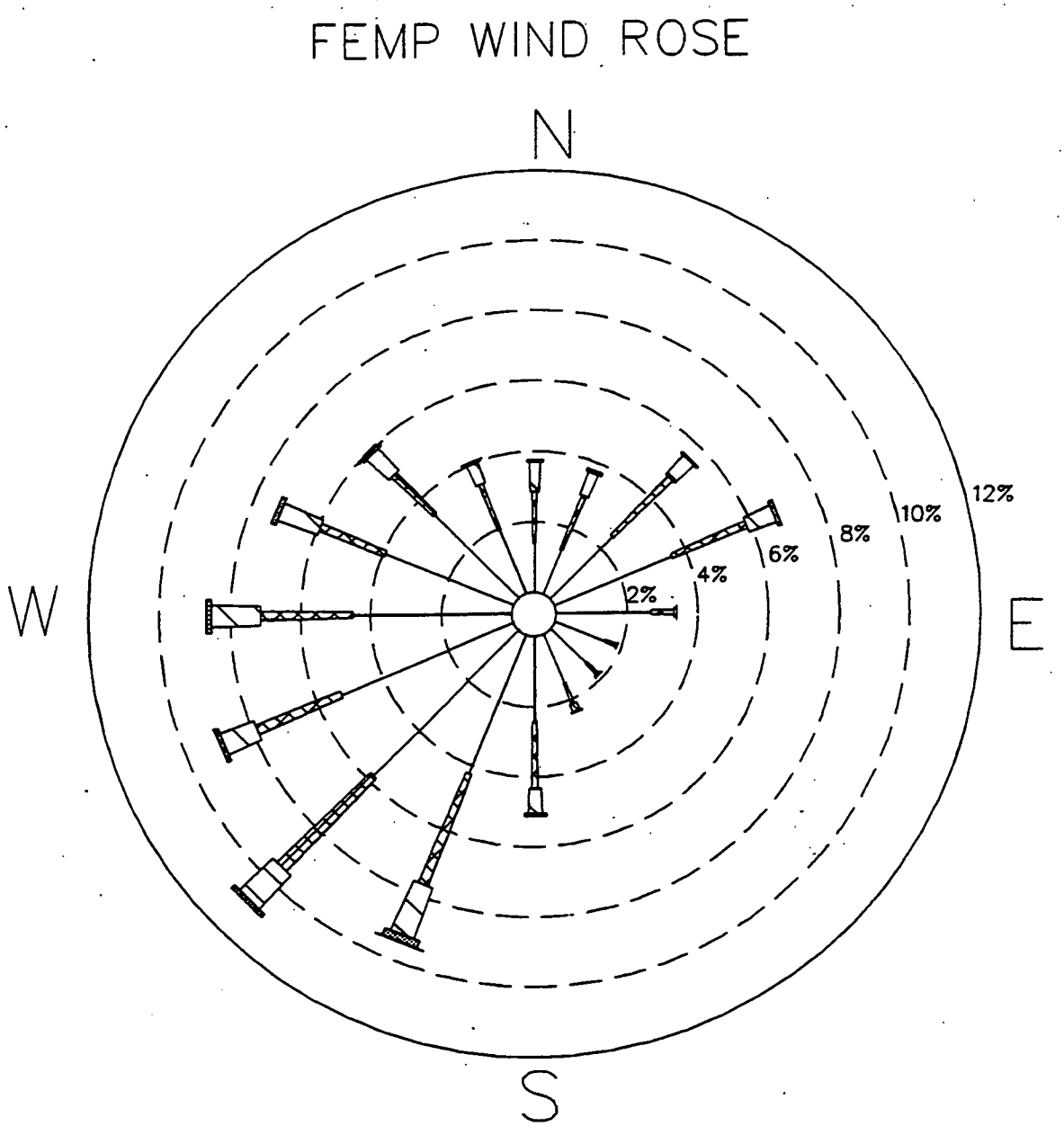
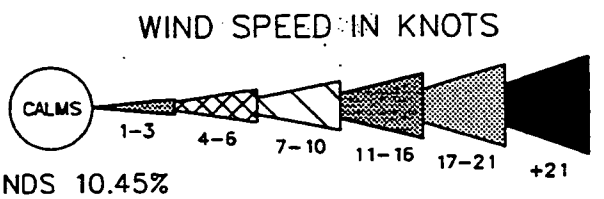


FIGURE A-20. PADDYS RUN 100-YEAR AND 500-YEAR FLOODPLAIN



NOTE: Frequencies indicate direction from which the wind is blowing.
Readings are at 33 feet above ground.



CALM WINDS 10.45%

FINAL

FIGURE A-21. FEMP WIND ROSE COMPOSITE OF 1987, 1988, 1989, 1991, AND 1992

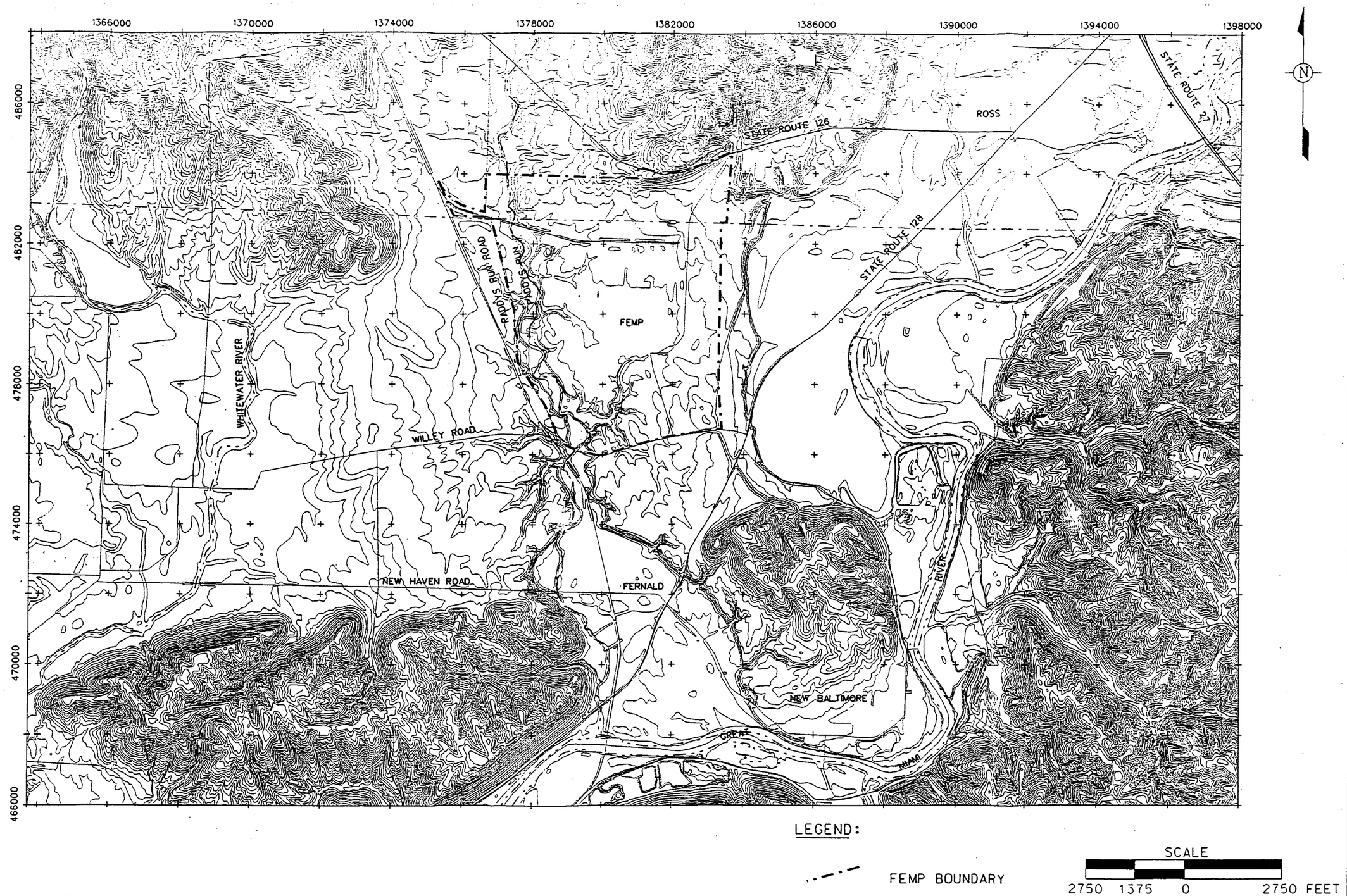
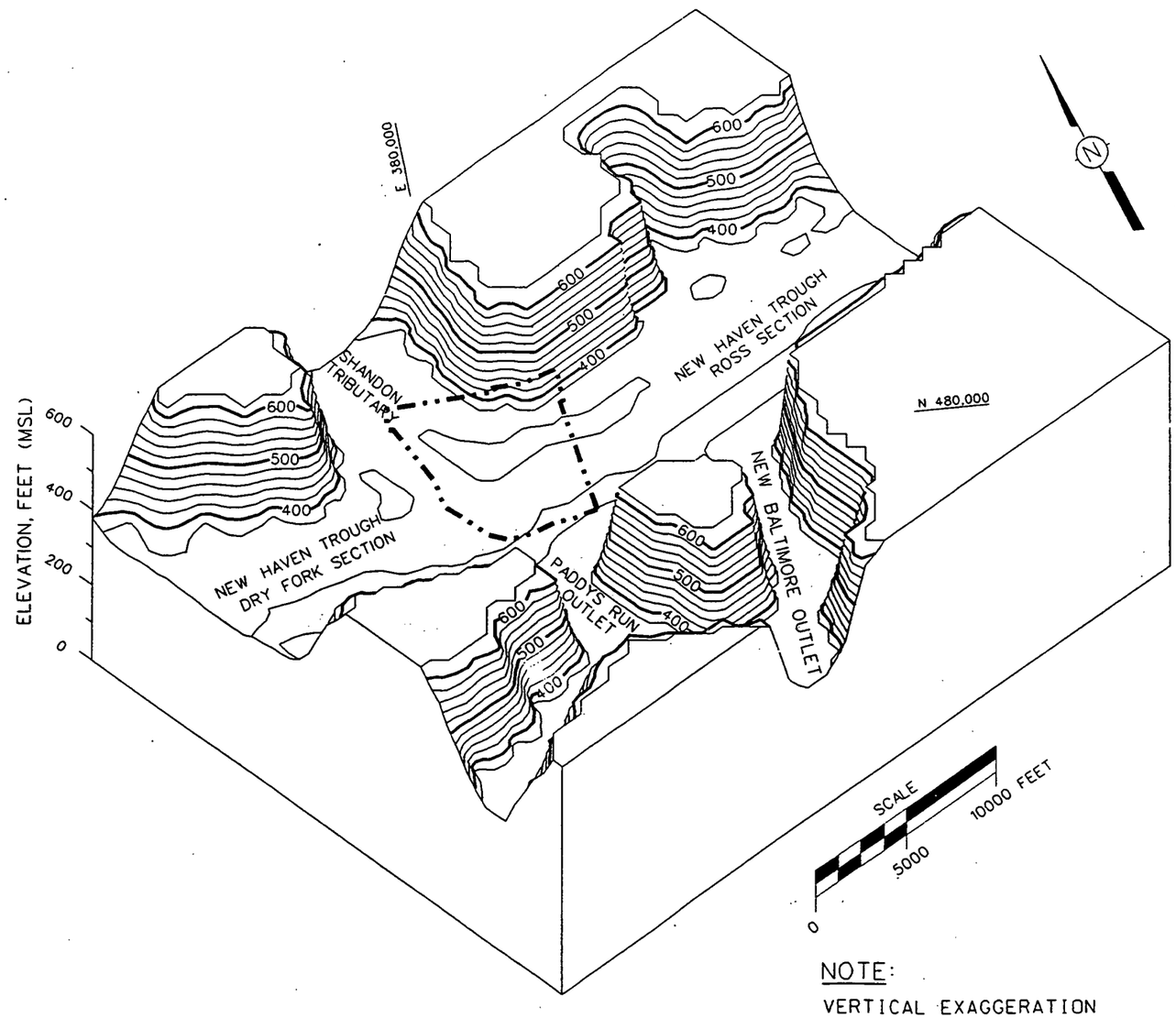


FIGURE A-22. FEMP TOPOGRAPHIC MAP

USR/ERMA3/SARN1/DGN/MAP/HDR/DPTH/C110072.DGN
FER OUS RIDATA 5-31-94 STATE PLANAR COORDINATE SYSTEM 1927

FINAL



NOTE:
VERTICAL EXAGGERATION
= 20X

LEGEND:

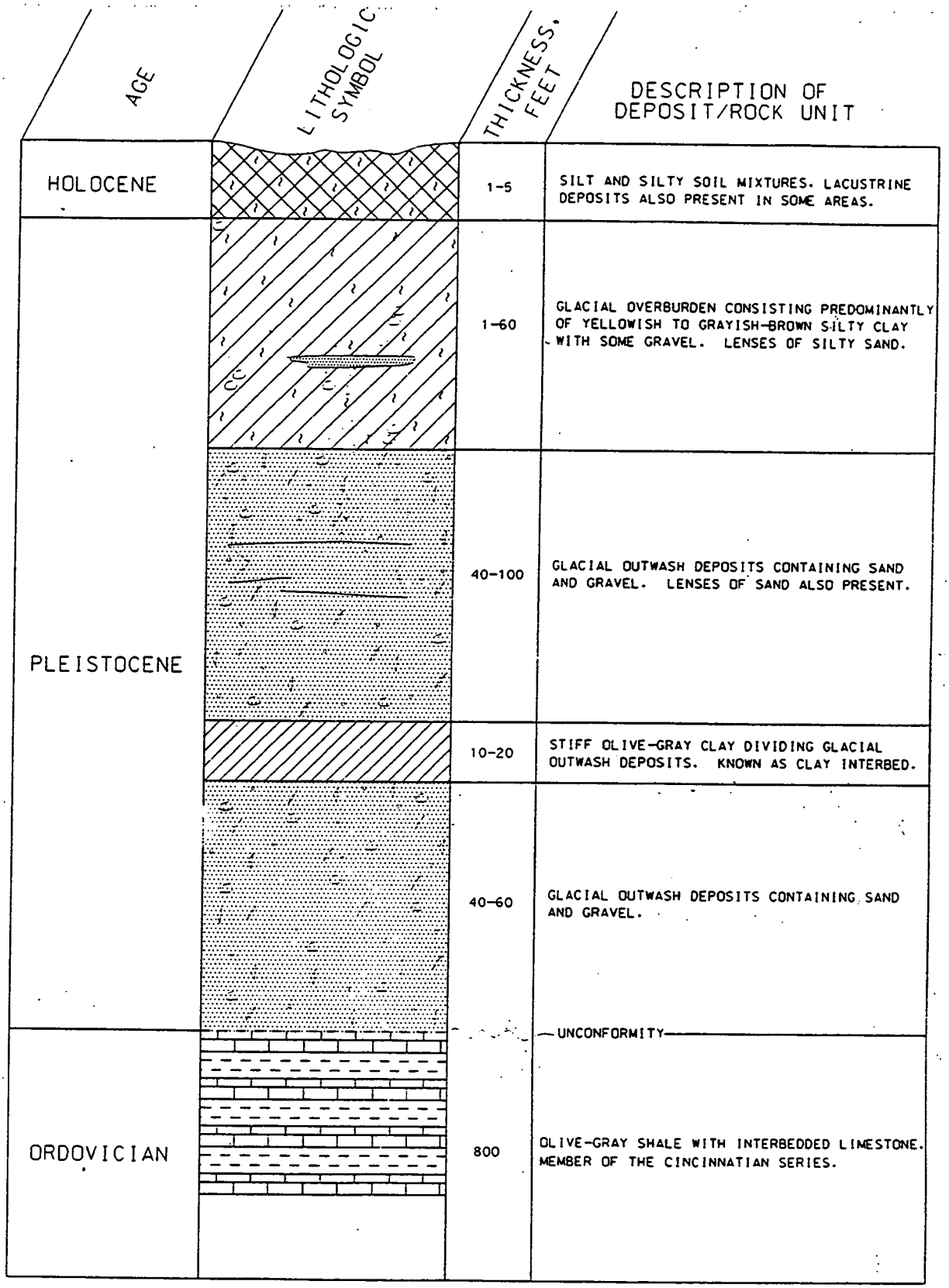
400 CONTOUR

FEMP BOUNDARY

FINAL

/USR/ERMA3/FMPC/IDX/A146.DGN FER OUS RIDATA 6-10-94 STATE PLANAR COORDINATE SYSTEM 1927

FIGURE A-24. THREE-DIMENSIONAL BEDROCK MAP OF FEMP AND SURROUNDING AREA



A137 (OU5)

FINAL

FIGURE A-23. GENERAL STRATIGRAPHIC COLUMN FOR THE FEMP SITE

000715A

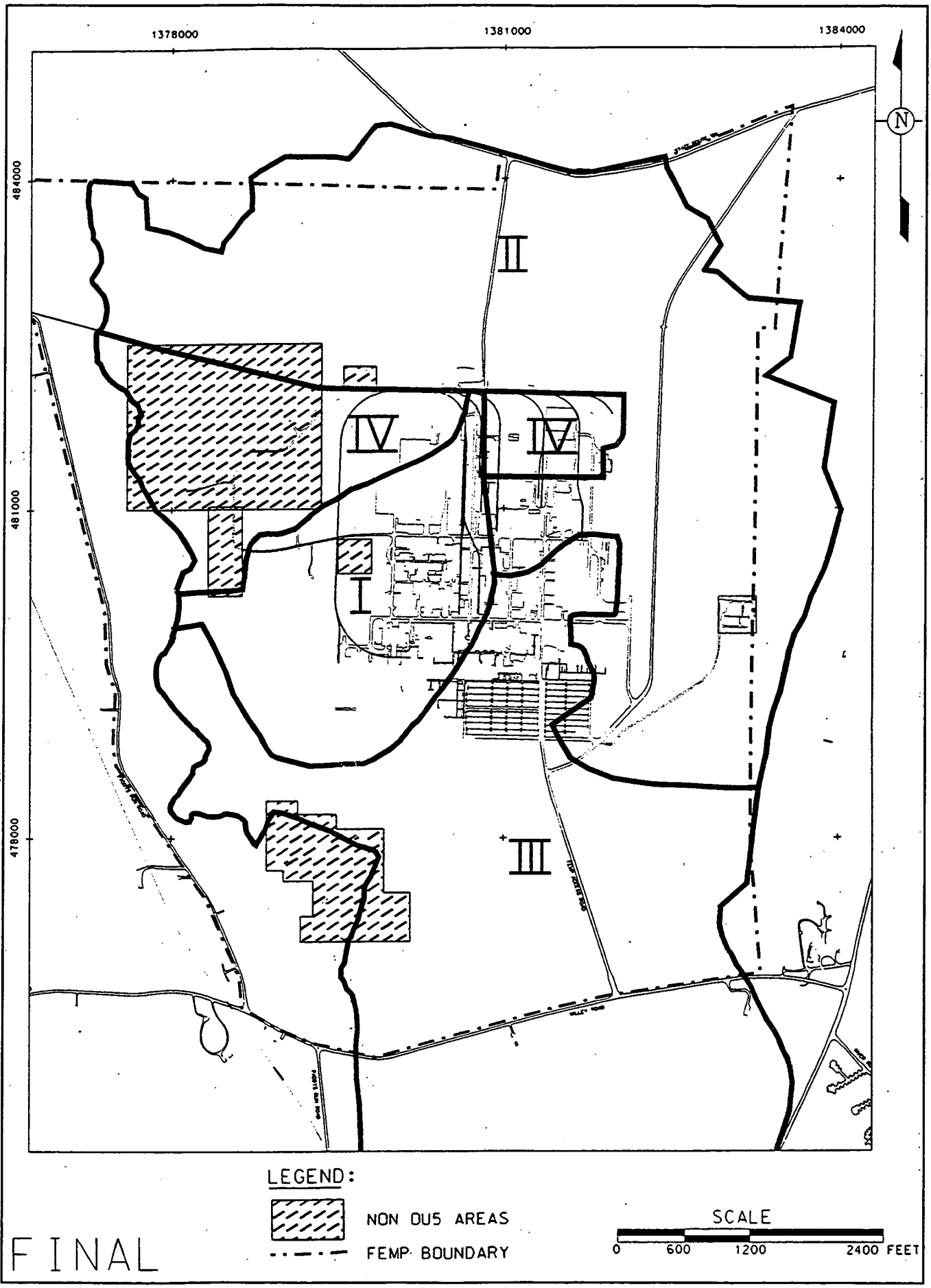
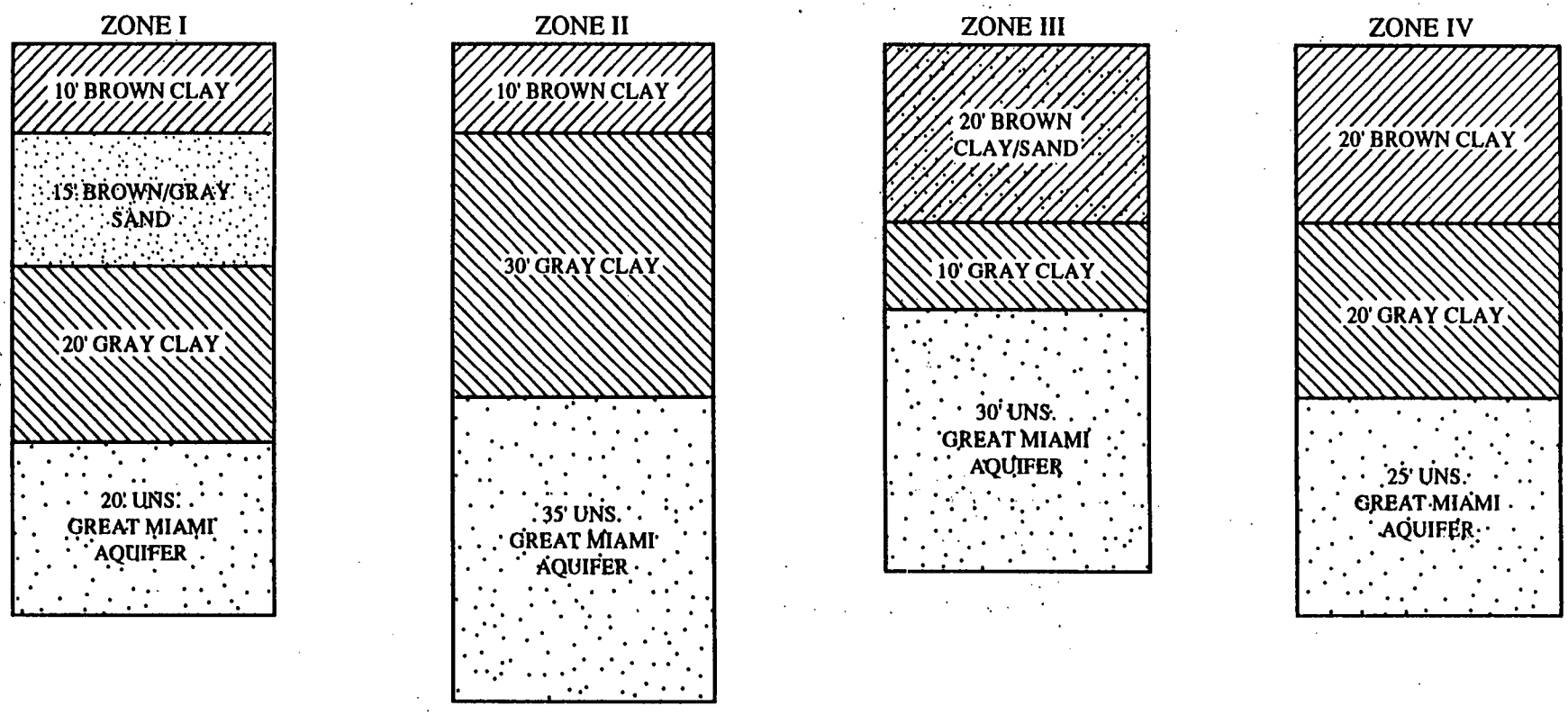


FIGURE A-25. ZONES OF GLACIAL OVERBURDEN (BASED ON THICKNESS OF GRAY CLAY)



LEGEND:

FORMATION -	K_h (cm/s)	NOTE: DATA SOURCE -
BROWN CLAY	3.59E -05	GEOMETRIC MEAN OF K_h FROM SLUG TESTS
GRAY CLAY	1.87E -06	GEOMETRIC MEAN OF K_h FROM SLUG TESTS
BROWN/GRAY SAND	1.10E -03	HARMONIC MEAN OF K_h FROM SLUG TESTS
BROWN CLAY/SAND	7.04E -05	HARMONIC MEAN OF K_h FROM SLUG TESTS

NOT TO SCALE

FINAL

ILLUS\OU-5\PO-116\GEN XSEC GLAC OBRDN.EPS

FIGURE A-26. GENERALIZED CROSS SECTION OF GLACIAL OVERBURDEN ZONES

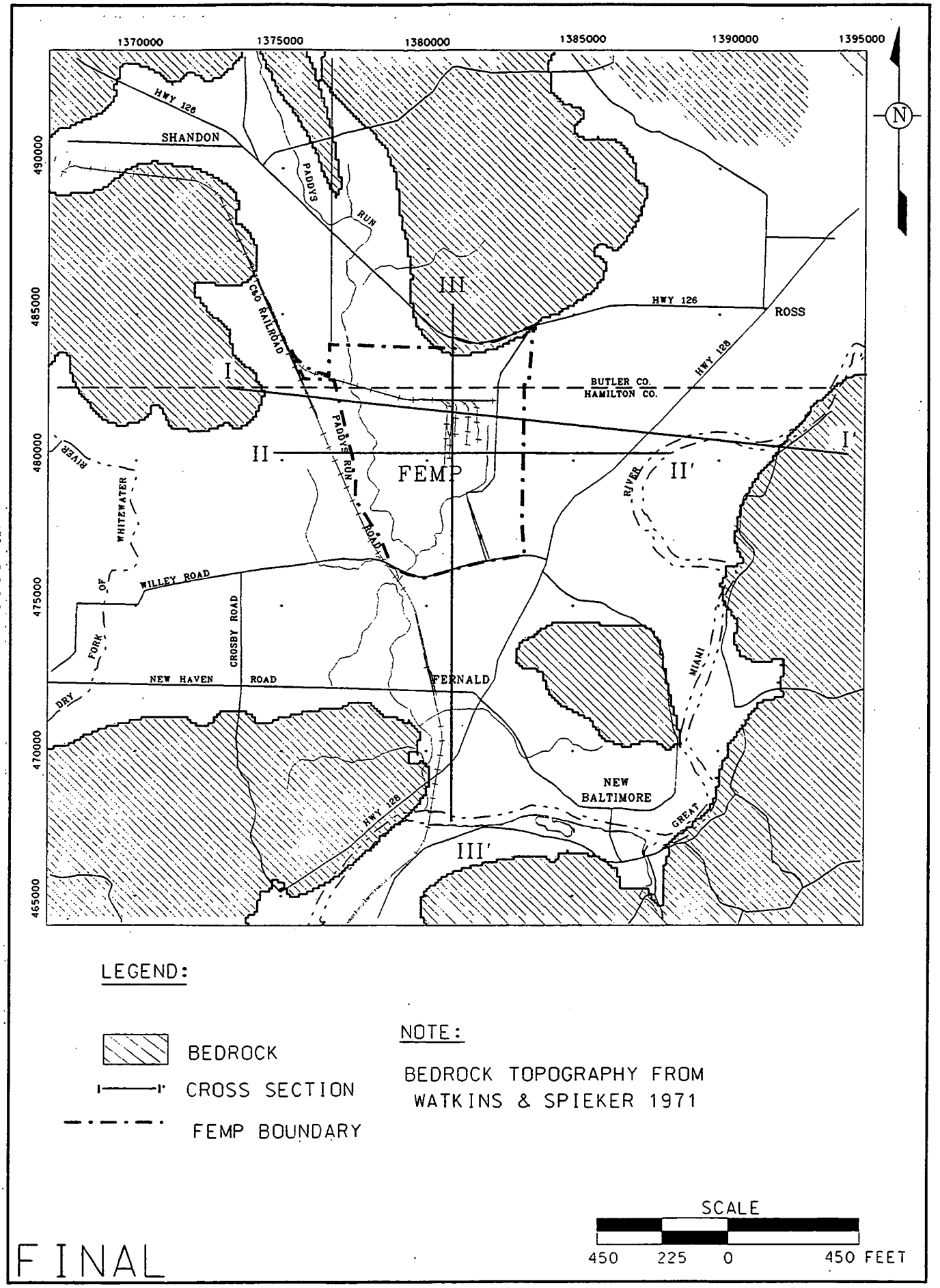
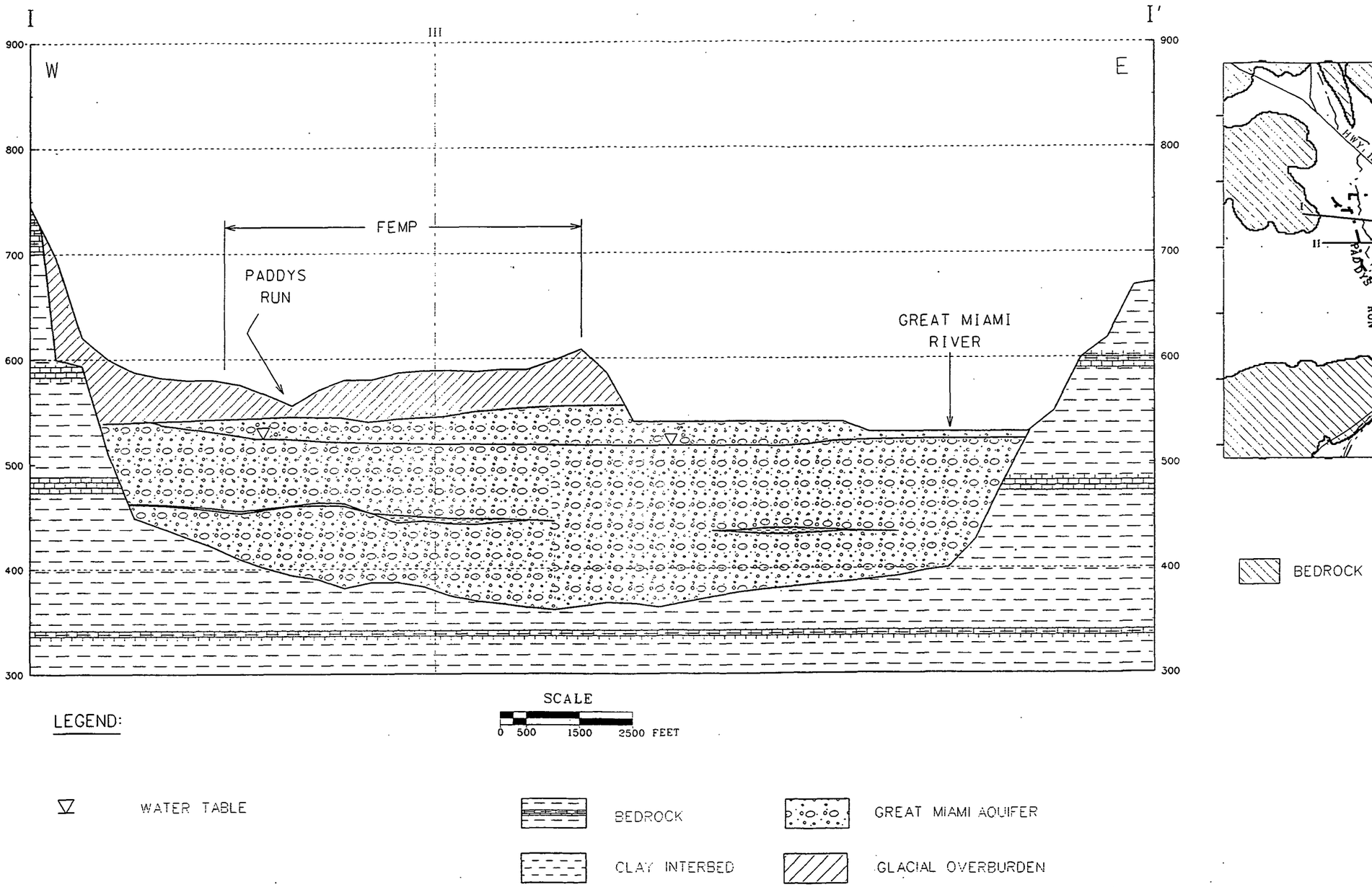


FIGURE A-27. STUDY AREA GEOLOGIC CROSS SECTION LOCATIONS



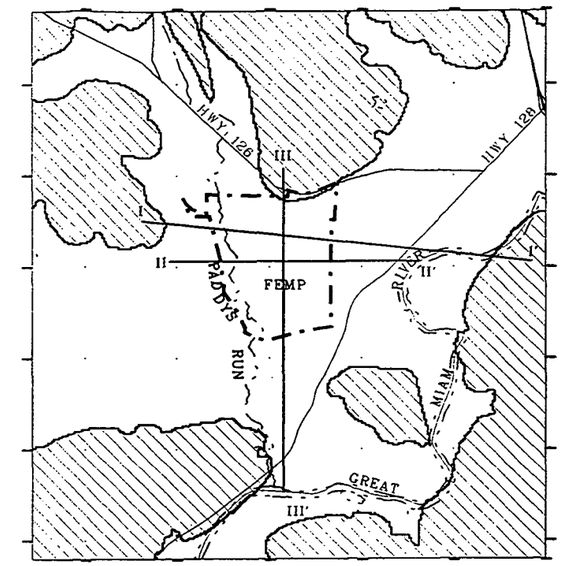
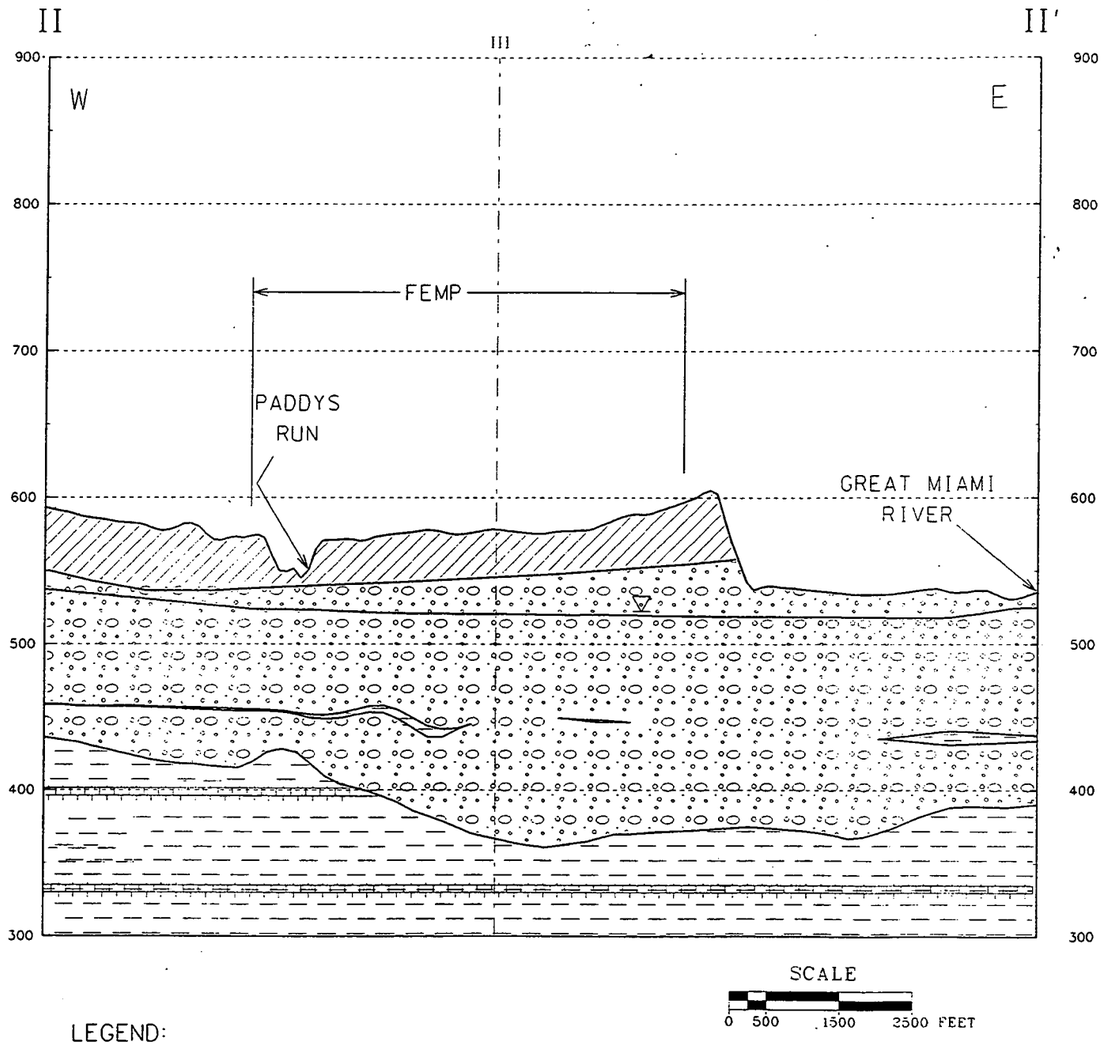
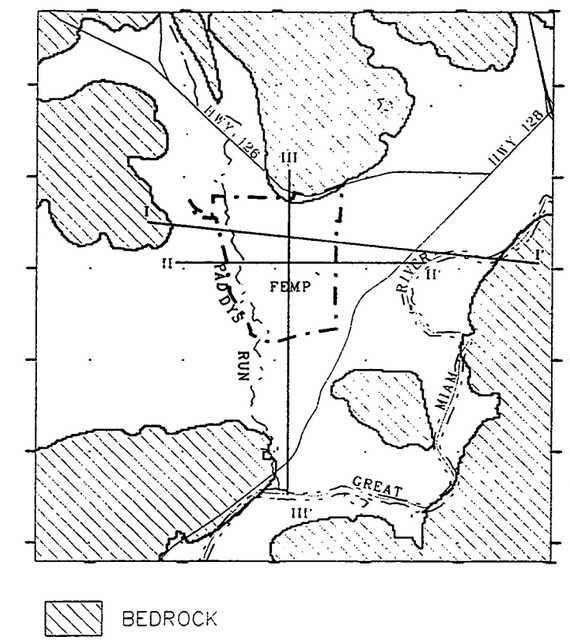


FIGURE A-28. GEOLOGIC CROSS SECTION I-I' STUDY AREA

FINAL

reg_xsect.m(1983.barney) erma@barney. Thu Jul 14 08:15:55 EDT 1994





LEGEND:

WATER TABLE

BEDROCK

GREAT MIAMI AQUIFER

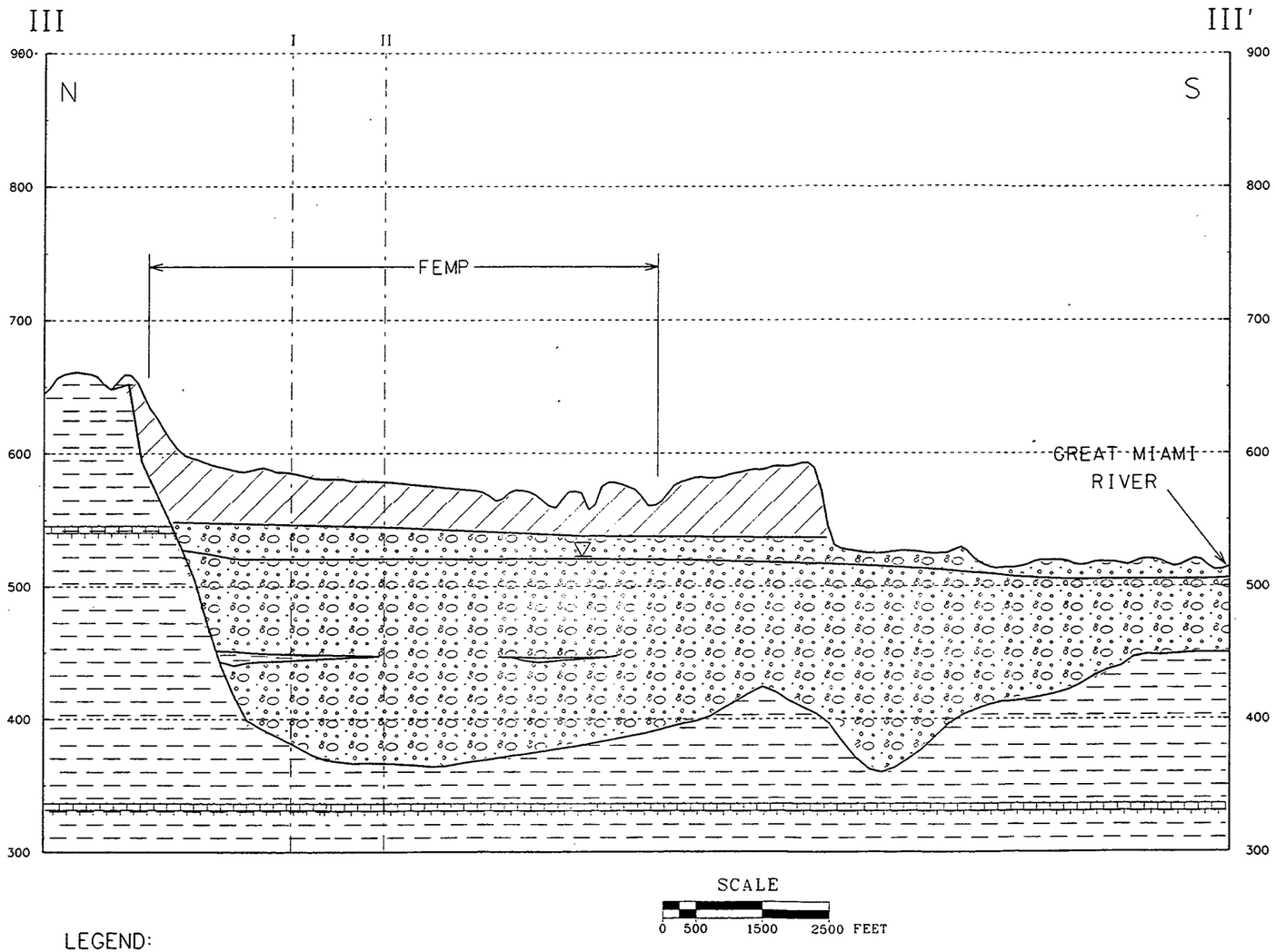
CLAY INTERBED

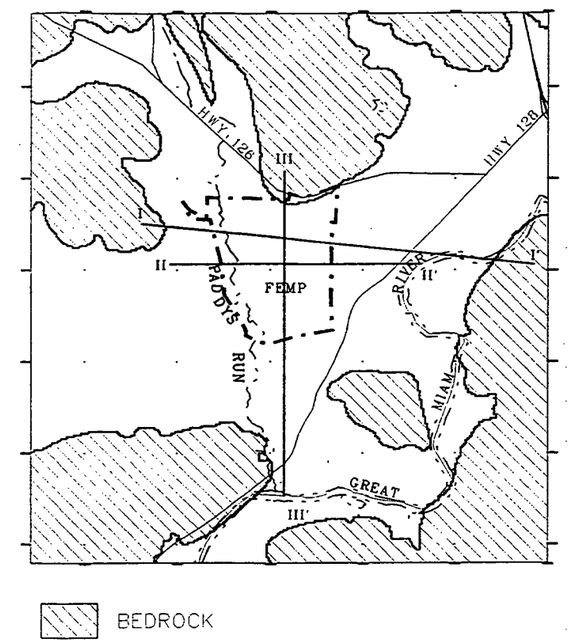
GLACIAL OVERBURDEN

FINAL

FIGURE A-29. GEOLOGIC CROSS SECTION II-II' STUDY AREA

reg_xsect.m(1984.barney) erma@barney. Thu Jul 14 08:18:56 EDT 1994





LEGEND:

WATER TABLE

BEDROCK

GREAT MIAMI AQUIFER

CLAY INTERBED

GLACIAL OVERBURDEN

FINAL

FIGURE A-30. GEOLOGIC CROSS SECTION III-III' STUDY AREA

reg_xsect.m(1985.barney) erma@barney. Thu Jul 14 08:19:32 EDT 1994

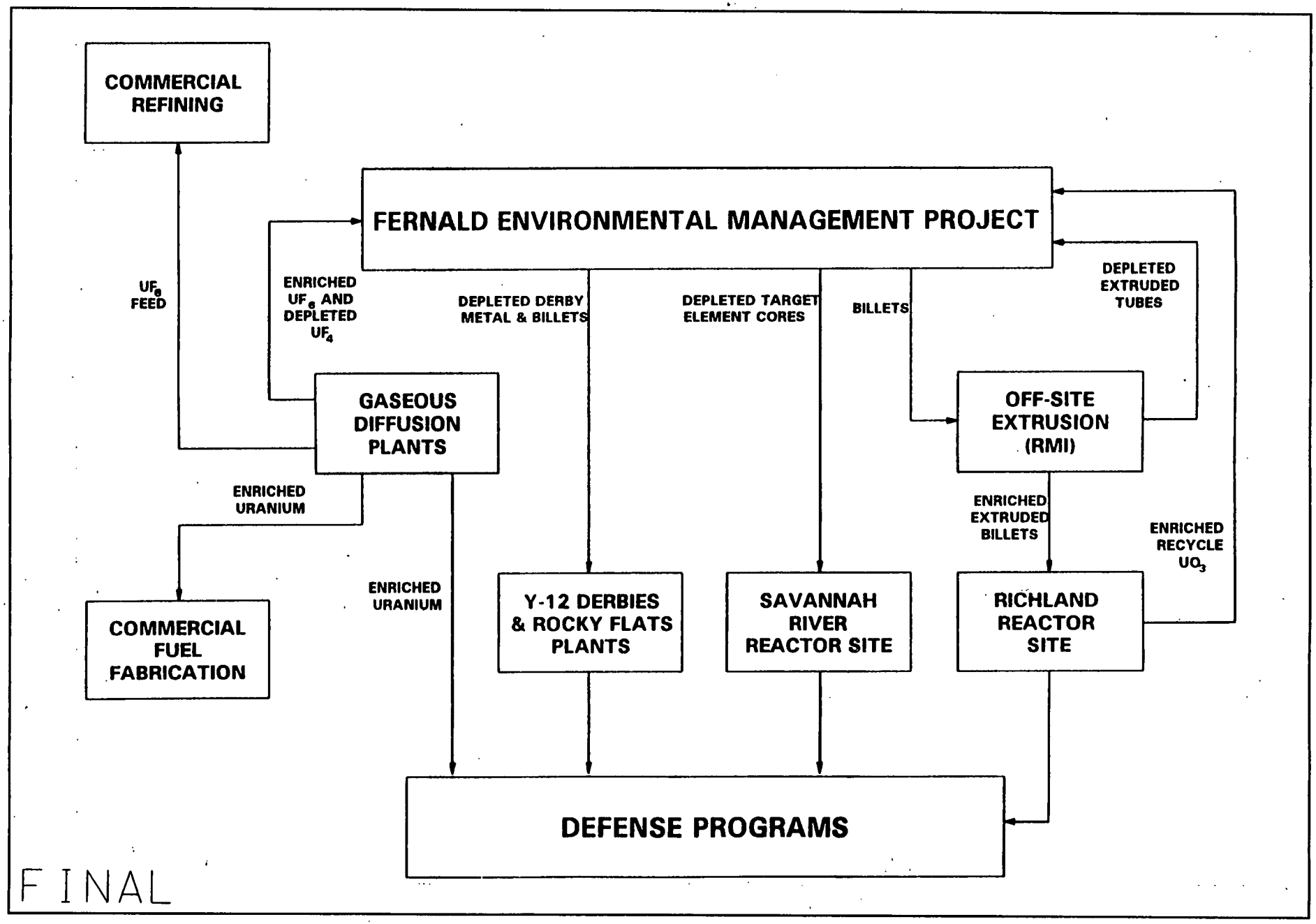


FIGURE A-31. FEMP INTEGRATION WITH OTHER DOE FACILITIES

272000

6902 2069

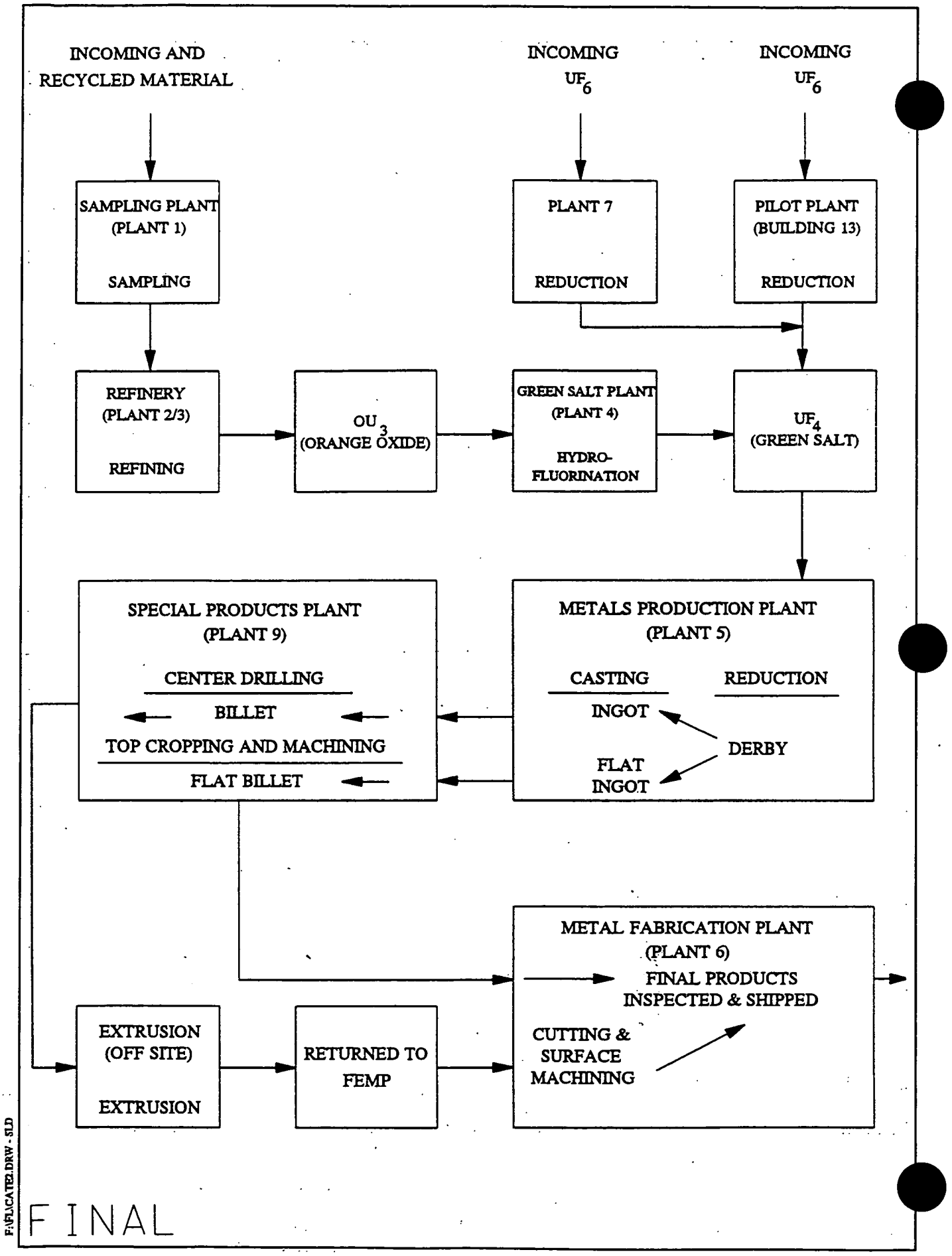


FIGURE A-32. URANIUM METAL PROCESS DIAGRAM

000723

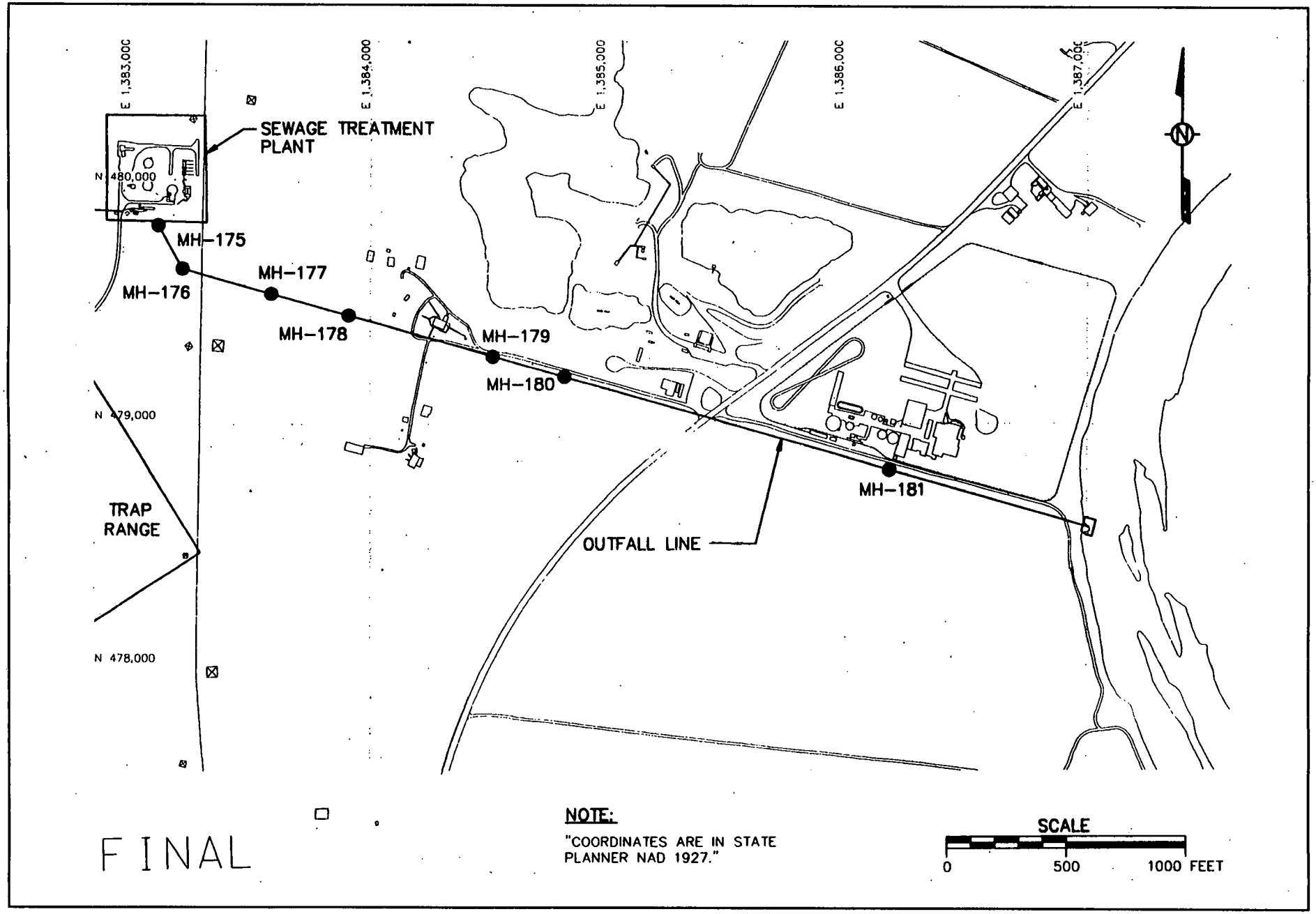
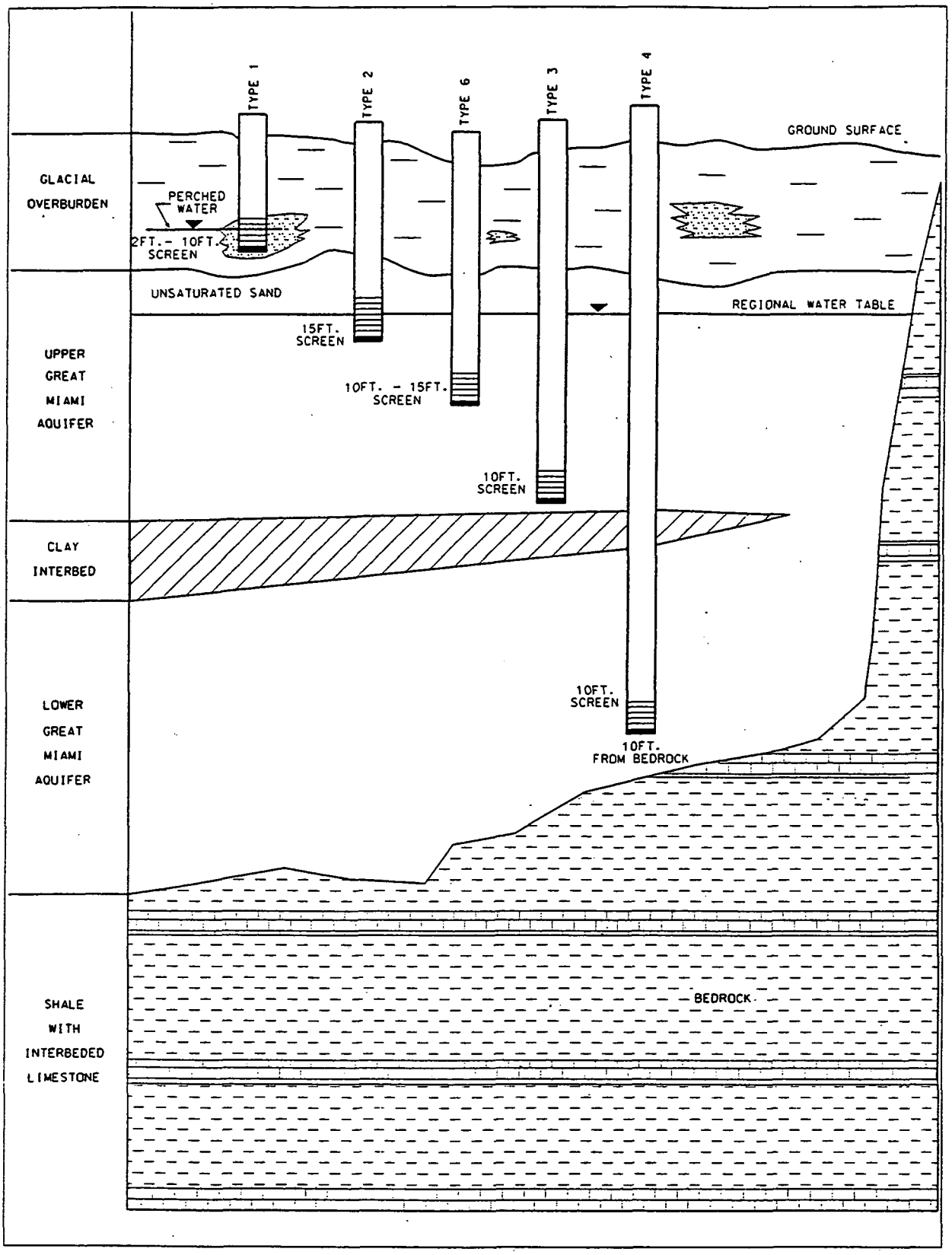


FIGURE A-33. FEMP OUTFALL LINE

000724

6902 2069

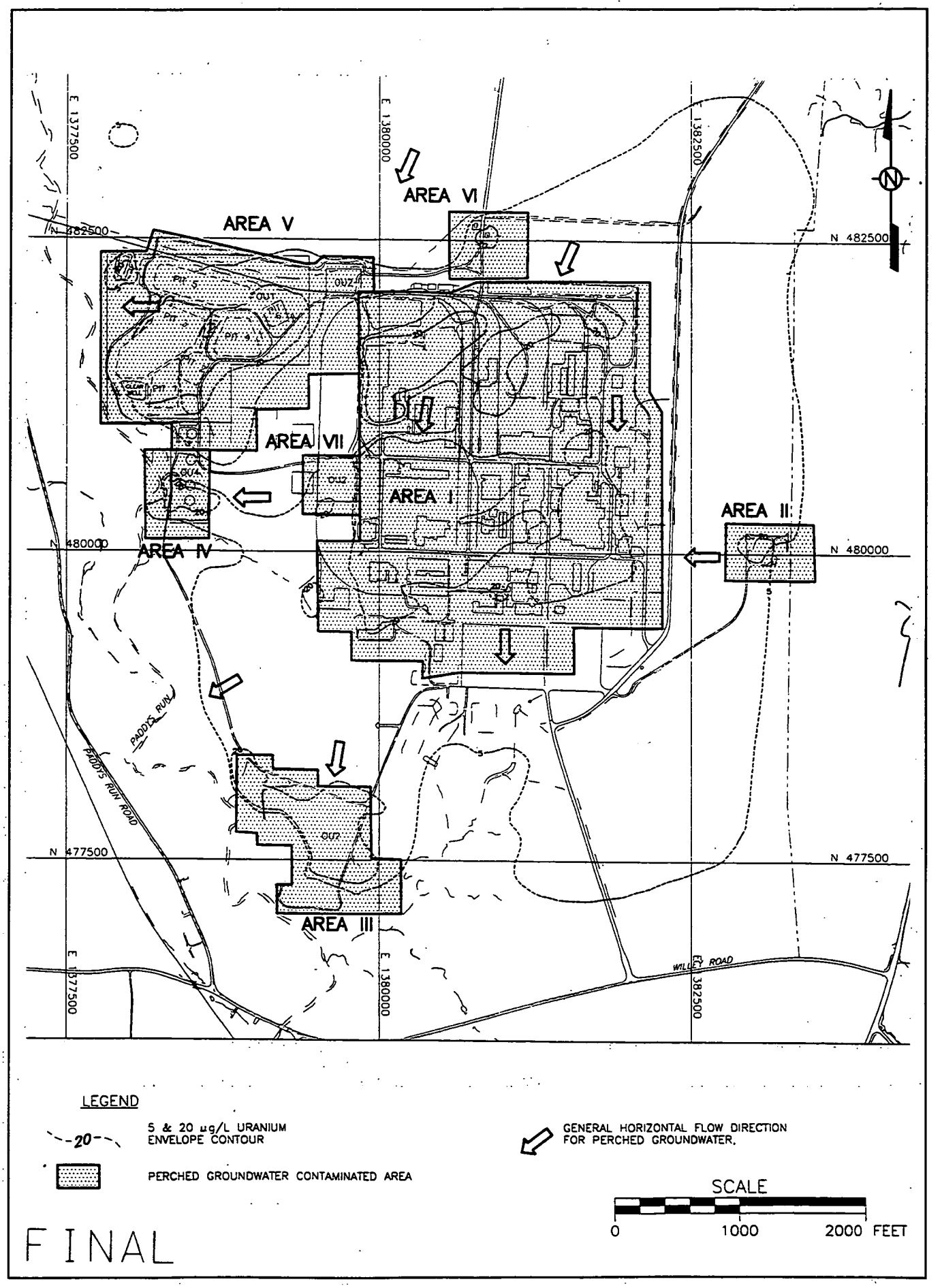


/USR/ERMA3/FMPC/IDX/WELLDPTH.DGN FER OU5 RIDATA 06/11/94

FINAL

FIGURE A-34. GROUNDWATER MONITORING WELL COMPLETION DEPTHS

000725



ACAD: N:\DATA\BBRE902\JUNE1994\4-92.DWG 10/24/94 MJJ STATE PLANAR COORDINATE SYSTEM 1927

FIGURE A-35. LOCATIONS OF PERCHED GROUNDWATER CONTAMINATED AREAS

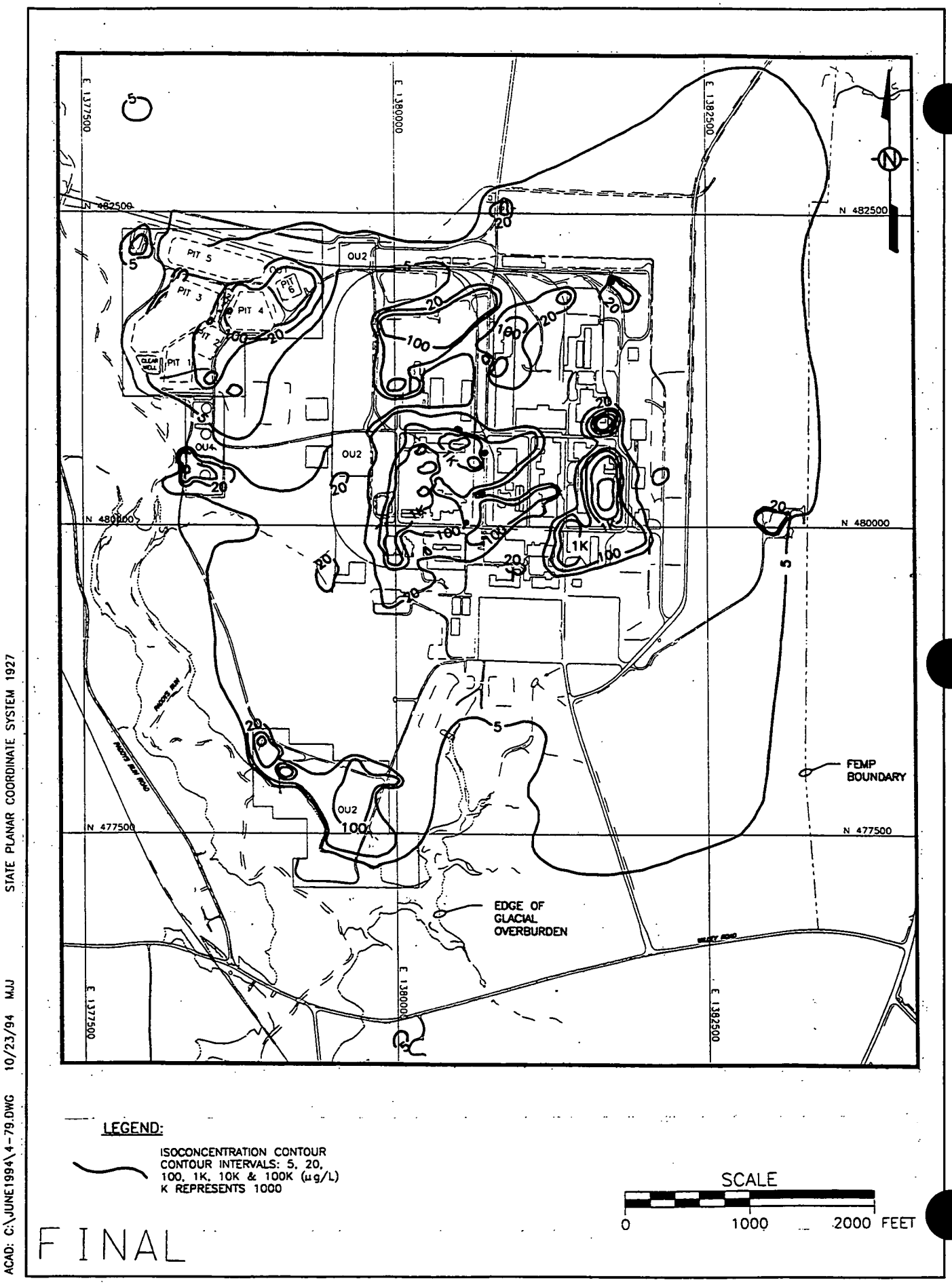
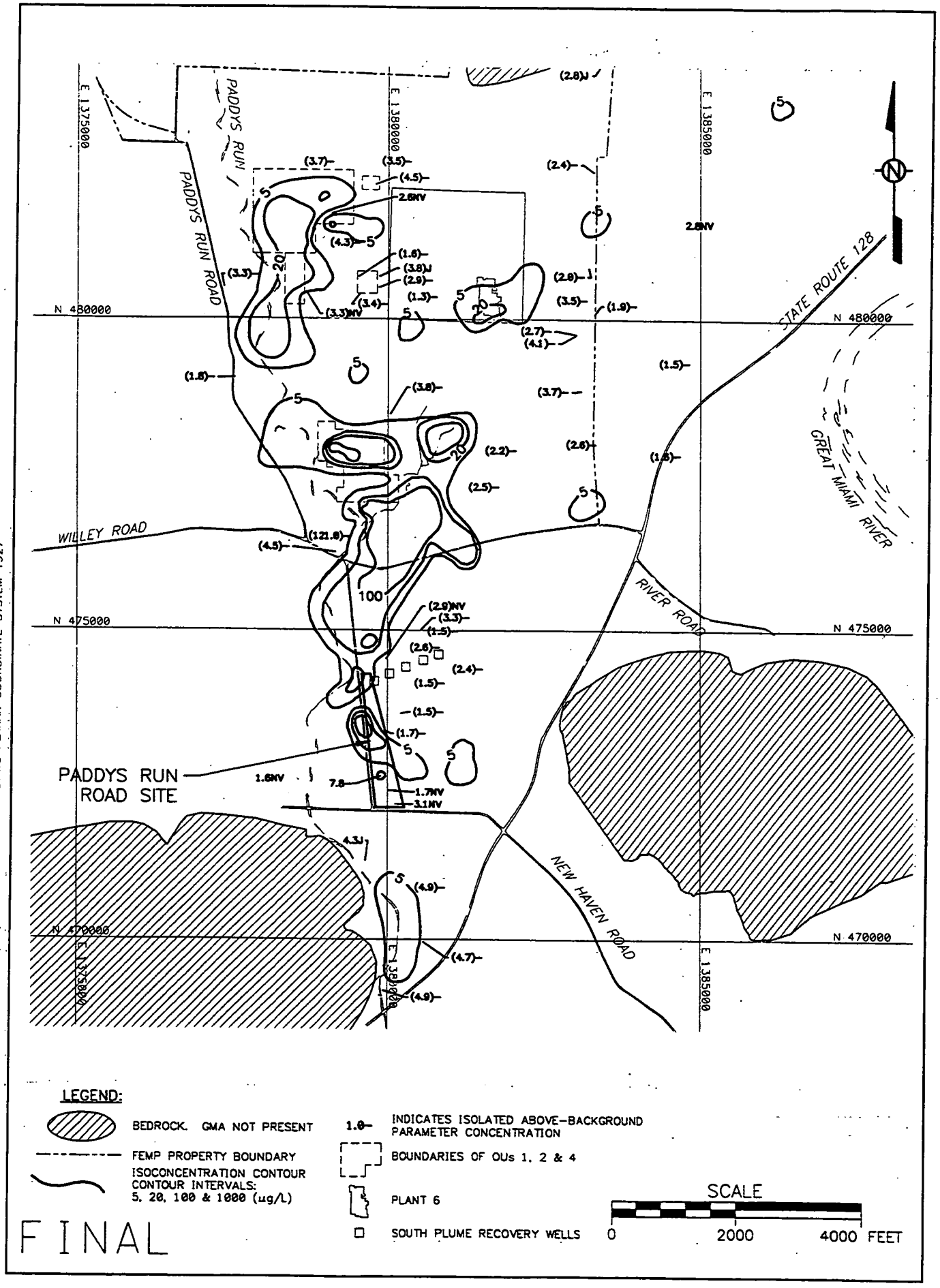


FIGURE A-36. ON-PROPERTY TOTAL URANIUM (ug/L) GROUNDWATER CONCENTRATIONS IN THE GLACIAL OVERBURDEN (PERCHED GROUNDWATER), 1993 SNAPSHOT INVESTIGATION



ACAD: N:\DATA\BBRE902\JUNE1994\4-93.DWG 10/24/94 MJJ STATE PLANAR COORDINATE SYSTEM 1927

FIGURE A-37. ON- AND OFF-PROPERTY TOTAL URANIUM (ug/L) GROUNDWATER CONCENTRATIONS, TYPE 2 WELLS (UPPER GREAT MIAMI AQUIFER), 1993 SNAPSHOT INVESTIGATION

APPENDIX B

POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED REQUIREMENTS FOR OPERABLE UNIT 5

TABLE OF CONTENTS

List of Tables	B-i
List of Figures	B-i
List of Acronyms	B-iii
B.1.0 Introduction	B-1-1
B.2.0 Chemical-Specific ARARs/TBCs	B-2-1
B.2.1 Drinking Water and Groundwater ARARs/TBCs	B-2-1
B.2.2 Surface Water ARARs/TBCs	B-2-2
B.2.3 Air Emission ARARs/TBCs	B-2-3
B.2.4 Soil ARARs/TBCs	B-2-3
B.2.5 Radiation ARARs/TBCs	B-2-4
B.2.6 As Low As Reasonably Achievable Criteria	B-2-4
B.3.0 Location-Specific ARARs/TBCs	B-3-1
B.3.1 On-Property Disposal	B-3-1
B.3.2 Other Location-Specific ARARs/TBCs	B-3-3
B.4.0 Action-Specific ARARs/TBCs	B-4-1
B.4.1 Corrective Action Management Unit (CAMU) Rule	B-4-1
B.4.2 Regulatory Definitions of Wastes	B-4-5
B.5.0 Other Potential Requirements	B-5-1
B.5.1 Superfund Off-Site Rule	B-5-1
B.5.2 Non-ARAR Requirements	B-5-1

LIST OF TABLES

NUMBER	TITLE	
B.1	Operable Unit 5 Potential Chemical-Specific Requirements	B.1-1
B.2	Operable Unit 5 Potential Location-Specific Requirements	B.2-1
B.3	Operable Unit 5 Potential Action-Specific Requirements	B.3-1
B.4	Operable Unit 5 Other Requirements	B.4-1
B.5.A	Compliance Status of Operable Unit 5 Alternatives with Chemical-Specific ARARs	B.5.A-1
B.5.B	Compliance Status of Operable Unit 5 Alternatives with Location-Specific ARARs	B.5.B-1
B.5.C	Compliance Status of Operable Unit 5 Alternatives with Action-Specific ARARs	B.5.C-1

LIST OF FIGURES

NUMBER	TITLE
B.1	Waste Management Flow Chart

LIST OF ACRONYMS

AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
AWWT	advanced wastewater treatment [facility]
BUSTR	Bureau of Underground Storage Tank Regulations
CAA	Clean Air Act
CAMU	corrective action management unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	constituent of concern
CRARE	comprehensive response action risk evaluation
CWA	Clean Water Act
DFO	Director's Finding and Orders
DOE	U. S. Department of Energy
DOT	U. S. Department of Transportation
EIS	environmental impact statement
EPA	U. S. Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FS	feasibility study
HDPE	high-density polyethylene
HEPA	high-efficiency particulate air [filter]
HWMU	hazardous waste management unit
LDR	land disposal restriction
MCL	maximum contaminant level [under SDWA]
MCL	maximum concentration limit [under RCRA]
MCLG	maximum contaminant level goal [under SDWA]
MTR	minimum technology requirements
NAAQS	National Ambient Air Quality Standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency

000751

7069

ORC	Ohio Revised Code
PAH	polycyclic aromatic hydrocarbon
PCA	polychloroethylane
PCB	polychlorinated biphenyl
PEIS	programmatic environmental impact statement
PP	proposed plan
ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
PRL	preliminary remediation level
RA	remedial action
RAC	Radiological Assessments Corporation
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Survey
SDWA	Safe Drinking Water Act
SOWC	Southwestern Ohio Water Company
SSOD	storm sewer outfall ditch
STP	site treatment plan
SWMU	solid waste management unit
TBC	to be considered
TSCA	Toxic Substances Control Act
TU	temporary unit
UMTRA	Uranium Mill Tailings Remediation Act
USDA	U. S. Department of Agriculture
UST	underground storage tank
VOC	volatile organic compound
WAC	waste acceptance criteria

000732

B.1.0 INTRODUCTION

This appendix includes the potential statutory and regulatory requirements impacting remedial alternatives for Operable Unit 5. Remedial action decisions must include consideration of any applicable or relevant and appropriate requirements (ARARs). Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and Section 300.68(i)(1) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) require CERCLA response actions to attain or exceed environmental and public health ARARs unless specific waivers are obtained from regulators. CERCLA lists specific federal environmental laws that must be considered as part of an ARARs analysis. This list includes:

- Toxic Substances Control Act (TSCA)
- Safe Drinking Water Act (SDWA)
- Clean Air Act (CAA)
- Clean Water Act (CWA)
- Solid Waste Disposal Act/Resource Conservation and Recovery Act (RCRA).

A requirement under these other environmental laws may be either "applicable" or "relevant and appropriate," but not both. Identification of ARARs is site-specific, and is defined as:

- Applicable requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance at a CERCLA site.

- Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

In addition to ARARs, the NCP directs that other nonpromulgated criteria, advisories, and guidance issued by federal or state government that are not legally binding may be used as "to be considered" (TBC) criteria and do not have the status of potential ARARs. However these TBC criteria are considered along with the ARARs in determining the necessary level of cleanup or technology requirements to protect human health and the environment.

Some TBC criteria include U.S. Department of Energy (DOE) Orders, which pertain only to DOE facilities through the Atomic Energy Act (AEA) requirements. The substantive requirements of DOE

Orders are TBCs, which, when specifically incorporated in a CERCLA Record of Decision (ROD), are enforceable cleanup standards under CERCLA. The U.S. Environmental Protection Agency's (EPA's) Compliance with Other Laws Manual (1988) states "DOE Orders are not promulgated requirements and are not potential ARARs." The manual further states that, "To the extent that DOE Orders are more stringent or cover areas not addressed by existing ARARs, they should be considered when necessary to develop a protective remedy."

The NCP has identified three categories of ARARs:

- Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies used to determine acceptable concentrations of chemicals that may be found in or discharged to the environment (e.g., maximum contaminant levels (MCLs) that establish safe levels in drinking water).

- Location-specific ARARs restrict actions or contaminant concentrations in certain environmentally sensitive areas. Examples of areas regulated under various federal laws include floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

- Action-specific ARARs are usually technology-, performance-, or activity-based requirements or limitations on actions or conditions involving special substances.

A description of the chemical-, location-, and action-specific requirements are included in this appendix. In addition, summary tables of the potential ARARs and TBC requirements are attached to this appendix for all the requirements.

Two types of tables are provided for ARARs identification for each of the chemical-, location-, and action- specific ARARs. The first type of table identifies the requirements that may be a potential ARAR or TBC for any anticipated remedial activities at this site (Tables B.1, B.2, B.3, and B.4 of this Appendix). This first type of table has several components, including: (1) an explanation of what the requirement is about, (2) identification of the requirement as an ARAR or TBC, and (3) why the requirement is an ARAR or TBC. The second type of table (B.5.A through B.5.C) summarizes what will be necessary to meet compliance of the requirements for the proposed remedial action alternatives in Operable Unit 5. TBCs (proposed requirements) are not included in the compliance tables because they are not ARARs, and, therefore, are not used to determine if an alternative will be in compliance with environmental regulations.

Note that the requirements column in the ARAR-specific tables (Tables B.1, B.2, B.3 and B.4) provide only a summary of the requirement. The regulation, statute, or Federal Register citation listed on the tables should be consulted for a full description of the requirement.

B.2.0 CHEMICAL-SPECIFIC ARARs/TBCs

Operable Unit 5 constituents of concern (COCs) includes contaminants detected in soil, surface water, and sediment from every operable unit on-site are presented in Table 2-3 of this document. These COCs are established by the potential risk that they may impose to the groundwater quality of the Great Miami Aquifer and, therefore, to the potential groundwater user. The chemical-specific ARARs for these COCs are considered according to the following categories:

- ARARs/TBCs for drinking water and groundwater
- ARARs/TBCs for surface water
- ARARs/TBCs for air emissions
- ARARs/TBCs for surface soil
- ARARs/TBCs for radiation
- As low as reasonably achievable (ALARA) criteria.

A summary of ARARs/TBCs for each of these categories is provided below.

B.2.1 Drinking Water and Groundwater ARARs/TBCs

The NCP [40 CFR 300.430 (e)(2)(i)(B)-(D)] states that nonzero maximum contaminant level goals (MCLGs) and the MCLs (if the MCLG is zero) are relevant and appropriate for any aquifer that is a potential drinking water source. Chemical-specific requirements for drinking water and groundwater beneath the site are relevant and appropriate for Operable Unit 5 remedial actions, because the Great Miami Aquifer is a drinking water source. The MCLs and MCLGs are not applicable to the Fernald Environmental Management Project (FEMP) site because there are no public drinking water systems retrieving groundwater that are impacted by contaminants from the FEMP site. No other requirements for drinking water or groundwater are applicable for Operable Unit 5.

Relevant and appropriate or TBC constituents are summarized in Table B.1 for drinking water standards (MCLs, MCLGs, and proposed MCLs); the standards were taken from the SDWA and the RCRA. Table B.1 and 2.3 also summarizes the Operable Unit 5 COCs with the corresponding MCLs or MCLGs listed from the SDWA and the State of Ohio drinking water regulations. MCLs listed by the State of Ohio become ARARs when they are more stringent than the federal counterpart (Table B.1).

If the natural background level of a chemical is higher than the MCLG or MCL, attainment of the MCLG or MCL would not be required. Under this criterion, the standard would not be considered relevant and appropriate (CERCLA Compliance with Other Laws Manual, Publication Quick Reference Sheet, EPA 1990).

Two Operable Unit 5 COCs found in the Great Miami Aquifer exceed background concentrations and the MCLs specified under the SDWA, which may be technically impractical to treat to MCLs within the proposed remediation time frame of 35 years. These COCs include arsenic (proposed MCL of 0.05 mg/L) and radium - 226 (proposed MCL of 20 pCi/L). If review and research of best available technology indicates that the geochemistry of the Great Miami Aquifer will not allow reduced concentrations of these constituents, then a waiver under CERCLA may be pursued because of the technical impracticability of removing these constituents to MCLs.

B.2.2 Surface Water ARARs/TBCs

CERCLA 121 states that hazardous substances, pollutants, or contaminants left on site at the conclusion of the remedial action shall attain federal water quality criteria where they are relevant and appropriate under the circumstances of the release or threatened release. CERCLA 121(d)(2)(B)(i) requires that this determination be based on the designated or potential use of the water, the media affected, the purpose of the criteria, and the current information. The Ohio Environmental Protection Agency (OEPA) has designated the following uses for the Great Miami River and its tributaries (including Paddys Run):

- Warm water aquatic life habitat
- Agricultural and industrial water supply
- Primary contact recreational use.

The definitions of these water designation terms are applicable to the FEMP site and presented in the Ohio Administrative Code (OAC 3745-1-07), as follows:

"Warm water" refers to water capable of supporting and maintaining a balanced, integrated, adaptive community of warm water aquatic organisms having a species composition, diversity, and functional organization comparable to the 25th percentile at the identified reference sites within the organism's ecoregion.

"Agricultural water" is water that is suitable for irrigation and livestock watering without treatment.

"Industrial water" is water that is suitable for commercial and industrial uses, with or without treatment.

The "primary contact recreational use" describes the full-body contact an individual may receive during recreational time in water such as, but not limited to, swimming, canoeing, and scuba diving with minimal threat to public health as a result of water quality.

The OEPA has promulgated water quality standards specific to state water and its actual or potential uses. The OEPA standards are considered applicable for the direct discharge of wastewater generated during a CERCLA action and relevant and appropriate for use in determining cleanup goals for soil or groundwater that has the potential to impact surface water. The OEPA standards provided in Table B.1 are in-stream levels established to be protective of the designated uses. Acceptable discharge levels are governed by the most stringent use standard based on the designated level of protection. The protection levels designated by OEPA are based on minimum low flow quantities of the receiving stream.

B.2.3 Air Emission ARARs/TBCs

EPA regulations for National Emission Standards for Hazardous Air Pollutants (NESHAP) provide an applicable air emission standard for remedial activities in Operable Unit 5 (40 CFR 61.92). This regulation limits airborne radionuclide emissions from DOE facilities to those amounts that will not cause any member of the public to receive an effective dose equivalent of more than 10 mrem per year. 40 CFR 192.02, Subpart A, requires that reasonable assurance be provided that releases of radon-222 from residual radioactive material to the atmosphere will not:

- Exceed an average release rate of 20 $pCi/m^2/s$ (averaged over the entire surface of the disposal site and over at least a one-year period)
- Increase the annual average concentration of radon-222 in the air at the disposal site or any location outside the disposal site by more than 0.5 pCi/L.

This requirement is relevant and appropriate because radium-226, an element that decays into radon-222, has been detected across the site in Operable Unit 5 soil.

The National Ambient Air Quality Standards (NAAQS) would be applicable for remedial treatment units (e.g., soil decontamination, stabilization) because they may release airborne pollutants. Any proposed remedial treatment units for Operable Unit 5, in addition to other FEMP emissions during remedial action, will be designed to maintain the NAAQS standards for carbon monoxide, nitrogen dioxide, particulate matter (PM_{10}), ozone, sulfur oxides, and volatile organic compounds. These standards are provided in Appendix B.

B.2.4 Soil ARARs/TBCs

The EPA has promulgated standards for radium-226 and radium-228 in soil at uranium and thorium mill tailings sites (40 CFR 192 Subpart B). While the FEMP is not a designated facility under 40 CFR 192, the standards are considered relevant and appropriate to Operable Unit 5 soil and sediment. The type and concentration of radiological contaminants present in Operable Unit 5 soil and sediment are similar in characteristics to soil found at designated uranium mill tailing sites.

Consistent with 40 CFR 192, these radionuclides are not to exceed background concentrations by more than 5 pCi/g in the top 6 inches of soil, or 15 pCi/g in each successive 6-inch layer beneath the surface, averaged over an area of 100 square meters.

RCRA contaminants have been identified in soil from the process area of the site and surrounding the fire training facility and the sewage treatment plant. These contaminants are typically found to be associated with hazardous waste management units (HWMUs) as source areas. Therefore, RCRA requirements for land disposal restrictions and treatment standards (40 CFR 268) are considered applicable where contaminants in soil can be traced back to a known RCRA waste source area, unless the corrective action management unit (CAMU) rule is applied. A description of the hazardous constituents detected in soil, in association with HWMUs and in other areas, is provided in Section 4.1.6.2.

B.2.5 Radiation ARARs/TBCs

The Atomic Energy Act (AEA) requirements for management of DOE's radioactive waste are incorporated in DOE Order 5820.2A, developed under the DOE's AEA authority. The order is generally consistent with, and typically includes equivalent Nuclear Regulatory Commission (NRC) 10 CFR Parts 40 and 61 requirements. DOE Order 5820.2A requirements are included as TBC requirements because they are not promulgated.

DOE Orders 5400.5 and 5820.2A provide dose levels for the protection of the general public from releases of radioactivity. Per DOE Order 5400.5, the exposure of members of the public to radiation sources shall not cause, in a year, an effective dose equivalent greater than 100 mrem. DOE Order 5820.2A, Chapter III(3), states that the concentrations of radioactive material associated with DOE waste management activity which may be released to the general environment in groundwater, surface water, air, soil, plants or animals, must not result in an annual dose to any member of the public exceeding 25 mrem.

B.2.6 As Low As Reasonably Achievable Criteria

DOE Order 5400.5, Chapter II, Section 2, defines the ALARA process as it applies to radiation protection requirements for the public and the environment. The goal of the DOE's ALARA process is to reduce exposures and the risk associated with residual contamination to levels that are "as low as reasonable achievable," considering technical, economic, and social constraints as appropriate. In applying the ALARA process at the FEMP, the two factors used in developing preliminary remediation goals (PRGs), which are ARAR-based environmental standards for protectiveness of human health and the environment, are combined with technical and economic considerations to identify the levels of risk reduction that might reasonably be achieved.

B.3.0 LOCATION-SPECIFIC ARARs/TBCs

Location-specific ARARs/TBCs are restrictions placed on the concentration of hazardous substances or the conduct of activities because they occur in specific locations. Some sensitive locations for which there are ARARs/TBCs include floodplains, wetlands, sole-source aquifers, historic places, and sensitive ecosystems and habitats.

> "A site's location is a fundamental determinant of its impact on human health and the environment. Location-specific ARARs are restrictions placed on concentrations of hazardous substances or the conduct of activities solely because they are in specific locations." (CERCLA Compliance with Other Laws, EPA/540/G-89/006, 1988.)

The following are the statutory location-specific standards or references that will be used for Operable Unit 5 to establish location-specific ARARs/TBCs:

- National Environmental Policy Act
- National Historic Preservation Act
- Archaeological and Historic Preservation Act
- Historic Sites, Buildings and Antiquities Act
- Fish and Wildlife Coordination Act
- Endangered Species Act
- Wild and Scenic Rivers Act
- Clean Water Act
- Anti-degradation Policy
- Rivers and Harbors Act of 1899.

B.3.1 On-Property Disposal

The most significant issue influencing the location-specific ARARs is the determination by EPA Region V (53 Federal Register 25670) under the federal SDWA that the buried valley aquifer system of the Great Miami/Little Miami rivers of southwestern Ohio (Great Miami Aquifer) is a sole or principal source of drinking water and that contamination of this aquifer would create a significant hazard to public health. The determination was effective July 8, 1988. The federal SDWA requires all federally funded projects to undergo a review to ensure that the project will not adversely impact a sole-source of drinking water.

OEPA has established solid waste siting criteria that prohibit locating a solid waste landfill over a sole-source aquifer [OAC 3745-27-07(H)(2)(c)]. OEPA has also established that a solid waste disposal facility may not be located above an unconsolidated aquifer capable of sustaining a yield of 100 gallons per minute for a 24-hour period [OAC 3745-27-07(H)(2)(d)]. The Great Miami Aquifer qualifies as both a sole-source and a 100 gallon-per-minute-yield aquifer. These requirements are derived from Ohio Revised Code (ORC) 3734.02(G) which instructs the Ohio director of environmental protection to adopt rules "in order to ensure that the facilities [solid waste] will be

located, maintained, and operated, and will undergo closure and post-closure care, in a sanitary manner so as not to create a nuisance, cause or contribute to water pollution, create a health hazard or violate 40 CFR § 257.3-2 or 3-8."

Therefore, in the event an alternative which contemplates on-site disposal is chosen as the preferred remedial alternative, a waiver pursuant to CERCLA §121(d)(4)(D) from OAC (H)(2)(c) and (H)(2)(d) would be required from EPA. The waiver request would be based on the ability of the selected remedial action, through the use of another method or approach, to attain a standard of performance that is equivalent to that required by the ARARs. The pertinent standard of performance in this case is the protection of human health and the environment as established by ORC 3734.02(G). The protective standard would be attained through a combination of site geology and engineering controls.

Protection of human health and the environment is a requirement of the CERCLA process by which all remedial alternatives are evaluated. Protective levels to meet this standard after remediation are determined through the risk assessment process using contaminant transport modeling based on the NCP acceptable risk range of 10^{-4} to 10^{-6} and compliance with MCLs. Transport modeling was performed for Operable Unit 5 to derive concentration-based waste acceptance criteria (WAC) for the disposal cell. These waste acceptance criteria are being established to ensure the long term performance of the disposal system, including protection of the water quality in the portions of the Great Miami Aquifer underlying the disposal facility. Detailed discussions on the fate and transport modeling conducted to derive these WAC are provided in Appendix F. Additionally, risk assessment and transport modeling were conducted for the Operable Unit 5 Comprehensive Response Action Risk Evaluation (CRARE) to verify that a comprehensive site-wide remedial strategy, which incorporates the application of on-property disposal in one central cell would provide long-term protection of human health and the environment. The results of the CRARE support the position that on-property disposal in a central cell would provide long-term protectiveness, including the protection of the water quality in the Great Miami Aquifer. The CRARE is presented in Appendix H.

A feasible location for the on-site disposal facility and the necessary engineering controls to meet the equivalent standard of performance to protect human health and the high-yield sole-source aquifer are addressed in Section 5.0 and Appendix F. The specific design of the engineering controls and location of the disposal facility would be finalized during the remedial design process.

To carry out potential remedial activities at the site for alternatives that propose the use of an on-property disposal facility, a waiver from EPA would be required for siting the cell above the Great Miami Aquifer. Without the waiver compliance could not be met for an on-property disposal facility because of two location-specific State of Ohio ARARs which: (1) prohibit siting a solid waste landfill above a sole-source aquifer such as the Great Miami Aquifer (OAC 3745-27-07 (H)(2)(c)) and

(2) prohibit siting a sanitary landfill above an unconsolidated aquifer capable of sustaining a yield of 100 gpm for a 24-hour period to a water supply well located within 1000 feet of solid waste placement (OAC 3745-27-07 (H)(2)(d)). A detailed discussion of these waiver requirements for an on-property disposal facility is provided in Section 5.0 of the Operable Unit 5 FS Report.

B.3.2 Other Location-Specific ARARs/TBCs

Other significant location-specific ARARs are the requirements associated with the potential effects of actions in floodplains and wetlands, and the location of disposal units in these areas (Tables B.2 and B.5.B). An updated floodplain determination was performed for Paddys Run using the U.S. Army Corps of Engineers standard HEC2 water surface profile analysis program in October 1993. The 100-year flood elevations reach the western side of the FEMP property from Paddys Run. A site-wide delineation of wetlands, performed in accordance with the U.S. Army Corps of Engineers Wetland Delineation Manual was completed in March 1993. EPA and DOE regulations (40 CFR 6.302 and 10 CFR 1022, respectively) require that impacts to wetlands and floodplains be avoided when a practicable alternative to the impact exists. OEPA regulations prohibit the siting of a new solid waste disposal facility in a floodplain or within 200 feet of a wetland. If it is necessary to adversely impact wetlands during remediation, Operable Unit 5 will comply with the substantive permitting requirements for impacts to wetlands under the CWA (33 CFR 323-330), and mitigate those wetlands to another area (see the supplemental discussion on the delineation of floodplains and wetlands in Appendix J).

B.4.0 ACTION-SPECIFIC ARARS/TBCS

Action-specific ARARs are technology- or activity-based requirements for activities taken with respect to remedial actions. Action-specific ARARs do not determine the remedial alternative but indicate how a selected alternative must be achieved, while maintaining compliance with other ARARs. Action-specific ARARs may establish performance levels, actions, or technologies, as well as specific levels for discharged or residual contaminants. The Compliance with ARARs Manual (EPA 1988) states:

> "Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy."

The following are common action-specific standards or references that will be used to establish action-specific ARARs/TBCs:

- Solid Waste Disposal Act
- Resource Conservation and Recovery Act/Land Disposal Restrictions/ Minimum Technology Requirements/Corrective Action Management Rule
- Clean Air Act, National Emission Standards for Hazardous Air Pollutants
- Hazardous Waste Permit Program
- National Pollutant Discharge Elimination System Program.

Each requirement must be compared to the specific actions proposed for remediation of the site.

The principal action-specific requirements for Operable Unit 5 are based upon the regulatory definitions and classifications of the remediation wastes in various areas of the site. This section describes the classification of remediation waste, and indicates the action-specific requirements associated with each waste. One principal action-specific requirement, the CAMU Rule, is applicable to RCRA hazardous and mixed-type wastes, and relevant and appropriate to all other remediation wastes. In addition to the waste-specific requirements, this section also describes the uses of the CAMU and the associated temporary unit (TU) under the CAMU Rule.

B.4.1 Corrective Action Management Unit (CAMU) Rule

This rule (40 CFR 264.552) supports treatment and consolidation of remediation waste from a portion of the site or from the total site, without invoking land disposal restrictions (LDRs) under RCRA.

The decisions for designation of CAMUs are related to the function and purpose of managing remediation wastes on site during cleanup, rather than to the areal extent and the contiguousness of the contamination prior to cleanup. Provisions for the CAMU Rule are determined by the EPA Regional Administrator. Through the application of this rule making contaminated media and any hazardous or solid wastes generated during the remediation of Operable Unit 5 may be managed in the CAMU, or moved between CAMUs, without triggering the applicability of the LDRs. LDRs prohibit the placement of hazardous wastes in land disposal units unless the waste has been treated to certain concentration levels or by using specified technologies. The intended use of the CAMU Rule is described in 58 Federal Register 8658 (February 16, 1993).

As defined in the CAMU Rule, "remediation waste" means all solid and hazardous waste and all media (including groundwater, surface water, soil, sediment and debris) which contain listed hazardous wastes or which themselves exhibit a hazardous waste characteristic, and are managed for the purpose of implementing corrective action or remedial action requirements.

The CAMU Rule also created a temporary unit (TU) that can be used for treatment or storage of remediation wastes during remedial activities. TUs can be located inside or outside the physical boundaries of a CAMU; however, they must be located at the facility. The designated requirements for siting, operating, monitoring and closing a TU are decided by the EPA Regional Administrator. These TUs are also not subject to LDRs and minimum technology requirements (MTRs). There is a one-year time limit on the use of the TU which can only be extended an additional year if the wastes have to remain in the unit due to "unforeseen, temporary, and uncontrollable" circumstances. Operable Unit 5 may also use interim status HWMUs for storage and treatment with the CAMU Rule. However, if TUs are used for the FEMP site, initial analysis within this FS indicates they may be needed for up to 22 years.

The use of existing interim status HWMUs as TUs under the CAMU Rule during the Operable Unit 5 remediation timeframe is anticipated to expedite remediation efforts because the need for construction of new storage or treatment facilities will be eliminated. In addition, the use of these existing facilities will not cause any additional impact to the environment because soil and groundwater contamination already exists beneath the FEMP site. Therefore, the need for MTRs, which are designed to prevent contamination, will not be required for the existing facilities.

According to 40 CFR §264.522(c), seven criteria are considered by a Regional Administrator to determine the site-specific requirements for using a CAMU. The seven criteria for designating a

CAMU are summarized below in italics, followed by the Operable Unit 5 explanation to meet each criteria through the alternatives requiring on-site disposal.

- *Facilitate the implementation of reliable, effective, protective, and cost-effective remedies.*

  The proposed on-site disposal facility will provide a reliable method of containment, which will be designed to be effective for 200 to 1000 years. The use of waste acceptance criteria (WAC) will ensure protection to the underlying Great Miami Aquifer, should breakthrough of the landfill facility liner occur. By eliminating the need to comply with LDRs, this method of on-site disposal will also be more cost-effective than shipping this waste offsite or meeting LDRs for on-site disposal.

- *Waste management activities will not create unacceptable risks to humans or to the environment resulting from exposure to hazardous wastes or hazardous constituents.*

  All RCRA waste constituents must meet the WAC for on-site disposal to ensure protection to human health and the environment. Placement of these wastes into the on-site disposal facility will minimize exposure of the COCs to the environment.

- *Include uncontaminated areas of the facility only if including such areas for the purpose of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.*

  If remediation techniques require the use of uncontaminated areas (or contaminated areas not containing RCRA constituents) of the facility then protective measures will be provided. These measures will be used to exclude the ability of any waste material to be released into the environment. DOE proposes to incorporate the entire FEMP site as the boundaries of the CAMU.

- *Wastes that will remain in place after closure of the CAMU shall be managed and contained so as to minimize future releases, to the extent practicable.*

All wastes to remain on site will be contained by the proposed on-site disposal facility or minimized and managed according to the alternative selected in the Operable Unit 5 ROD.

- *Expedite the timing of remedial activity implementation when appropriate and practicable.*

  The CAMU Rule will allow for expedited remediation of the facility because treatment technologies will be used to meet the WAC for on-site disposal to be protective, but will not require the additional time to segregate hazardous soil from nonhazardous soil, or to meet the specific treatment requirements for individual hazardous constituents, as specified in the LDR requirements. If constituents do not meet the WAC for on-site disposal, then they will be shipped off-site for disposal.

- *Use treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of wastes that will remain in place after closure of the CAMU.*

  Treatment technologies to be applied will include low-temperature thermal desorption for RCRA organics and cement stabilization for RCRA inorganics.

- *To the extent practicable, minimize the land area of the facility upon which wastes will remain in place after closure of the CAMU.*

  The Operable Unit 5 FS presents alternatives that will minimize, to the maximum extent possible, the area of land that the proposed disposal facility will occupy after closure of the CAMU.

The CAMU Rule is applicable for Operable Unit 5 soil, which contains hazardous constituents from various locations on site. Therefore, the use of some RCRA requirements will be considered relevant and appropriate, such as, general facility standards and some monitoring requirements. Operable Unit 5 anticipates placing all wastes allocated for on-property disposal in one facility. This would require commingling of soil types and remediation waste from several areas across the site into one disposal facility, causing extension of the CAMU boundaries to encompass the entire FEMP site. A flow chart which provides an overview of the management of environmental media during remediation is contained in Figure B.4-1.

B.4.2 Regulatory Definitions of Wastes

Operable Unit 5 soil contains a variety of waste classifications that will direct pertinent action-specific ARARs/TBCs for in situ containment, on-site disposal, and/or off-site disposal. The different types of wastes are:

- Low-level radioactive waste/Residual radioactive material
- Solid waste
- Hazardous waste
- Mixed low-level waste
- Residual radioactive material and soil not considered waste
  - Soil below the preliminary remediation level (PRLs)
  - Residual radioactive material below PRLs
  - Treated soil below PRLs.

Remedial actions will be required to meet the most stringent requirements of rules that apply for each type of wastes being managed together. However, under the CAMU Rule all of these wastes will be managed as remediation wastes.

A specific discussion of each classification of Operable Unit 5 wastes is presented below. Detailed definitions and the technical requirements for in situ capping or disposal of each of these wastes are provided in Section 4 of this document.

Low-Level Radioactive Waste/Residual Radioactive Material

The term low-level radioactive wastes is defined broadly as a radioactive material that is not a high level waste, spent nuclear fuel, transuranic wastes, or byproduct material AEA, 42 U.S.C. 2014(e)(2)]. The DOE, under its AEA authority, has established a more specific definition for residual radioactive material. Residual radioactive material is defined as residual concentrations of radionuclides in soil, debris, surface contamination, air emissions and water discharges (DOE Order 5400.5). Residual radioactive material can be free released from federal control (not considered a waste) if concentrations are below the functional definition of a level that would adversely affect human health or the environment. Free release levels for nonvolumetrically contaminated building materials are defined in DOE Order 5400.5. These criteria have been adopted as a TBC to support the dismantlement of any remedial support facilities. Free release levels for soil or volumetrically contaminated material do not presently exist within promulgated federal, state, or local regulations.

Solid Waste

The federal definition of solid waste is any discarded material that is not specifically excluded by the regulations. Discarded material is any material which is abandoned, recycled, or "inherently waste-like." Source, special nuclear, or byproduct material, as defined by the AEA of 1954 as amended, is not solid waste under the federal definition (40 CFR 257).

The OEPA's definition of solid waste is "any unwanted residual solid or semisolid material resulting from industrial, commercial, agricultural, and community operations, excluding earth or material from construction, mining, or demolition operations, or other waste materials of the type that would normally be included in demolition debris, nontoxic fly ash, spent nontoxic foundry sand, and slag and other substances that are not harmful or inimical to public health, and includes, but is not limited to, garbage, tires, combustible and noncombustible material, street dirt, and debris. Solid waste does not include any material that is an infectious waste or a hazardous waste."

Hazardous Waste

Hazardous waste is any contaminant that is either listed by EPA in the regulations or is "characteristically hazardous." A waste is characteristically hazardous if it is ignitable, corrosive, reactive or exceeds a toxic characteristic level as defined by 40 CFR 261. To determine if a waste is "listed" under RCRA it is necessary to know the source of the waste.

The sources of hazardous constituents in soil and groundwater in Operable Unit 5 are varied and not generally traceable to specific locations. Several circumstances may have caused the presence of these constituents in environmental media, such as unrecorded spills, leaks, or deminimus losses from nonspecific sources, as well as losses from Hazardous Waste Management Units (HWMUs). Section 4.1.7 outlines the strategy for managing the RCRA constituents detected in the Operable Unit 5 environmental media. The RCRA Subtitle C CAMU Rule is proposed as an applicable requirement for on-site remedial alternatives and the RCRA Subtitle C LDRs are proposed as applicable requirements for all off-site alternatives. The strategy discussion in Section 4.1.7 discusses the manner in which listed and characteristic hazardous waste will be tracked during remediation for both the on-site and the off-site alternatives.

Mixed Low-Level Waste

A mixed low-level waste, also called mixed waste, is a waste that contains both low-level radioactive waste regulated by the AEA and hazardous waste subject to the RCRA. DOE Orders 5400.5 and 5820.2A also provide guidance for managing and disposing of mixed waste. LDR mixed wastes are also regulated by the Federal Facility Compliance Act. This act provides for the creation of treatment capacity to address the restricted components of DOE mixed waste to render the wastes viable for land disposal. Mixed wastes that remain on site for disposal must meet the site-specific WAC. Mixed waste that is shipped for off-site disposal must meet LDR standards and WAC for that off-site disposal facility.

Residual Radioactive Materials and Soil Below the PRLs

Soil and sediment containing residual radioactivity below PRLs determined through the CERCLA process are deemed protective of human health and are therefore not considered to be a waste. The

OEPA Closure Plan Review Guidance for RCRA Facilities, Interim Final (September 1, 1993) references the RCRA Subtitle C "contained in" policy for environmental media. The "contained in" policy does not consider environmental media to be a waste material. In summary, the policy states that if the waste constituents can be removed, the environmental media is no longer a hazardous waste. As a TBC, the OEPA policy, cited above, applied this concept to petroleum-contaminated soil by stating that soil containing a petroleum hydrocarbon would not need to be managed as a solid waste if the contaminants are removed. Soil or sediment attaining the risk-based or ARAR-based PRLs are not considered waste materials and can reliably be used as backfill on property. Treated soil or sediment attaining these same PRLs would similarly not be considered waste material and can be used for on-property backfill without invoking solid or hazardous waste disposal restrictions or requirements.

B.5.0 OTHER POTENTIAL REQUIREMENTS

Other potential requirements (Table B.4) include those that would be required regardless of CERCLA activities. Typically these are off-site activities, or are nonenvironmental in nature. The Superfund off-site rule and other requirements are significant potential requirements for Operable Unit 5. These are described below.

B.5.1 Superfund Off-Site Rule

The Federal Register dated September 22, 1993 (58 Federal Register 49200) mandates that selection of an appropriate facility for off-site management of hazardous substances from CERCLA response actions meet the following requirements:

- The hazardous waste management facility must have an applicable RCRA permit or interim status.
- A RCRA compliance inspection must be performed not more than six months before the hazardous waste management facility's initial receipt of hazardous substances.
- If land disposal of the hazardous substance occurs, the landfill or surface impoundment must meet the minimum technology requirements of a double liner and a leachate collection system. The receiving land disposal unit(s) must not have releases to the environment.
- If land disposal is proposed at a facility with interim status, adequate groundwater monitoring data is required to identify whether or not releases have occurred at the facility. The receiving land disposal units must not have releases to the environment.
- The hazardous waste management facility must be free of significant RCRA violations or adverse environmental impacts unless the owner/operator has committed to correcting the problems through an enforceable agreement that disposal will occur only within a new or existing unit that is in compliance with RCRA requirements and is not contributing to the adverse conditions at the facility.
- The receiving facility must be approved by EPA to receive CERCLA waste.

B.5.2 Non-ARAR Requirements

Non-ARAR requirements are federal and state requirements that are applicable to activities regardless of their status as a CERCLA site. Generally, these requirements are of a nonenvironmental nature, or they apply to off-site activities. Examples include worker safety regulations, civil rights statutes, tax laws, etc. Non-ARARs are of significance in this context only if the particular requirement is specifically applicable to the remedial activity being undertaken. If a non-ARAR requirement applies, it must be fully complied with; both substantive and administrative requirements must be met. Those non-ARAR requirements of particular interest to remedial action decision makers are those that affect

or are closely related to particular remedial alternatives. Worker protection requirements, waste acceptance criteria, and Department of Transportation (DOT) requirements are examples of regulations, criteria or standards that must be complied with, yet are not typically identified as ARARs for the CERCLA action.

TABLE B.1

OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
DRINKING WATER			
	MCLs for Radiologic Contaminants		
EPA National Primary Drinking Water Regulations 40 CFR §141.15 and §141.16 Ohio Drinking Water Regulations OAC 3745-81-15 OAC 3745-81-16	The following are maximum contaminant levels for radiological contaminants: Combined radium-226 and -228 ..... 5 pCi/L Gross alpha particle activity ..... 15 pCi/L (including radium-226 but excluding radon and uranium) Beta and photon radioactivity ..... 4 mrem/year from man-made radionuclides Strontium 90 ..... 8 pCi/L	Relevant and Appropriate	This requirement is not applicable to OU5 activities because there are no public drinking water systems involved with this remediation. The MCLs are considered relevant and appropriate to the GMA as it is a sole source aquifer currently used to supply drinking water to the regional area.
	Proposed MCLs for Radiologic Contaminants		
56 Federal Register 33050 (July 18, 1991)	The following are the proposed maximum contaminant levels for radiological contaminants: Radium-226 ..... 20 pCi/L Radium-228 ..... 20 pCi/L Radon-222 ..... 300 pCi/L Uranium ..... 20 μg/L Beta and photon emitters ..... 4 mrem cede/year (excluding radium-228) Adjusted gross alpha emitters ..... 15 pCi/L (excluding radium-226, uranium, and radon-222)	TBC	These proposed MCLs are not ARARs because they are not promulgated. The proposed MCLs have been adopted as TBCs because they represent health-based guidance for application to the GMA to ensure protectiveness of human health.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
Groundwater Standards (Uranium Mill Tailings Radiation Control Act)			
Groundwater Standards for Remedial Actions at inactive Uranium Processing Sites 40 CFR §192.02 (a)(3)	The following are drinking water standards for processed and unprocessed uranium mill tailings: Uranium (234+238) ..... 30 pCi/L Molybdenum ..... 0.1 mg/L	Relevant and Appropriate	These standards are relevant and appropriate because uranium mill tailings were processed at the Fernald Facility. Compliance with standards set for other constituents under this requirement will be met through the Safe Drinking Water Act as prescribed by the NCP.
MCLs and MCLGs for Volatile Organic Contaminants (Safe Drinking Water Act)			
EPA National Primary Drinking Water Standards for MCLGs 40 CFR §141.12 and §141.50 EPA National Primary Drinking Water Standards for MCLs 40 CFR §141.61 Ohio Drinking Water Regulations for MCLs OAC 3745-81-12	The following are the non-zero Federal maximum contaminant level goals (MCLG) and State of Ohio and Federal maximum contaminant levels (MCL) for volatile organic contaminants in mg/L: Benzene: Federal MCLG (mg/L) –; Federal or Ohio MCL (mg/L) 0.005 Carbon tetrachloride: - ; 0.005 Chloroform: - ; 0.1/0.08 Dibromochloropropane (DBCP): - ; 0.0002 Dichloroethane (1.2-): - ; 0.005 Dichloroethylene (1,1-): 0.007 ; 0.007 Dichloromethane: - ; 0.005 Dichloropropane (1,2-): - ; 0.005 Ethylbenzene: 0.7 ; 0.7 Monochlorobenzene: 0.1 ; 0.1 Styrene: 0.1 ; 0.1 Toluene: 1 ; 1 Trichloroethane (1,1,1-): 0.2 ; 0.2 Trichloroethane (1,1,2-): 0.003 ; 0.005 Trichloroethylene: - ; 0.005 Vinyl chloride: - ; 0.002 Xylenes: 10 ; 10	Relevant and Appropriate	This requirement is not applicable to OU5 activities because there are no public drinking water systems involved with this remediation. The MCLs and non-zero MCLGs are considered relevant and appropriate to the GMA as it is a sole source aquifer currently used to supply drinking water to the regional area. Where the State of Ohio standard is more stringent than the federal standard, the Ohio standard is presented. - = Represents a MCLG of zero. Only non-zero MCLGs are pertinent per CERCLA.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
MCLs and MCLGs for Semivolatile Organic Contaminants (Safe Drinking Water Act)			
EPA National Primary Drinking Water Regulations for MCLGs and MCLs 40 CFR 141.11 40 CFR 141.51 40 CFR 141.62 Ohio Drinking Water Regulations OAC 3745-81-11 OAC 3745-81-23	The following are the Federal maximum contaminant level goals (MCLG) and State of Ohio and Federal maximum contaminant levels (MCL) for semivolatile organic contaminants in mg/L. Benzo(a)pyrene (PAH) — Federal MCLG (mg/L): - — Federal or Ohio MCL (mg/L): 0.0002 Dichlorobenzene o- — 0.6 — 0.6 Dichlorobenzene m- — 0.6 — 0.6 Dichlorobenzene p- — 0.075 — 0.075 Hexachlorobenzene — - — 0.001 Hexachlorocyclopentadiene — 0.05 — 0.05 Pentachlorophenol — - — 0.001 2,3,7,8-TCDD (Dioxin) — - — 3E-08 Trichlorobenzene (1,2,4) — 0.07 — 0.07	Relevant and Appropriate	This requirement is not applicable to OU5 activities because there are no public drinking systems involved with this remediation. The MCLs and MCLGs are considered relevant and appropriate to the GMA as it is a sole source aquifer currently used to supply drinking water to the regional area. - = Represents a MCLG of zero. Only non-zero MCLGs are pertinent per CERCLA.
Proposed MCLs and MCLGs for Semivolatile Organic Contaminants (Safe Drinking Water Act)			
55 Federal Register 30370 (July 25, 1990)	The following are proposed non-zero Federal maximum contaminant level goals (MCLG) and maximum contaminant levels for semivolatile organic contaminants in mg/L: Benz(a)anthracene (PAH) — Federal MCLG (mg/L): - — Federal or Ohio MCL (mg/L): 0.0001 Benzo(b)fluoranthene (PAH) — - — 0.0002 Benzo(k)fluoranthene (PAH) — - — 0.0002 Bromodichloromethane — - — 0.1/0.08 Butyl benzyl phthalate (PAE) — - — 0.1 Chloroform — - — 0.1/0.08 Chrysene (PAH) — - — 0.0002 Dibenz(a,h)anthracene (PAH) — - — 0.0003 Hexachlorobutadiene — 0.001 — NA Indenol(1,2,3,-c,d)pyrene (PAH) — - — 0.0004	TBC	These proposed MCLs are not ARARs because they are not promulgated. The proposed MCLs have been adopted as TBCs because they represent health-based guidance for application to the GMA to ensure protectiveness of human health. - = Represents a MCLG of zero. Only non-zero MCLGs are pertinent per CERCLA. NA = Not Available

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
MCLs and MCLGs for Pesticides/PCB Contaminants (Safe Drinking Water Act, continued...)			
EPA National Primary Drinking Water Regulations for MCLGs and MCLs 40 CFR 141.11 40 CFR 141.51 40 CFR 141.62 Ohio Drinking Water Regulations OAC 3745-81-11 OAC 3745-81-23	The following are the non-zero Federal maximum contaminant level goals (MCLG) and State of Ohio and Federal maximum contaminant levels (MCL) for pesticides/PCB contaminants in mg/L. Adipate (diethylbexyl): Federal MCLG 0.4 (mg/L); Federal or Ohio MCL 0.4 (mg/L) Arochlor: - ; 0.002 Atrazine: 0.003 ; 0.003 Chlordane: - ; 0.002 Endrin: - ; 0.0002[a] Heptachlor: - ; 0.0004 Heptachlor epoxide: - ; 0.0002 Lindane: 0.0002 ; 0.0002 Methoxychlor: 0.04 ; 0.04 Polychlorinated biphenyls (PCBs): - ; 0.0005 Toxaphene: - ; 0.003	Relevant and Appropriate	This requirement is not applicable to OU5 activities because there are no public drinking systems involved with this remediation. The MCLs and MCLGs are considered relevant and appropriate to the GMA as it is a sole source aquifer currently used to supply drinking water to the regional area. [a] = Ohio Drinking Water MCL - = Represents a MCLG of zero. Only non-zero MCLGs are pertinent per CERCLA. NA = Not Available
MCLs and MCLGs for Herbicide Contaminants (Safe Drinking Water Act, continued...)			
EPA National Primary Drinking Water Regulations for MCLGs and MCLs 40 CFR 141.11 40 CFR 141.51 40 CFR 141.62 Ohio Drinking Water Regulations OAC 3745-81-11 OAC 3745-81-23	The following are the non-zero Federal maximum contaminant level goals (MCLG) and State of Ohio and Federal maximum contaminant levels (MCL) for herbicide contaminants in mg/L. 2,4-D: Federal MCLG 0.07 (mg/L); Federal or Ohio MCL 0.07 (mg/L) Dinoseb: 0.007 ; 0.007 2,4,5-TP: 0.05 ; 0.01[a]	Relevant and Appropriate	This requirement is not applicable to OU5 activities because there are no public drinking systems involved with this remediation. The MCLs and MCLGs are considered relevant and appropriate to the GMA as it is a sole source aquifer currently used to supply drinking water to the regional area. [a] = Ohio Drinking Water MCL

000254

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
MCLs and MCLGs for Inorganic Contaminants (Safe Drinking Water Act, continued...)			
EPA National Primary Drinking Water Regulations for MCLGs and MCLs 40 CFR 141.11 40 CFR 141.51 40 CFR 141.62 Ohio Drinking Water Regulations OAC 3745-81-11 OAC 3745-81-23	The following are the Federal non-zero maximum contaminant level goals (MCLG) and State of Ohio and Federal maximum contaminant levels (MCL) for inorganic contaminants in mg/L. Antimony: Federal MCLG 0.006; Federal or Ohio MCL 0.006 Barium: 2; 2 Beryllium: 0.004; 0.004 Cadmium: 0.005; 0.005 Chromium (total): 0.1; 0.05[a] Copper: 1.3; TT Lead: -; TT Mercury: 0.002; 0.002 Nickel: 0.1; 0.1 Selenium: 0.05; 0.01 Thallium: 0.0005; 0.002	Relevant and Appropriate	This requirement is not applicable to OU5 activities because there are no public drinking systems involved with this remediation. The MCLs and MCLGs are considered relevant and appropriate to the GMA as it is a sole source aquifer currently used to supply drinking water to the regional area. [a] = Ohio Drinking Water MCL TT = Copper - action level 1.3 mg/L; Lead - action level 0.015 mg/L. - = Represents a MCLG of zero. Only non-zero MCLGs are pertinent per CERCLA.
Proposed MCLs and MCLGs for Inorganic Contaminants (Safe Drinking Water Act, continued...)			
EPA National Primary Drinking Water Regulations for MCLGs and MCLs 40 CFR 141.11 40 CFR 141.51 40 CFR 141.62 Ohio Drinking Water Regulations OAC 3745-81-11 OAC 3745-81-23	The following are the proposed Federal non-zero maximum contaminant level goals (MCLG) and State of Ohio and Federal maximum contaminant levels (MCL) for inorganic contaminants in mg/L. Arsenic: Federal MCLG NA; Federal or Ohio MCL 0.05 Cyanide: 0.2; 0.2 Silver: 0.05; 0.05	TBC	This requirement is not an ARAR to OU5 activities because there are no public drinking systems involved with this remediation. The MCLs and MCLGs are considered relevant and appropriate to the GMA as it is a sole source aquifer currently used to supply drinking water to the regional area. NA = Not Available

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
MCLs for Resource Conservation and Recovery Act, Subtitle C and D			
Chemicals in Drinking Water (Solid Waste Disposal Facility) 40 CFR 257.4 Ohio Solid Waste Regulations OAC 3745-27-10(D) Chemicals in Drinking Water (Hazardous Waste Disposal Facility) 40 CFR 264.94 Ohio Hazardous Waste Regulations OAC 3745-54-94	A solid waste disposal facility shall not contaminate an underground drinking water source beyond the solid waste boundary (outermost perimeter of the waste). The concentration of chemicals shall not exceed background levels or listed MCLs, whichever is higher. A hazardous waste disposal facility must comply with the requirements specified in the facility permit for the uppermost aquifer underlying the waste management area beyond the point of compliance, which is a vertical surface located at the hydraulically downgradient limit of waste management that extends down into the uppermost aquifer underlying the regulated area. The concentration of chemicals in groundwater shall not exceed background levels or the listed maximum concentration level (MCL) of the constituent for groundwater protection, whichever is higher. **Inorganic Chemicals** — Solid Waste RCRA MCL (mg/L) / Hazardous Waste RCRA MCL (mg/L) Arsenic 0.05 / 0.05 Barium 1.00 / 1.00 Cadmium 0.01 / 0.01 Chromium 0.05 / 0.05 Lead 0.05 / 0.05 Mercury 0.002 / 0.002 Selenium 0.01 / 0.01 Silver 0.05 / 0.05 **Organic Chemicals** Benzene .005 / NA Carbon tetrachloride .005 / NA 1,2-Dichloroethane .005 / NA 1,1-Dichloroethene .007 / NA Trichloroethylene .005 / NA **Radionuclides** Combined Ra-226 & Ra-228 5 pCi/L Gross alpha particle activity (excluding radon & uranium) 15 pCi/L	Relevant and Appropriate	40 CFR 257.4 and 40 CFR 264.94 and their Ohio equivalents are relevant and appropriate because OU5 contains several of the chemicals listed in the regulation. Compliance with the MCLGs and MCLs under the Safe Drinking Water Act (SDWA) will assure compliance with these RCRA MCLs as discussed in the NCP. The RCRA MCLs reflect earlier versions of the SDWA but the intent is to follow the updated standards of the SDWA (Compliance With Other Laws Manual). These regulations are pertinent to remedial alternatives that involve the use of capping systems or engineered cells. On-property disposal of remediation waste might cause migration into the underlying aquifer and potentially contaminate drinking water systems as a consequence of remedial actions. NA = Not Available
Total trihalomethanes in community water systems OAC 3745-81-12(A) 40 CFR 141.12	The maximum contaminant level for total trihalomethanes is 0.10 mg/L and applies only to community water systems which serve a population of 10,000 or more individuals and which add a disinfectant (oxidant) to the water in any part of the drinking water process.	Relevant and appropriate	This requirement would be relevant and appropriate if DOE managed a community water system for a population of 10,000 or more individuals.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
SURFACE WATER			
	Discharges of Liquid Waste to Surface Waters		
Ohio Water Quality Standards OAC 3745-1-04	"Five Freedoms" for Surface Water are provided by the State of Ohio: All surface waters of the State shall be free from: • Objectionable suspended solids • Floating debris, oil and scum • Materials that create a nuisance • Toxic, harmful or lethal substances • Nutrients that create nuisance growth	Relevant and Appropriate	OAC 3745-1-04 pertains to both discharges to surface waters of the State as a result of remediation and any on-site surface waters affected by site conditions. All action alternatives involve effluent discharges to the Great Miami River. The no action alternative assumes surface water discharges to Paddys Run.
	Use Designation of Surface Water		
Ohio Water Quality Standards OAC 3745-1-21	Paddys Run and the Great Miami River are designated as: • Warmwater aquatic life habitat • Agricultural and industrial water supply • Primary contact recreation	Applicable	The Great Miami River between Ross Road (River Mile (RM)95.7) to Taylorsville Dam (RM 92.6) is a state resource water and RM 130 and 118 are public water supplies. Discharges to the Great Miami River and Paddys Run must not cause a violation of applicable numeric or narrative water quality standards for these designations.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
Warmwater Habitat Water Quality Criteria			
Ohio Water Quality Standards OAC 3745-1-07	Surface waters in the State of Ohio must comply with the maximum concentrations of each contaminant listed below for inside and outside the mixing zones of the receiving water to protect warm water aquatic habitats. "Outside Mixing Zone" shall be met after the effluent and the receiving water have been determined to be reasonably well mixed based upon information readily available to the Director. The criteria listed as "Inside Mixing Zone Maximum" shall be applicable as end-of-pipe maximum effluent limits or as criteria to be met within a short distance of the effluent pipe if it can be demonstrated that discharge-induced mixing occurs as per the definition of "area of initial mixing" in rule OAC 3745-1-02.	Applicable	OAC 3745-1-07 is applicable because the site is bordered by the Great Miami River and Paddys Run. All remedial alternatives involving remedial action involve discharges to the Great Miami River. The No Action alternative assumes surface water discharges to Paddys Run.

Parameter (μg/L or as marked)	Outside Mixing Zone Max.	Outside Mixing Zone 30-Day Avg.	Inside Mixing Zone Max.	Rationale
Antimony (total)	650	190	1,300	NA = Not Available
Arsenic	360	190	720	
Benzene	1,100	560	2,100	
Beryllium (total)	520	23	1,000	Beryllium is based on a presumed water hardness of 100 mg/L calcium carbonate $CaCO_3$.
Bis(2-ethylhexyl) phthalate	1,100	8.4	2,200	
Cadmium	5.6	1.4	11	
Carbon tetrachloride	1,800	280	3,500	
Chlordane	NA	0.01	NA	
Chlorobenzene	590	26	1,200	
Chromium	1,800	210	3,600	
Chloroform	1,800	79	3,600	
2-Chlorophenol	200	8.8	400	
Copper (total)	18	12	35	Copper is based on a presumed water hardness of 100 mg/L $CaCO_3$.
Cyanide (free)	46	12	92	
1,2 Dichloroethane	12,000	3,500	24,000	
Dieldrin	NA	0.005	NA	

000278

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement				ARAR/TBC	Rationale
	Parameter (μg/L or as marked)	Outside Mixing Zone Max.	30-Day Avg.	Inside Mixing Zone Max.		Lead is based on a presumed water hardness of 100 mg/L $CaCO_3$.
	Lead (total)	130	6.9	260		
	Mercury (total)	1.1	0.2	2.2		
	Methylene chloride	9,700	430	19,000		
	Nickel (total)	1,600	170	3,100		Nickel is based on a presumed water hardness of 100 mg/L $CaCO_3$.
	Pentachlorophenol	5.3	3.2	11		
	PCBs	NA	0.001	NA		
	Selenium (total)	20	5.0	40		
	Silver (total)	1.6	1.3	3.2		Silver is based on a presumed water hardness of 100 mg/L $CaCO_3$.
	Tetrachloroethylene	540	73	1,100		
	Trichloroethylene	1,700	75	3,400		
	Thallium (total)	71	16	140		
	Zinc (total)	120	110	230		Zinc is based on a presumed water hardness of 100 mg/L $CaCO_3$.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
Human Health and Agricultural Water Supply Criteria			
Ohio Water Quality Standards OAC 3745-1-07	See previous requirement for explanation of inside/outside mixing zones. The maximum (outside mixing zone) concentrations for contaminants listed below are based on the designated use of the surface water body as Human Health or Agricultural.	Applicable	OAC 3745-1-07 is applicable because the site is bordered by the Great Miami River and Paddys Run. All remedial alternatives involving remedial action involve discharges to the Great Miami River. The No Action alternative assumes surface water discharges to Paddys Run. NA = Not Available

Parameter (μg/L or as marked)	Outside Mixing Zone 30-Day Average: Human Health	Outside Mixing Zone 30-Day Average: Agricultural
Antimony (total)	4,300	NA
Arsenic	NA	100
Benzene	710	NA
Beryllium (total)	1.17	100
beta-BHC	0.55	NA
Bis(2-ethylhexyl) phthalate	59	NA
Cadmium	NA	50
Carbon tetrachloride	44	NA
Chromium (total)	3,433,000	100
Copper (total)	NA	500
1,2 Dichloroethane	990	NA
Dieldrin	0.00076	NA
Fluoride (mg/L)	NA	2.0
Lead (total)	NA	100
Mercury (total)	0.012	10
Nickel (total)	4,600	200
N-Nitrosodi-n-propylamine	12.4	NA
PCBs	0.00079	NA
PAHs	0.31	NA
Selenium (total)	NA	50
Thallium (total)	48	NA
Vinyl chloride	5,250	NA
Zinc Total	NA	25,000

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
Management and Control of Radioactive Materials in Liquid Discharges DOE Order 5400.5 Chapter II, (3) Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (3)(a) 10 CFR 834 (PROPOSED)	In addition to the requirements to limit dose to members of the public (onsite and offsite) in accordance with the standards established in paragraphs II (1)(a) and II (1)(d), further controls are imposed on liquid releases to protect resources such as surface water. Derived Concentration Guides (DCGs) are not release limits, but rather are screening values for considering Best Available Technology (BAT) for these discharges and for making dose estimates. These requirements apply at the point of discharge from the conduit to the environment (see DCGs in DOE Order 5400.5 Chapter III (3)). The BAT is the prescribed level of treatment for liquid radioactive discharges to surface waters that would otherwise contain radioactive concentrations greater than the DCG values. Implementation of the BAT process is not required for waste streams that contain radionuclide concentrations of not more than the DCG values at the point of discharge to a surface waterway. Residual concentrations of radionuclides in water that may be ingested are listed in tabular form in DOE Order 5400.5 Chapter III . The derived concentration guides (DCGs) for the COCs are based on a committed effective dose equivalent (CEDE) of 100 mrem/yr, assuming ingestion of 2 liters/day. Note that these DCGs apply only if ingestion is the single pathway of exposure.	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in the exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (3)(a)(4) 10 CFR 834 (PROPOSED)	Liquid process waste streams containing radioactive material in the solid present in the waste stream must not exceed 5 pCi/g above background level of settleable solids for alpha-emitting radionuclides or 50 pCi/g above background of settleable solids for beta-gamma-emitting radionuclides.	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.
DOE Order 5400.5 Chapter II (3)(a)(5) 10 CFR 834 (PROPOSED)	The absorbed dose to native aquatic animal organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
RADIATION LIMITS			
Dose Limits for Individual Members of the Public			
Ohio General Radiation Protection Standards OAC 3701-38-15 (A)(1),(B) DOE Order 5400.5 Chapter II (1)(a) 10 CFR 834 (PROPOSED)	Operations causing air emissions shall be conducted such that: • The total effective dose equivalent to individual members of the public from the operation does not exceed 0.1 rem (100 mrem) in a year • The dose in any unrestricted area from external sources does not exceed 0.002 rem (2mrem) in any one hour	Relevant and Appropriate	This OAC standard is not applicable because it applies to radiation sources which are not regulated by the United States Atomic Energy Act authority. However, this standard is relevant and appropriate because of the potential to result in the exposure to members of the public. NESHAP 40 CFR 61.91 will assure compliance with the first bullet. The second bullet is not found in NESHAP or in DOE Orders. 10 CFR 834 is included as a TBC because it is presently a proposed rule.
Radiation Dose Limit Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (1) DOE Order 5400.5, Chapter II (1)(a) DOE Order 5400.5, Chapter II (1)(a)(3) 10 CFR 834 (PROPOSED)	The public dose limits include consideration of all exposure modes from all DOE activities (including remedial activities). Effective dose equivalent is the sum of the effective dose equivalent (weighted summation of doses to various organs of the body) from exposures to radiation sources external to the body during the year plus the committed effective dose equivalent from radionuclides taken into the body during the year. Medical sources, consumer products, residual fallout from past nuclear accidents and weapons tests and naturally occurring radiation sources are not included in this summation. The exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent of more than 100 mrem for all exposure pathways. If unusual circumstances affect a DOE activity in such a manner that the potential public dose could exceed an effective dose equivalent of 0.1 rem (100 mrem) in a year, DOE may authorize a temporary increase of the dose limit up to 0.5 rem (500 mrem).	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.

000762

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
As Low As Reasonably Achievable (ALARA) DOE Order 5400.5 Chapter II, 2. 10 CFR 834 (PROPOSED)	Field Elements shall develop a program and shall require contractors to implement an ALARA Process for DOE activities and facilities that have the potential to cause radiation exposure to the public.	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.
STORAGE OF RADIOACTIVE MATERIAL			
Control of Residual Radioactive Material DOE Order 5400.5 Chapter IV (6)(b) 10 CFR 834 (PROPOSED)	Interim storage must provide: 1) Control and stabilization features shall be designed to provide, to the extent reasonably achievable, an effective life of 50 years with a minimum life of at least 25 years. 2) Controls to be designed such that Radon-222 concentrations in the atmosphere above facility surfaces or openings in addition to background levels, will not exceed: (a) 100 pCi/L at any given point; (b) An annual average concentration of 30 pCi/L over the facility site; and (c) An annual average concentration of 3 pCi/L at or above any location outside the facility site. (d) Flux rates from the storage of radon producing wastes shall not exceed 20 pCi/sq.m-sec, as required by 40 CFR Part 61. 3) Controls to be designed such that concentrations of radionuclides in the groundwater and quantities of residual radioactive material will not exceed applicable Federal or State standards. 4) Access to a property and use of onsite material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR Part 192. These control features should be designed to provide, to the extent reasonable, an effective life of at least 25 years.	TBC	All OU5 alternatives except the no action alternative will provide for the interim storage of contaminated materials. 10 CFR 834 is included as a TBC because it is presently a proposed rule.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
Control of Residual Radioactive Material DOE Order 5400.5 Chapter IV (6)(d) 10 CFR 834 (PROPOSED)	1) Long-term management of uranium, thorium, and their decay products must provide: (a) Control and stabilization features designed to provide, to the extent reasonably achievable, an effective life of 1,000 years with a minimum life of at least 200 years. (b) Control and stabilization features designed to limit Radon-222 emanation to the atmosphere from the wastes to less than an annual average release rate of 20 pCi/m^2/s and prevent increases in the annual average Radon-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates shall be in accordance with the requirements of 40 CFR Part 61. (c) A long-term management facility for any potentially biodegradable contaminated wastes properly conditioned so that the generation and escape of biogenic gases will not cause the requirement in paragraph IV.6d(1)(b) to be exceeded and that biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph IV.6d(a). (d) Ground water protected in accordance with legally applicable Federal and State standards. (e) Access to a property and use of onsite material contaminated by residual radioactive material controlled through appropriate administrative and physical controls such as those described in 40 CFR Part 192 for Uranium Mill Tailings designed to be effective to the extent reasonable for at least 200 years. 2) In addition, long-term management of other radionuclides shall be in accordance with Chapters II, III, and IV of DOE 5820.2A, as applicable.	TBC	All remedial actions will provide for the long term storage of contaminated materials. Remedial alternatives under land use 2, 3, and 4 involve the long term management of radioactive materials. DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.

000764

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
AIR			
National Emissions Standards for Emissions of Radionuclides Other than Radon From DOE Facilities			
National Emission Standards for Hazardous Air Pollutants 40 CFR §61.190, 61.192 Subpart Q	No source at a DOE facility shall emit more than 20 pCi/m²s of radon-222 as an average for the entire source, into the air.	Applicable	This requirement is applicable because the FEMP presently and/or will continue to be a storage and disposal facility for radium-bearing material. This requirement explicitly includes the FEMP in its designation of facilities.
National Emission Standards for Hazardous Air Pollutants 40 CFR §61.90, 61.91 and 61.92 - .97 Subpart H	These requirements are applicable to DOE owned and operated facilities that emit any radionuclides other than radon-222 and radon-220 into the air. Emissions of radionuclides (except radon-220 and radon-222) to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. To determine compliance with the standard, radionuclide emissions shall be determined and effective dose equivalent values to members of the public calculated using EPA approved sampling procedures, computer models CAP-88 or AIRDOS-PC, or other procedures for which EPA has granted prior approval.	Applicable	All remedial alternatives have the potential to release radionuclides to the atmosphere through fugitive dust and/or point source emissions.
Control of Radon Emissions			
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.06 (b) Subpart A 40 CFR §192.32 (b)(1)(ii) Subpart D National Emission Standards for Hazardous Air Pollutants, Radon-222 Emissions 40 CFR 61, Subpart Q	The following standards apply to the: • Control of residual radioactive materials from inactive uranium processing sites. • Management of uranium byproduct materials after closure of a disposal area. • Long-term management of uranium, thorium, and their decay products. Controls shall be designed to provide reasonable assurance that releases of radon-222 from the above materials to the atmosphere will not: • Exceed an average release rate of 20 pCi/m²/s (averaged over the entire surface of the disposal site and over at least a one year period). • Increase the annual average concentration of radon-222 in air or above any location outside the disposal site by more than 0.5 pCi/L.	Relevant and Appropriate	Radioactive materials in this operable unit are as a result of releases from uranium processing. Contaminated soil and sediment are similar in characteristic to materials addressed by these regulations. Requirements for design of controls for on-property disposal should be consistent with design for control of other residual radioactive materials such as mill tailings.

000295

7069

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
AIR EMISSION STANDARDS			
Lead in Air EPA Regulations on National Primary and Secondary Ambient Air Quality Standards 40 CFR 50.12 Ohio Ambient Air Quality OAC 3745-17-08	Lead and its compounds measured as elemental lead should not exceed 1.5 micrograms per cubic meter, maximum arithmetic mean averaged over a calendar quarter.	Relevant and Appropriate	The Federal regulation at 40 CFR 50.12 is relevant and appropriate because it sets a standard for lead in air and lead has been identified as a contaminant of concern at OU5. All alternatives contemplating action have a potential to release quantities of lead bearing soil as fugitives during excavation and disposal operations. Additionally, lead could be a contaminant in particulate emissions from point source discharges from sludge dewatering and soil treatment/stabilization.
Definition of Derived Concentration Guides for Radionuclides DOE Order 5400.5 Chapter III 10 CFR 834 (PROPOSED)	The derived concentration guides (DCGs) are provided as reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. • Ingestion of water • Inhalation of air • immersion in a gaseous cloud The DCG values for internal exposure are based on a committed effective dose equivalent of 100 mrem for the radionuclide taken into the body by ingestion or inhalation during one year. The DCG values account for only three exposure pathways (ingested water <u>or</u> inhaled air <u>or</u> air immersion) and do not include other potentially significant pathways. When more complex environmental pathways are involved, a more complete pathway analysis is required for calculating public radiation doses resulting from the operation of DOE facilities.	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter III 10 CFR 834 (PROPOSED)	Residual concentrations of radionuclides in air in an uncontrolled area are limited to the following (for known mixtures of radionuclides, the sum of the ratios of the observed concentration of each radionuclide to its corresponding limit must not exceed 1.0). Derived Concentration Guide[a] (μCi/mL) ISOTOPE / D / W / Y Actinium-227: 2×10^{15} / 7×10^{15} / 1×10^{14} Lead: 9×10^{13} / --- / --- Polonium-210: 1×10^{12} / 1×10^{12} / --- Protactinium-231: --- / 9×10^{15} / 1×10^{14} Radium-224: --- / 4×10^{12} / --- Radium-226: --- / 1×10^{12} / --- Radium-228: --- / 3×10^{12} / --- Technetium-99: 1×10^{8} / 2×10^{9} / --- Strontium-90[c]: 5×10^{11} / --- Thorium-228: --- / 5×10^{14} / 4×10^{14} Thorium-230: --- / 4×10^{14} / 5×10^{14} Thorium-232: --- / 7×10^{15} / 1×10^{14} Uranium-234: 4×10^{12} / 2×10^{12}	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.
Derived Concentration Guides for Radionuclides DOE Order 5400.5 Chapter III,3. 10 CFR 834 (PROPOSED)	The DCGs are given for different lung retention classes (noted as D,W, or Y, where D equals a removal half-time of 0.5 days, W equals a removal half-time of 50 days, and Y equals a removal half-time of 500 days). Derived Concentration Guide[a] ISOTOPE / D / W / Y Uranium-235: 5×10^{12} / 2×10^{12} / 1×10^{13} Uranium-236: 5×10^{12} / 2×10^{12} / 1×10^{13} Uranium-238: 5×10^{12} / 2×10^{12} / 1×10^{13} Exposure conditions assume an inhalation rate of 8,400 m^3 of air per year (based on an exposure over 24 hours per day, 365 days per year).	TBC	DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in exposure to members of the public. 10 CFR 834 is included as a TBC because it is presently a proposed rule.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
SOIL AND CONTAMINATED MATERIALS			
Cleanup of Soil Contaminated with Residual Radioactive Materials			
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR 192.02 Subpart A 40 CFR 192.12(a) Subpart B 40 CFR 192.20 Subpart C	Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials, the concentration of radium-226 in land averaged over any area of 100 m^2 shall not exceed the background level by more than: • 5 pCi/g averaged over the first 15 cm of soil below the surface, and • 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface. Compliance with this requirement should be shown through measurements performed within the accuracy of currently available types of field and laboratory instruments in conjunction with reasonable survey and sampling procedures.	Relevant and Appropriate	The contaminated materials associated with OU5 are similar in characteristics to uranium mill tailings (UMT). This regulation is not applicable as the FEMP is not a designated UMT facility. This standard is relevant and appropriate to all remedial alternatives.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR 192.21 (f) and 192.22 (b) Subpart C	Where radionuclides other than radium-226 and its decay product are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials, remedial actions shall, in addition to satisfying the standards of 40 CFR 192.02, Subpart A and 192.12, Subpart B (both listed above), reduce other residual radioactivity to levels that are as low as is reasonably achievable.	Relevant and Appropriate	Contaminated material associated with OU5 are similar in characteristics to uranium mill tailings. This standard is relevant and appropriate to all remedial alternatives.
Post Closure Standards for Uranium and Thorium Mill Tailings 40 CFR 192.32 (b)(2) Subpart D	The requirements for the management of uranium byproduct materials after closure of a disposal area (40 CFR 192.32 (b)(1)) shall not apply to any portion of a disposal site which contains a concentration of radium-226 in land, averaged over areas of 100m^2, which, as a result of uranium byproduct material, does not exceed the background level by more than: • 5 pCi/g averaged over the first 15 cm of soil below the surface, and • 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.	Relevant and Appropriate	Contaminated materials associated with OU5 are similar in characteristics to uranium mill tailings. This standard is relevant and appropriate to all remedial alternatives.
Management of Thorium Mill Tailings 40 CFR 192.40-192.42 Subpart E	The following are requirements for the management of thorium byproduct materials: • The provisions for the management of uranium byproduct material (40 CFR §192.32) shall apply to thorium byproduct material and: - Provisions applicable to the element uranium shall also apply to the element thorium - Provisions applicable to radon-222 shall also apply to radon-220 - Provisions applicable to radium-226 shall also apply to radium-228 With the concurrence of EPA, alternative provisions may be substituted for any of the above requirements provided the alternative provisions will provide at least an equivalent level of protection for human health and environment.	Relevant and Appropriate	Contaminated material associated with OU5 are similar in characteristics to uranium mill tailings. This standard is relevant and appropriate to all remedial alternatives.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
	Hot Spots		
Radiation Protection of the Public and the Environment in soil DOE Order 5400.5 Chapter IV (4)(a)(1) 10 CFR 834 (PROPOSED)	If the average residual concentration of radionuclides in any surface soil or below surface area less than or equal to 25 m^2, exceeds the limit or guideline by a factor of$(100/A)^{0.5}$ [where A is the area (in square meters) of the region in which the concentrations are elevated], limits for "hot spots" shall also be developed and applied. Procedures for calculating these hot spots limits, which depend on the extent of the elevated local concentrations, are given in DOE/CH-8901. In addition, reasonable efforts shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit in the soil, irrespective of the average concentration in the soil.	TBC	All OU5 alternatives involve the excavation of contaminated soil and sediment. DOE Orders provide guidance on addressing contaminated soil and sediment at DOE facilities. DOE orders are TBC rather than ARARs because they are not promulgated. 10 CFR 834 is included as a TBC because it is presently a proposed rule.
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (4)(a)(2)(3) 10 CFR 834 (PROPOSED)	The generic guidelines for residual concentrations of radium-226, radium-228, thorium-230, and thorium-232 are: • 5 pCi/g, averaged over the first 15 cm of soil below the surface; and • 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface. These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If both thorium-230 and radium-226, or both thorium-232 and radium-228, are present and not in secular equilibrium, the appropriate guideline is applied as a limit for the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that either the dose for the mixture will not exceed the basic dose limit or the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1. Explicit formulas for calculating residual concentrations guidelines for mixtures are given in DOE/CH-8901.	TBC	Radionuclides are Constituents of Concern for soil within the scope of OU5. All OU5 actions except the no action alternative involve excavation of soil contaminated with these Constituents of Concern. DOE orders are TBC rather than ARARs because they are not promulgated. This citation is included as a TBC as it is more restrictive than the federal standard in 40 § CFR 192, .02, .12(a), .20, .21(f), .22(b), .32(b)(2), .40-.42. 10 CFR 834 is included as a TBC because it is presently a proposed rule.
Guidelines for Residual Radioactive Material--Surface contamination DOE Order 5400.5, Chapter IV (4)(d) 10 CFR 834 (PROPOSED)	These generic surface contamination guidelines are applicable to existing structures and equipment. These guidelines are generally consistent with standards of the NRC (1982) and functionally equivalent to Section 4, "Decontamination for Release for Unrestricted Use," of Regulatory Guide 1.86, but apply to nonreactor facilities. These limits apply to both interior equipment and building components that are potentially salvageable or recoverable scrap. If a building is demolished, the guidelines in paragraph IV (6)(a) are applicable to the resulting contamination in the ground.	TBC	These criteria will be used for any process facility building built and/or used for the remedial action, including the AWWT, soil washing, soil staging, etc., structures and buildings. DOE orders are not ARARs because they are not promulgated. This DOE order is a TBC because all alternatives have the potential to result in structures and equipment containing residual radioactivity. 10 CFR 834 is included as a TBC because it is presently a proposed rule.

TABLE B.1 (Continued)
OPERABLE UNIT 5 POTENTIAL CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
Lead Soil Cleanup Standards			
Resource Conservation and Recovery Act 40 CFR 268.41	The maximum concentration of lead (5.0 mg/L) may not be exceeded whether it is the extract of a waste or waste treatment residual.	Applicable	Lead is a Constituent of Concern in soil and sediment in OU5. This requirement is applicable to all remedial alternatives.
Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities OSWER Directive # 9355.4-12	• Screening levels of lead in soil for residential land use is proposed for 400 ppm; • Site-specific preliminary remediation goals (PRGs) at CERCLA sites and media cleanup standards (MCLs) at RCRA Corrective Action facilities for residential land use are described and, • A plan for soil lead cleanup at CERCLA sites and RCRA Corrective Action facilities that have multiple sources of lead are described.	TBC	This policy is not ARAR because it is not a promulgated regulation. This interim directive is a TBC because it establishes an approach for determining protective levels for lead in soil at CERCLA sites and RCRA facilities that are subject to corrective action under RCRA Section 3004(v) or 3008(h).
PCB Soil Cleanup Standards			
PCB Spill Cleanup Policy 40 CFR 761.125 40 CFR 761.125 (c)	PCBs at concentration of greater than 50 ppm are subject to TSCA decontamination requirements in 40 CFR 761.120 (b). Soil in non-restricted access areas contaminated by a PCB spill will be decontaminated to 10 ppm PCBs by weight, provided that the soil is excavated to a minimum depth of 10 inches. The excavated soil will be replaced with clean soil, i.e., containing less than 1 ppm PCBs, and the spill site will be restored (e.g., replacement of turf) [761.125 (c)(4)(v)]. For soils in restricted access areas, decontaminate to 25 ppm PCBs by weight [761.125(c)(3)(v)].	TBC	PCBs are a Constituent of Concern in soil for OU5. Concentrations of PCBs at OU5 are expected to be less than 50 ppm. Although published in the Code of Federal Regulations, this is a policy, not a promulgated rule, and hence a TBC. This TBC is pertinent to all remedial alternatives and will be considered relative to Operable Unit 5 PRLs for soil containing PCBs as CERCLA wastes, per the NCP.

000820

TABLE ARAR B.2

OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
THREATENED & ENDANGERED SPECIES			
HABITAT PROTECTION			
Procedures for Implementing the National Environmental Policy Act 40 CFR §6.302(h) 10 CFR 1021 Endangered Species Act 16 U.S.C. §1531, et. seq. Endangered and Threatened Wildlife and Plants 50 CFR §17.21, §17.31, §17.61, §17.71, and §17.94 Interagency Cooperation-Endangered Species Act 50 CFR §402.01	All Federal agencies must ensure that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of the constituent elements essential to the conservation of a listed species within a defined critical habitat. Additional requirements apply if it is determined that a proposed activity could adversely affect these species or their habitat.	Applicable	In 1993 and 1994 updated surveys at the FEMP determined the presence of the state-listed Sloan's Crayfish (Orconectes sloanii) in Paddys Run. Additionally, it was determined that good habitat exists for the federally-listed endangered Indiana bat (Myotis sodalis) along Paddys Run and the storm sewer outfall ditch. Moderate and marginal habitat exist in a very limited area for the state-listed endangered cave salamander (Eurycea lucifuga). Surveys did not locate habitat or populations for the federally-listed endangered running buffalo clover (Trifolium stoloniferum) or the state-listed endangered mountain bindweed (Polygonum cilinode) and slender fingergrass (Digitaria filiformis). In addition, neither habitat or populations of the state-listed threatened spring coralroot (Corallorhiza wisteriana) were found on FEMP property.
Interagency Cooperation-Endangered Species Act 50 CFR §402.12 (a),(b)	A biological assessment shall evaluate the potential effects of the action on listed and proposed critical habitat and determine whether any such species or habitat are likely to be adversely affected by the action and is used in determining whether formal consultation or a conference is necessary.	Applicable	These procedures are required for Federal actions that are "major construction activities".

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
SPECIES PROTECTION			
Ohio Endangered Species Regulations ORC 1531.25	No person shall take or possess any native species of wild animal, or any eggs, or offspring thereof, that is endangered with state-wide extinction.	Applicable	Updated surveys in 1993-94 found state-listed threatened Sloan's crayfish (Orconects sloanii) populations in sections of Paddys Run. Moderate habitat for the state-listed endangered cave salamander (Eurycea lucifuga) was also determined during a 1993 survey of the FEMP.
Ohio Endangered Species Regulations ORC 1518.02 OAC 1501:18-1	No person shall root-up, injure, destroy, remove, or carry away on or from public highways, public property, or waters of the state, or on or from the property of another, without the written permission of the owner, lessee, or other person entitled to possession, any endangered plant listed in OAC 1501:18-1.	Applicable	Surveys in 1994 did not locate the federally-listed endangered running buffalo clover (Trifolium stoloniferum), the state-listed endangered mountain bindweed (Polygonum cilinode) or slender finger grass (Digitaria filiformis), or state-listed threatened spring coralroot (Corallorhiza wisteriana).
Classification of Solid Waste Disposal Facilities and Practices 40 CFR §257.3-2	Solid waste disposal facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. Solid waste disposal facilities or practices shall not result in the destruction or adverse modification of the critical habitat of endangered or threatened species as identified in 50 CFR Part 17.	Applicable	This regulation is applicable to alternatives involving the use of capping systems or engineered cells.
HISTORIC AND CULTURAL RESOURCE PROTECTION			
ANTIQUITY AND HISTORIC SITE PRESERVATION			
Antiquities Act of 1906 16 U.S.C. §431-433 and Historic Sites Preservation Act 16 U.S.C. §461-467	No person may appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity situated or controlled by the Government of the United States without an applicable permit. Identification and preservation of cultural resources on federal lands is required, including natural land marks.	Applicable	Proposed areas of disturbance associated with Operable Unit 5 remedial actions will be surveyed and the Advisory Council on Historic Preservation and the State Historic Preservation Office (SHPO) will be consulted as agreed upon in a programmatic agreement with DOE, SHPO, and the Advisory Council. This regulation is applicable to all alternatives contemplating soil excavation, which include all except No Action.

000772

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
ARCHAEOLOGICAL RESOURCE RECOVERY AND PRESERVATION			
Procedures for Implementing the National Environmental Policy Act 40 CFR §6.301 (c) Archaeological Resources Protection Act (16 USC § 47099-47011) Protection of Archaeological Resources 43 CFR §7.4(a)	No person may excavate, remove, damage, or otherwise alter or deface or attempt to excavate, remove, damage, or otherwise alter or deface any archaeological resource located on public lands unless such activity is pursuant to a permit.	Applicable	Compliance will be coordinated through Section 106 of the National Historic Preservation Act.
HISTORIC PRESERVATION			
National Historic Preservation Act 16 USC § 470C Consideration of Historic Properties 36 CFR Part 800	DOE must take into account the effect of an undertaking on Historic Properties and accord the Advisory Council on Historic Preservation a reasonable opportunity to comment. Historic properties are defined as any prehistoric or historic district, building, site, structure, or object included in or eligible for inclusion in, the National Register of Historic Places. This term includes artifacts, records, and persons released to and located within such properties. Historic properties that are to be substantially altered or demolished must be recorded for future use and reference.	Applicable	Proposed areas of disturbance associated with Operable Unit 5 remedial activities will be surveyed to determine applicable requirements and the Advisory Council will be consulted as agreed upon in a programmatic agreement with DOE, SHPO, and the Advisory Council. This requirement is applicable to all remedial alternatives except the no action alternative.
Archaeological and Historic Preservation Act 16 U.S.C. §469, §470	Upon discovery that a project may cause the irreparable loss, destruction, significant scientific finding, prehistorical finding, or loss of historical or archeological data, DOE must notify DOI in writing and provide appropriate information concerning the project. DOE must, with possible assistance from SHPO, undertake recovery, protection, and preservation of the data.	Applicable	See previous comment.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
HISTORIC PRESERVATION (Continued)			
American Indian Religious Freedom Act, 42 U.S.C. §1996	Provides for tribal access by native peoples to grave sites and sites of cultural, symbolic, or religious significance.	Applicable	See previous comment.
Executive Order 11593, Protection and Enhancement of Cultural Environment 3 CFR 54	An inventory of a site with potential historic places is required for eligibility in the National Register of Historic Places.	Applicable	See previous comment.
Native American Graves Protection and Repatriation Act 25 U.S.C. §3001	Identification and preservation of cultural resources on federal lands is required, including natural landmarks. DOE must consult with appropriate Indian tribes prior to the intentional excavation or removal after an inadvertent discovery of Native American cultural items including human remains and objects of cultural significance.	Applicable	See previous comment.
SENSITIVE ENVIRONMENTAL LOCATIONS			
FLOODPLAIN/WETLANDS			
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.11 (a), (b), (c)	Concurrent with its review of a proposed action to determine appropriate NEPA requirements, DOE shall determine applicability of the floodplain management and wetlands protection requirements of this part. In making a floodplain determination, DOE shall utilize the Flood Insurance Rate Maps (FIRMs) or the Flood Hazard Boundary Maps (FHBMs) prepared by the Federal Insurance Administration of the Department of Housing and Urban Development to determine if a proposed action is located in the base or critical action floodplain, as appropriate. For a proposed action in an area of predominately Federal or State land holdings where FIRM or FHBM maps are not available, information shall be sought from the land administering agency (e.g., Bureau of Land Management, Soil Conservation Service, etc.) or from agencies with floodplain analysis expertise.	Applicable	Review will be conducted concurrently with NEPA determinations for proposed actions. This requirement is applicable to all remedial alternatives except the no action alternative.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
FLOODPLAIN/WETLANDS (Continued)			
DOE Compliance with Floodplain/Wetlands Assessments 10 CFR §1022.12(a)	Prior to any proposed remedial action, DOE shall prepare a floodplain/wetlands assessment.	Applicable	Floodplain/wetland assessments will be prepared as required. This requirement is applicable to all remedial alternatives except the no action alternative.
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.15(a)	If DOE finds that no practicable alternative to locating in the floodplain/wetland is available, consistent with the policy set forth in Executive Order 11988, DOE shall, prior to taking action, design, or modify its action in order to minimize potential harm to or within the floodplain or wetland.	Applicable	Floodplain/wetland impacts will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
FLOODPLAIN/WETLANDS (Continued)			
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.3(a), (b)(1),(2),(3),(5),(6),(c), (d),(e)	DOE shall exercise leadership and take action to: • Avoid to the extent possible the long- and short-term adverse impacts associated with the destruction of wetlands and the occupancy and modification of floodplain and wetlands, and avoid direct and indirect support of floodplain and wetlands development wherever there is a practicable alternative. • Incorporate floodplain management goals and wetlands protection considerations into its planning, regulatory, and decision making processes and shall to the extent practicable: - Reduce the hazard and risk of flood loss. - Minimize the impact of floods on human safety, health, and welfare. - Restore and preserve natural and beneficial values served by the floodplain. - Minimize the destruction, loss, or degradation of wetlands. - Preserve and enhance the natural and beneficial values of wetlands. • Undertake a careful evaluation of the potential effects of any DOE action taken in a floodplain and any new construction undertaken by DOE in wetlands not located in a floodplain. • Identify, evaluate, and as appropriate, implement alternative actions which may avoid or mitigate adverse floodplain/wetlands impacts. • Provide opportunity for early public review of any plans or proposals for actions in floodplain and new construction in wetlands.	Applicable	Short and long term impacts associated with Operable Unit 5 remedial activities will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.5(b),(h)	This part shall apply to all proposed floodplain/wetlands actions, including those sponsored jointly with other agencies, where practicable alternatives to the proposed actions are still available. The policies and procedures of this part which are applicable to floodplain actions shall apply to all proposed actions which occur in a wetlands located in a floodplain.	Applicable	Short and long term impacts associated with Operable Unit 5 remedial activities will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
WETLANDS			
Procedure for Implementing the National Environmental Policy Act 40 CFR §6.302(a) [Executive Order 11990]	Federal agencies conducting certain activities must avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands when a practicable alternative exists.	Applicable	Approximately 35.9 acres of jurisdictional wetlands and 8.9 acres of waters of the United States were identified on-site as a result of the 1993 FEMP Wetland Delineation. The U.S. Army Corps of Engineers officially approved the delineation on August 19, 1993. Wetland impacts associated with Operable Unit 5 remedial activities will be minimized and avoided to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.
Executive Order 11990, Protection of Wetlands	This order requires that Federal agencies take action to avoid adversely impacting wetlands wherever possible, to minimize wetland destruction and to preserve the values of wetlands.	Applicable	Wetland impacts associated with Operable Unit 5 remedial activities will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.
Nationwide Permit Program, 33 CFR §330	The U.S. Army Corps of Engineers has authorized certain categories of activities involving the discharge of dredged and fill material into wetlands and waters of the U.S. under the Nationwide Permit (NWP) Program. Impacts involving the discharge of dredged and fill material will be conducted in accordance with the substantive requirements of applicable NWPs as required. Discharges not authorized by NWP will be conducted in accordance with the substantive requirements of 33 CFR 323 and 40 CFR 230.	Applicable	Approximately 35.9 acres of jurisdictional wetlands and 8.9 acres of waters of the United States have been identified on-site. Impacts to these areas will be avoided and minimized to the maximum extent practicable. Discharges of dredged and fill material authorized by NWPs will be conducted in accordance with the substantive requirements of the respective permits. This requirement is applicable to all remedial alternatives except the no action alternative.
Permits for the Discharge of Dredged and Fill Material into waters of the United States 33 CFR §323	Remedial actions involving the discharge of dredge and fill material into these areas shall meet the substantive requirements of this section and 40 CFR §230.	Applicable	Discharges of dredged and fill material not authorized by NWP will be conducted in accordance with the substantive requirements of these regulations. This requirement is applicable to all remedial alternatives except the no action alternative.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
WETLANDS (Continued)			
Section 404(b)(1) Guidelines for Specification of Disposal Sites for Dredged and Fill Material, 40 CFR §230	40 CFR 230 sets guidelines for evaluation of discharges of dredged and fill material into wetlands and waters of the U.S. The requirements specify that no discharge of dredged or fill material shall take place unless the permit authorizing agency makes a determination of the short-term effects of the discharge on the environment of the site, and if: 1. There is no practicable alternative to the action; 2. A State Water Quality Standard will not be violated; and 3. It does not contribute to or causes the significant degradation of waters of the United States.	Applicable	Discharges of dredged and fill material associated with Operable Unit 5 remedial actions will be evaluated and conducted against the substantive requirements of these regulations. This requirement is applicable to all remedial alternatives except the no action alternative.
Section 401 State Water Quality Certifications, OAC 3745-32	Section 401 State Water Quality Certification is required to conduct dredged and fill activities within wetlands or waters of the U.S. State Water Quality Certification is granted provided: 1. The discharge does not prevent or interfere with the attainment or maintenance of applicable water quality standards; and 2. The discharge does not result in a violation of any applicable provisions of CWA.	Applicable	Discharges of dredged and fill material associated with Operable Unit 5 remedial actions will meet the substantive requirements of these regulations. This requirement is applicable to all remedial alternatives except the no action alternative.
Protection of Wetlands 40 CFR §258.12	New municipal solid waste landfill units must not be located in wetlands unless Ohio approves otherwise.	Applicable	Wetland impacts associated with Operable Unit 5 remedial actions will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (G)(15)	A solid waste disposal facility may not be located in a floodway.	Applicable	Floodway impacts associated with Operable Unit 5 remedial activities will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(4)(d)	The limits of waste placement cannot be located within 200 feet of a stream, lake, or natural wetland, unless deemed acceptable by the Director of the OEPA.	Applicable	Wetland impacts associated with Operable Unit 5 remedial actions will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.

000278

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
FLOODPLAINS			
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (G)(15)	The limits of solid waste placement and the leachate management system cannot be located in a regulatory floodplain, unless deemed acceptable by the Director of the OEPA.	Applicable	Several remedial alternatives involve the siting of a solid waste disposal facility. This requirement is applicable to all alternatives contemplating use of capping systems or engineered cells.
Ohio Solid Waste Disposal Regulations OAC 3745-29-07 (G)(15)	The limits of solid waste placement and the leachate management system cannot be located in a regulatory floodplain, unless deemed acceptable by the Director of the OEPA.	Applicable	Several remedial alternatives involve the siting of a solid waste disposal facility. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.
Procedures for Implementing the National Environmental Policy Act 40 CFR §6.302(b)	Federal agencies must evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain.	Applicable	Floodplain impacts associated with Operable Unit 5 remedial activities will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.
Floodplain Management Executive Order 11988	This order requires Federal agencies undertaking actions within a floodplain to evaluate the potential action has for adverse impact on the floodplain. If it is determined that adverse impacts could occur, the effects of the action must be minimized to the extent practical.	Applicable	Floodplain impacts associated with Operable Unit 5 remedial activities will be avoided and minimized to the maximum extent practicable. This requirement is applicable to all remedial alternatives except the no action alternative.

SOLID WASTE SITING CRITERIA

SOLE SOURCE AQUIFERS			
Siting Over a Sole Source Aquifer Safe Drinking Water Act 42 U.S.C. §1424(e)	All Federal financially assisted projects constructed in the area of a sole source aquifer and its principal recharge zone will be subject to EPA's review to insure that these projects are designed and constructed so that they do not create a significant hazard to public health.	Applicable	A notice in 53 FR 15876 (May 4, 1988) designated the Buried Valley Aquifer System of the Great Miami/ Little Miami River Basins of southwestern Ohio as a sole or principal source of drinking water. The Fernald site is located above this aquifer. This requirement is applicable to all remedial alternatives except the no action alternative.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(2)(c)	A solid waste landfill facility cannot be located above an aquifer declared by the federal government under the Safe Drinking Water Act to be a sole source aquifer.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
SOLE SOURCE AQUIFERS (Continued)			
OEPA Guidance on Solid Waste Siting Criteria: GD202.101	The Director may grant an exemption to the prohibition of siting a sanitary landfill facility over a sole source aquifer (OAC 3745-27-07(H)(2)(c)) under ORC 3743.02(G). In order to grant an exemption, the Director needs to determine that no adverse impact to human health or safety or the environment will occur due to granting the exemption. The decision to grant an exemption from this rule is made on a site by site basis. Among the items that should be considered when determining if a waiver will be granted are whether a significant thickness of low permeable material exists between the sanitary landfill facility liner and the sole source aquifer and whether there is an inter-connection between the sole source aquifer and any significant saturated zones which exist above the sole source aquifer.	TBC	Several remedial alternatives involve the on-property disposal of solid waste. This requirement pertains to all alternatives contemplating the use of capping systems or engineered cells.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(2)(d)	A sanitary landfill facility cannot be located above an unconsolidated aquifer capable of sustaining a yield of 100 gallons per minute for a 24-hour period to a water supply well located within 1,000 feet of the limits of solid waste placement, unless deemed acceptable by the Director of the OEPA.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
SOLE SOURCE AQUIFERS (Continued)			
OEPA Guidance on Solid Waste Siting Criteria: 100 Gallon Per Minute Aquifer GD202.102	An exemption to the prohibition of siting a sanitary landfill facility over an unconsolidated aquifer capable of sustaining a yield of 100 gallons per minute for a 24-hour period (OAC 3745-27-07(H)(2)(d)) may be obtained by demonstrating that the thickness and lack of permeability of the sediment that exists between the bottom of the proposed sanitary landfill facility liner and the top of the unconsolidated high yield aquifer provide adequate protection to the unconsolidated high yield aquifer from the effects of a release of leachate from the sanitary landfill facility. The sediment should prevent leachate from migrating from the bottom of the sanitary landfill facility liner to the high yield aquifer in a time period equal to the active life of the facility including the post-closure care period.	TBC	This guidance is a TBC rather than a ARAR because it is not promulgated. This guidance is a TBC for all alternatives contemplating the use of capping systems or engineered cells.
OTHER SOLID WASTE SITING LIMITATIONS			
Distance from a Public Water Supply Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(3)(a)	A sanitary landfill facility may not be located within the surface and subsurface areas surrounding a public water supply well through which contaminants may move toward and may reach the public water supply well within a period of five (5) years.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (G)(16)	Limit of solid waste placement and leachate management system are not located within 200 feet of fault that has displacement in Holocene time.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
OTHER SOLID WASTE SITING LIMITATIONS (Continued)			
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(3)(c)	The limits of solid waste placement cannot be located within 1,000 feet of a water supply well or developed spring unless it is deemed acceptable by the Director of the OEPA or it is: • Controlled by the applicant, is needed as a source of nonpotable water, no other reasonable alternate water source is available, and the well is constructed to prevent contamination of the groundwater, or • Located at least 500 feet hydrogeologically upgradient from the limits of solid waste placement, or • Separated from the limits of solid waste placement by a hydrogeologic barrier, or • Constructed and used solely for monitoring groundwater quality.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(4)(b)	The limits of waste placement cannot be located within 300 feet of the sanitary landfill facility's property line, unless deemed acceptable by the Director of the OEPA.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(4)(c)	The limits of solid waste placement cannot be located within 1,000 feet of a domicile whose owner has not consented in writing to the location of the sanitary landfill facility.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (H)(2)(e)	The isolation distance between the uppermost aquifer system and the bottom of the recompacted soil liner of a sanitary landfill system cannot be less than 15 feet of in situ or added geologic material deemed acceptable by the Director of the OEPA.	Applicable	Several remedial alternatives involve the on-property disposal of solid waste. This requirement is applicable to all alternatives contemplating the use of capping systems or engineered cells.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
OTHER SOLID WASTE SITING LIMITATIONS (Continued)			
OEPA Guidance on Solid Waste Siting Criteria: Minimum Distance From a Public Water Supply Well GD202.105	The minimum distance to a public water supply well (OAC 3745-27-07 (H)(3)(c)) will be considered by the application of this criteria: - The five year time of travel shall be calculated between the boundary of the solid waste landfill facility and the closest public water supply. A period of no less than 5 years will be required before ground water flowing in a downgradient direction from the facility can intersect with a public water supply well screen. - To be considered for an exemption from this rule, the following will need to be demonstrated: - That there is at least 50 feet of separation between the bottom of the solid waste landfill facility liner and the aquifer system in which the public water supply well is screened. - That any release of leachate shall be detected prior to reaching the aquifer system in which the public water supply well is screened. - That once leachate is released below the liner, the leachate shall not reach the aquifer system in which the public water supply well is screened within a time span of 100 years plus the anticipated life of the solid waste landfill facility which shall include the 30 year post-closure care period.	TBC	Several remedial alternatives involve the on-property disposal of solid waste. This guidance is a TBC rather than a ARAR because it is not promulgated. This guidance is a TBC for all alternatives contemplating the use of capping systems or engineered cells. A public water supply exists outside of the 5-year time of travel from the FEMP property boundary. In addition, this public water supply system will be removed in the near future.
OEPA Guidance on Solid Waste Siting Criteria: Minimum Isolation Distances to Wells and Developed Springs GD0202.103	This guidance clarifies when exceptions to the required 1,000 foot isolation distance from water supply wells and developed springs (OAC 3745-27-07 (H)(3)(c)) apply and when a situation contrary to the rule can be deemed acceptable to the Director of the OEPA.	TBC	This guidance is a TBC rather than a ARAR because it is not promulgated. This guidance is a TBC for all alternatives contemplating the use of capping systems or engineered cells.

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
OTHER SOLID WASTE SITING LIMITATIONS (Continued)			
OEPA Guidance on Solid Waste Siting Criteria: Material Acceptable to the Director GD202.104	For geologic material to be deemed acceptable to the Director of the OEPA as added fill under OAC Rule 3745-27-07 (H)(2)(e), it must be able to meet the following criteria: • The geologic material must be impermeable enough so it will not store, transmit or yield a significant amount of water to a well or spring • The geologic material must be able to impede both physically and chemically, the flow of leachate constituents through it In order to meet both criteria listed above, the added geologic material should: • Be classified as CL, SC, GC, CL-ML, or CH under the Unified Soil Classification System (USCS) • Be composed of particles of which at least 25% by dry weight will pass through a No. 200 (75 μm) sieve • Be composed of no more than 25% by dry weight particles which will not pass through a No. 4 sieve • No particle should be greater than 8 inches in diameter • Have a final permeability of no more than $1x10^{-5}$ cm/sec • Be recompacted in a manner that when the landfill is constructed on it, no damage to the landfill liner will occur due to settling of the added material	TBC	This guidance is a TBC rather than a ARAR because it is not promulgated. This guidance is a TBC for all alternatives contemplating the use of capping systems or engineered cells.

000784

TABLE B.2 (Continued)
OPERABLE UNIT 5 POTENTIAL LOCATION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Rationale
HAZARDOUS WASTE			
LOCATION OF HAZARDOUS WASTE FACILITIES			
Hazardous Waste Facility Environmental Impact OAC 3745:05(D)(6)(c)	A hazardous waste facility installation and operation permit shall not be approved unless it proves that the facility represents the minimum adverse environmental impact, considering the state of available technology, the nature and economics of various alternatives and other pertinent considerations	Applicable	This requirement is applicable for several alternatives which consider treatment, storage, or disposal of hazardous wastes if HWMUs are to be constructed during remediation. This requirement may serve as a siting criteria.
Hazardous Waste Facility Minimum Risk OAC 3745.05(D)(6)(d)	A hazardous waste facility installation and operation permit shall not be approved unless it proves that the facility represents the minimum risk of all the following: 1) contamination of groundwater and surface waters; 2) fires or explosions from treatment, storage, or disposal methods; 3) accident during transportation; 4) impact to public health and safety; 5) air pollution; and 6) soil contamination	Applicable	Use of any existing or potential HWMUs for remediation where hazardous wastes may be stored, treated, or disposed must meet these substantive requirements. This requirement may serve as a siting criteria.

TABLE B.3

OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
HAZARDOUS WASTES			
	HAZARDOUS WASTE STORAGE		
Empty Containers OAC 3745-51-07 (A) and (B) RCRA 40 CFR 261.7 Subpart A	Any hazardous waste remaining in either an empty container or an inner liner removed from an empty container is not subject to regulation under 40 CFR Parts 261 through 265 (RCRA requirements). A container is empty if: 1) All wastes have been removed that can be removed using the practices commonly employed to remove materials from that type of container (e.g., pouring, pumping, and aspirating); and 2) No more than 2.5 cm (1 inch) of residue remain on bottom of the container or inner liner; or 3) No more than 3% by weight of the total capacity of the container remains in the container or inner liner if the container is less than or equal to 110 gal in size, or no more than 0.3% by weight of the total capacity of the container remains in the container or inner liner if the container is greater than 110 gal in size.	Relevant and Appropriate	This requirement is relevant and appropriate when containerizing soils contaminated by RCRA waste. This requirement would also be relevant and appropriate for containerizing any treatment residues exhibiting RCRA characteristics including Advanced Wastewater Treatment (AWWT) sludges and soil decontamination residues. OEPA has the overriding authority for on-site management of RCRA wastes.
Condition of Containers OAC 3745-66-71 through 74, 76 and 77 RCRA 40 CFR 265.171 through .174, .176 and .177 Subpart I	If a container holding hazardous waste is not in good condition (e.g., severe rusting, apparent structural defects) or it begins to leak, the owner or operator must transfer the hazardous waste from this container to a container that is in good condition or manage the waste in some other way that complies with this requirement.	Relevant and Appropriate	This requirement is relevant and appropriate to handling containers holding environmental media contaminated with RCRA waste. OEPA has the overriding authority for on-site management of RCRA wastes.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
Waste Storage Piles OAC 3745-56-51, 54, and 58 40 CFR 264.251 through .259	A waste pile used to store or treat hazardous waste must have: 1) A liner that is designed, constructed, and installed to prevent any migration of waste out of the pile into the adjacent subsurface soil or groundwater or surface water at any time during the active life (including the closure period) of the waste pile, and 2) A leachate collection and removal system immediately above the liner that is designed, constructed, maintained, and operated to collect and remove leachate from the pile. The owner/operator must design, construct, operate, and maintain a run-on control system capable of preventing flow onto the active portion of the pile during peak discharge from at least a 25-yr storm and manage a runoff management system to collect and control at least the water volume resulting from a 24-hr, 25-yr storm. Collection and holding facilities associated with run-on and run-off control system must be inspected weekly and be emptied or otherwise managed expeditiously after storms to maintain design capacity of the system. If the pile contains any particulate matter which may be subject to wind dispersal, the owner or operator must cover or otherwise manage the pile to control wind disposal. During construction or installation, liners and cover systems must be inspected for uniformity, damage, and imperfections. At closure, the owner/operator must remove or decontaminate all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate, and manage them as hazardous waste unless OAC 3745-51-03(D) applies. If after, removing or decontaminating all residues and making all reasonable effort to effect removal or decontamination of contaminated components, subsoils, structures, and equipment, the owner/operator finds that not all contaminated subsoils can be practically removed or decontaminated, he must close the facility and perform post-closure care in accordance with OAC 3745-57-10.	Relevant and Appropriate	This requirement is relevant and appropriate for on-site hazardous waste piles used for longer than 90 days unless the CAMU Rule is applied.

000782

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
Containment OAC 3745-55-75 RCRA 40 CFR 265.175(a) through (c) Subpart I	A containment system for RCRA containment storage areas must be designed and operated to provide: 1) A sufficiently impervious base, which is sloped to collect any leaking liquids. 2) Sufficient capacity to contain liquids. 3) Prevention of run-on into the containment system. 4) A sump to prevent overflow of the collection system. Storage areas for containers holding only wastes that do not contain free liquids need not have a containment system provided that: 1) The storage area is sloped or is otherwise designed and operated to drain and remove liquid resulting from precipitation, or 2) The containers are elevated or are otherwise protected from contact with accumulated liquid.	Relevant and Appropriate	This requirement is relevant and appropriate to handling soil contaminated with listed or characteristic RCRA waste. A Part B Permit Application for RCRA storage has been submitted to the OEPA.
Containment Building RCRA 40 CFR 264.1100 through .1102 Subpart DD 57 FR 37194 8/18/92	The owner or operator is not subject to the definition of land disposal in RCRA section 3004(k) provided that the unit: 1) Is a completely enclosed, self-supporting structure that is designed and constructed of manmade materials of sufficient strength and thickness to support themselves, the waste contents, and any personnel and heavy equipment that operate within the unit, and to prevent failure due to pressure gradients, settlement, compression, or uplift, physical contact with the hazardous wastes to which they are exposed, climatic conditions, and the stresses of daily operation, including the movement of heavy equipment within the unit and contact of such equipment with containment walls; 2 Has a primary barrier for management of solids, in addition to a liquid collection system and secondary containment for management of liquids. 3) Has controls sufficient to prevent fugitive dust emissions to meet the no visible emission standard in Sec. 264.1101(c)(1)(iv); and 4) Is designed and operated to ensure containment and prevent the tracking of materials from the unit by personnel or equipment. At closure, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components, contaminated subsoils, and structures and equipment contaminated with waste and leachate, and handle them as a hazardous waste.	Relevant and appropriate	This requirement is not applicable because the facility is currently in interim status; 40 CFR 264 requirements only apply to facilities with a Part B Permit. Excavated RCRA soils and sediments may require temporary storage during the remedial action.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
HAZARDOUS WASTE MANAGEMENT AND DISPOSAL			
Preparing and Transporting Hazardous Waste Off-site RCRA 40 CFR 262.20 through .23, .30 and .33 Subparts B and C OAC 3745-53-20 through 31 OAC 3745-52-30 and 33	General Requirements for transporting hazardous waste for off-site disposal require a Manifest. Pre-transporting requirements include appropriate packaging, labeling, marking, and placarding.	Applicable	Any residues determined to be RCRA hazardous waste destined for off-site disposal are subject to manifest requirements. Remedial actions involving off-site disposal of RCRA wastes will be subject to this requirement.
Landfill Design RCRA 40 CFR 265.301(a)	Construction of a landfill must include two (2) or more liners and a leachate collection and removal system above and between such liners.	Applicable	If on-site disposal is selected for Operable Unit 5 low-level mixed wastes then this requirement will be applicable.
Land Disposal Restrictions RCRA 40 CFR 268.40 through .44 Subpart D OAC 3745-59	A restricted hazardous waste may be land disposed only if: 1) An extract of the waste or of the treatment residue of the waste does not exceed the value shown in 40 CFR 268.41. 2) It is treated using a technology specified in 40 CFR 268.42(a) or an equivalent treatment method. 3) The constituent concentrations in the waste or treatment residue of the waste do not exceed the value shown in 40 CFR 268.43.	Applicable	This requirement is applicable to those RCRA listed hazardous wastes that will be disposed of off-site. Land disposal restrictions will not apply to on-property disposal within a CAMU under the CAMU Rule.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
HAZARDOUS WASTE MANAGEMENT AND DISPOSAL (Continued)			
Contaminated Debris RCRA 40 CFR 268.2 Subpart A 40 CFR 268.45 Subpart D 40 CFR 261.3 Subpart A	Debris means solid material exceeding a 60 mm particle size that is intended for disposal and that is a manufactured object, plant or animal matter, or natural geologic material. Hazardous debris means debris that contains a listed hazardous waste, or that exhibits a characteristic of hazardous waste. Hazardous debris must be treated prior to land disposal unless the EPA determines that the debris is no longer contaminated with hazardous waste or the debris is treated to the waste-specific treatment standard for the waste contaminating the debris. Provided the debris does not exhibit a RCRA characteristic it is not subject to regulation under 40 CFR parts 260, 261 to 266, 268, or 270 if: 1) The hazardous debris has been treated using one of the required extraction or destruction technologies specified in 40 CFR 268.45 or 2) The debris, considering the extent of contamination, is determined to no longer be contaminated with hazardous waste.	Applicable	This requirement is applicable to hazardous debris that will be disposed of off site. Land disposal restrictions will not apply to on-property disposal within a CAMU.
GENERAL FACILITY STANDARDS			
Hazardous Waste Determination RCRA 40 CFR 262.11 Subpart A OAC 3745-52-11 (A) through (F)	A person who generates a solid waste must determine if that waste is a hazardous waste using the following method: 1) He should first determine if the waste is not a solid waste (40 CFR 261.4). 2) He must then determine if the waste is listed as a hazardous waste in Subpart D of 40 CFR Part 261. 3) For purposes of compliance with 40 CFR Part 268, or if the waste is not listed in subpart D of 40 CFR part 261, the generator must then determine whether the waste is identified in subpart C [characteristic] of 40 CFR part 261.	Relevant and Appropriate	This requirement is relevant and appropriate for soils contaminated with a RCRA listed waste, or a RCRA characteristic waste, and for residues from treatment of soil contaminated with RCRA listed waste, if the waste is to be managed or stored on-property within a CAMU. This requirement would further apply to waste sludges generated by the AWWT or the soil decontamination process where RCRA constituents may be present. A hazardous waste determination will be applicable for any RCRA regulated waste destined for off-site disposal.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
GENERAL FACILITY STANDARDS (Continued)			
Treatment, Storage, and Disposal General Facility Standards RCRA 40 CFR 265.13 through .16 Subpart B OAC 3745-65-13 through 16	General facility standards require that operators of a facility must obtain chemical and physical analyses of a representative sample of each hazardous waste to be treated, stored, or disposed of at the facility prior to treatment, storage, or disposal. The analysis may include existing published or documented data on the hazardous waste or on hazardous waste generated from similar processes. The operator of facility must also provide controlled access for the facility. In addition, the operator must maintain and inspect all monitoring equipment, safety and emergency equipment, security devices and operating and structural equipment that are important to preventing human health hazards. Operators must train personnel for procedures relevant to their emergency response training.	Relevant and Appropriate	These standards are relevant and appropriate where RCRA wastes are managed on site. All alternatives must meet compliance if they require action that involves storage and treatment of soil containing listed waste.
Treatment, Storage, and Disposal Facility Preparedness and Prevention RCRA 40 CFR 265.31 through .35, .37 Subpart C OAC 3745-65-31 through 35, 37	TSD operators must design, construct, maintain and operate facilities to minimize the possibility of fire, explosion or any unplanned sudden or nonsudden release of hazardous waste to air, soil, or surface water which might threaten human health or the environment.	Relevant and Appropriate	This requirement is relevant and appropriate for all alternatives involving the storage and treatment of RCRA listed waste. RCRA listed waste or characteristic waste may be disposed in an on-property disposal facility.
Treatment, Storage, and Disposal Facility Contingency Plan and Emergency Procedures RCRA 40 CFR 265.51, .52, and .55 through .56, Subpart D OAC 3745-65-51, 52, and 55 through 56	Each facility operator must have a contingency plan designed to minimize hazards to human health and the environment due to fires, explosions, or any unplanned releases of hazardous waste constituents to air, soil or surface/groundwater.	Relevant and Appropriate	This requirement is relevant and appropriate for all alternatives involving the storage and treatment of RCRA listed waste. RCRA listed waste or characteristic waste may be disposed in an on-property disposal facility.

000791

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
GENERAL FACILITY STANDARDS (Continued)			
Treatment, Storage, and Disposal of Hazardous Waste in Miscellaneous Units OAC 3745-57-91 through 93 40 CFR 264.601 through .603	Prevention of any release that may have adverse effects on human health or the environment includes, but is not limited to: A. Migration of waste constituents in the groundwater or subsurface environment. B. Migration of waste constituents in surface water, or wetlands or on the soil surface. C. Migration of waste constituents in the air. Monitoring, tests, analytical data, inspections, response, and reporting procedures and frequencies must ensure compliance portions of the OAC. A miscellaneous unit that is a disposal unit must be maintained in a manner that complies with OAC 3745-57-91 during the post closure care period. If a treatment or storage unit has contaminated soils or groundwater that can not be completely removed or decontaminated during closure, the unit must also meet the requirements of OAC 3745-57-91 during the post-closure care. The post-closure plan under OAC 3745-55-18 must specify the procedures that will be used to satisfy this requirement.	Relevant and Appropriate	These requirements are relevant and appropriate to on-site facilities that treat, store, or dispose of hazardous waste in miscellaneous units unless the CAMU Rule is applied.
GROUNDWATER MONITORING			
Groundwater Monitoring Program RCRA 40 CFR 265.90 Subpart F OAC 3745-65-90	The owner or operator of a surface impoundment, landfill, or land treatment facility which is used to manage hazardous waste must implement a ground-water monitoring program capable of determining the facility's impact on the quality of ground water in the uppermost aquifer underlying the facility.	Applicable	This requirement is applicable to all interim-status RCRA land-based units and to select remedial alternatives that involve the disposal of soil containing listed hazardous waste. The Ohio EPA Director's Final Findings and Orders (DFOs) signed September 10, 1993, provides an alternate groundwater monitoring program from 40 CFR 265.92, Subpart F, to integrate the RCRA program with the CERCLA response actions.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
GROUNDWATER MONITORING (Continued)			
Groundwater Protection Standard RCRA 40 CFR 264.92 through .100 Subpart F OAC 3745-54-92 through 100	The owner or operator must ensure that hazardous constituents detected in the groundwater from a regulated unit do not exceed the concentration limits for MCLs in the uppermost aquifer underlying the waste management area beyond the point of compliance during the compliance period. The groundwater monitoring requirements include procedures for detection, compliance, and corrective action monitoring programs.	Relevant and Appropriate	This requirement is relevant and appropriate to land-based units, which would include any alternatives using on-site disposal facility and/or a consolidation area. However, the FEMP is currently an interim status facility with a Part B Permit application pending.
CLOSURE UNDER RCRA			
Closure Performance Standard for HWMUs RCRA 40 CFR 265.111 Subpart G OAC 3745-66-11	The owner or operator must close a facility in a manner that: 1) Minimizes the need for further maintenance; and 2) Controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere; and 3) Complies with these closure requirements.	Applicable	This requirement is applicable to HWMU closures occurring during the remedial action. This requirement is relevant and appropriate, not applicable, to alternatives involving disposal in an on-property disposal facility and/or consolidation area.
Closure Performance Standard RCRA 40 CFR 265.114 Subpart G OAC 3745-66-14	During the partial and final closure periods, all contaminated equipment, structures, and soils must be clean closed, have risk-based closure, or be closed in place. If the owner or operator demonstrates that not all contaminated soils can be practically removed or decontaminated then the owner or operator must close the tank system and perform post-closure care in accordance with the closure and post-closure care requirements that apply to landfills (40 CFR 264.310)	Applicable	This requirement is applicable to actions involving removal, treatment or storage of soils contaminated by RCRA constituents from HWMUs.
Storage Area Closure RCRA 40 CFR 264.178 Subpart I OAC 3745-55-78	At closure, all hazardous waste and hazardous waste residues must be removed from the containment system. Remaining containers, liners, bases, and soil containing, or contaminated with hazardous waste, or hazardous waste residues must be decontaminated or removed. If the owner or operator demonstrates that not all contaminated soils can be practically removed or decontaminated then the owner or operator must close the tank system and perform post-closure care in accordance with the closure and post-closure care requirements that apply to landfills (40 CFR 264.310)	Relevant and Appropriate	This requirement is relevant and appropriate to Operable Unit 5 for handling hazardous waste or environmental media. This requirement is not applicable because the FEMP is currently in interim status; 40 CFR 264 requirements only apply to facilities with a Part B Permit.

000693

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
CLOSURE UNDER RCRA (Continued)			
Closure of Tank Systems RCRA 40 CFR 265.197 Subpart J OAC 3745-66-97	At closure of a tank system, the owner or operator must remove or decontaminate all waste residues, contaminated containment system components (liners, etc), contaminated soils, and structures and equipment contaminated with waste, and manage them as hazardous waste. If the owner or operator demonstrates that not all contaminated soils can be practicably removed or decontaminated then the owner or operator must close the tank system and perform post-closure care in accordance with the closure and post-closure care requirements that apply to landfills (40 CFR 264.310).	Relevant and Appropriate	This requirement is relevant and appropriate to RCRA wastes contained in tanks that will be used by Operable Unit 5 during remedial actions.
Contained-In Policy RCRA 58 FR 48092 9/14/93 Proposed rule. 58 FR 59976 11/12/93 Notice to extend comment. 59 FR 10778 3/8/93 Clarification, partial withdrawal.	Hazardous soil means soil that contains RCRA hazardous waste(s) listed in 40 CFR part 261, subpart D, or that exhibits one or more of the characteristics of a hazardous waste as defined in 40 CFR part 261, subpart C. This proposed rule recommends contained-in determinations for hazardous debris, hazardous soil and other environmental media. Any person may petition the Regional Administrator to exclude, under 261.(f)(2) or 261.3(g) of this chapter, hazardous debris and hazardous soil or other environmental media, including but not limited to, ground water, surface water, and sediments, from regulation as hazardous waste. The petition for a contained-in determination must include information sufficient to demonstrate that specific constituent concentrations in the hazardous debris, hazardous soil, or other environmental media to be excluded do not pose a hazard to human health and the environment at that site. (Such a petition is not necessary for remedial actions conducted pursuant to RCRA or CERCLA authorities provided that a similar determination is made by the Regional Administrator based on information substantially equivalent to the information listed below including public notice and comment requirements).	TBC	Policies are not promulgated and therefore cannot be ARARs. This policy will be considered for managing treated soils that are contaminated with RCRA waste.
Risk-Based Remediation Standards Ohio EPA Closure Plan Review Guidance for RCRA Facilities. Interim Final. 9/1/93	Federal regulations of May 2, 1986 (50 FR 16422) and March 19, 1987 (52 FR 8704) modified the closure performance standard such that risk assessment, or what constitutes "decontamination" of a site, may be considered by the EPA as a closure option. The Ohio EPA adopted the equivalent of the EPA's March 19, 1987, regulations on December 8, 1988 (see OAC 3745-67-28), clarifying that risk assessment may be an option. It is Ohio EPA and DHWM practice to consider risk assessment as a possible third option for closure for all types of units.	TBC	The use of risk-based closures is to be considered for closing HWMUs with media contamination as integrated with the CERCLA remedial action.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
LANDFILL CLOSURE AND CORRECTIVE ACTION			
Corrective Action Management Unit RCRA 40 CFR 264.552 Subpart S 58 FR 865829 2/16/93	Corrective action management unit or CAMU means an area within a facility that is designated by the Regional Administrator under part 264 subpart S, for the purpose of implementing corrective action requirements under Sec. 264.101 and RCRA section 3008(h). A CAMU shall only be used for the management of remediation wastes pursuant to implementing such corrective action requirements at the facility. For the purpose of implementing remedies under Sec. 264.101 or RCRA Section 3008(h), the Regional Administrator may designate an area at the facility as a corrective action management unit, as defined above. One or more CAMUs may be designated at a facility under the following conditions: 1) Emplacement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes. 2) Consolidation or emplacement of remediation wastes into or within a CAMU does not constitute creation of a unit subject to minimum technology requirements. The owner/operator shall provide sufficient information to enable the Regional Administrator to designate a CAMU in accordance with the criteria in Sec. 264.552. Note: RCRA regulated units (HWMUs) within a CAMU are fully subject to RCRA Closure regulations.	Applicable	All action alternatives involve the excavation and handling of soil containing hazardous waste, therefore the CAMU concept is applicable to the remedial action for RCRA wastes. "Placement" as defined in HSWA does not occur in a CAMU. Therefore, land disposal restrictions (LDRs) and minimum technology requirements (MTRs) are not "triggered" as ARARs during and after the remedial activity within the boundaries of the CAMU.
Post-Closure Care RCRA 40 CFR 265.117 Subpart G OAC 3745-66-17	Post-closure care for each hazardous waste management unit must begin after completion of closure of the unit and continue for 30 years after that date and must consist of at least the following: 1) Monitoring and reporting in accordance with the requirements of Subparts F,K,L,M,N, and X of this part; and 2) Maintenance and monitoring of waste containment systems in accordance with the requirements of Subparts F,K,L,M,N, and X of this part. Post-closure use of property on or in which hazardous wastes remain after partial or final closure must never be allowed to disturb the integrity of the final cover, liner(s), or any other component of the containment system, or the function of the facility's monitoring systems. If clean closure is performed then post closure care is not required.	Applicable	This requirement is applicable to all alternatives, except the no action alternative, involving the closure of existing HWMUs.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
	LANDFILL CLOSURE AND CORRECTIVE ACTION (Continued)		
Minimum RCRA Landfill Design Requirements for Closure RCRA 40 CFR 265.310 Subpart N OAC 3745-68-10	At final closure of the landfill or upon closure of any cell, the owner or operator must cover the landfill or cell with a final cover designed and constructed to: 1) Provide long-term minimization of migration of liquids through the closed landfill; 2) Function with minimum maintenance; 3) Promote drainage and minimize erosion or abrasion of the cover; 4) Accommodate settling and subsidence so that the cover's integrity is maintained; and 5) Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present. After final closure, the owner of operator must comply with all post-closure requirements, including maintenance and monitoring throughout the post-closure care period. The owner or operator must: 1) Maintain the integrity and effectiveness of the final cover, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events; 2) Continue to operate the leachate collection and removal system until leachate is no longer detected; 3) Maintain and monitor the leak detection system; 4) Maintain and monitor the ground-water monitoring system; 5) Prevent run-on and run-off from eroding or otherwise damaging the final cover; and 6) Protect and maintain surveyed benchmarks.	Relevant and Appropriate	This requirement is relevant and appropriate for on-property consolidation, capping, and/or disposal that may contain RCRA waste. This requirement is not applicable because the FEMP is currently in interim status; 40 CFR 264 requirements only apply to facilities with a Part B Permit.

RADIOACTIVE WASTES

	MANAGEMENT AND DISPOSAL OF URANIUM MILL TAILINGS		
Landfill Requirements AEA/UMTRCA 40 CFR 192.02(a) Subpart A	Control of residual radioactive material shall be designed to: Be effective for up to 1000 years, to the extent reasonably achievable, and in any case, for at least 200 years, and provide protection of groundwater.	Relevant and Appropriate	The requirement is relevant and appropriate for residual radioactive materials because they are sufficiently similar to contaminated soils and sediments being addressed by Operable Unit 5. This requirement will be met as a general performance standard for all alternatives requiring on-property or off-site disposal.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
MANAGEMENT AND DISPOSAL OF URANIUM MILL TAILINGS (Continued)			
Implementation of Standards in 40 CFR 192, Subparts A and B AEA/UMTRCA 40 CFR 192.20 Subpart C	Implementing agencies shall establish methods and procedures to provide reasonable assurance that the provisions of Subparts A (above) and B (Table B.1) are satisfied. This should be done through use of analytical models and site specific analyses for Subpart A, and through measurements performed within the accuracy of currently available types of field and laboratory instruments along with reasonable survey and sampling procedures. This includes measuring the flow rate of uranium and groundwater.	Relevant and appropriate	This requirement is relevant and appropriate for ensuring compliance with 40 CFR 192 Subparts A and B. Note that Subpart B is listed as an ARAR in the chemical-specific ARAR table, B.1.
Management of Uranium By-Product Materials AEA/UMTRCA 40 CFR 192.30 through .34 Subpart D	This subpart applies to the management of uranium byproduct materials under section 84 of the Atomic Energy Act of 1954, as amended, during and following processing of uranium ores, and to restoration of disposal sites following any use of such sites under section 83(b)(1)(B) of the Act. Uranium byproduct materials shall be managed to conform with groundwater protection, which includes detection monitoring. Subpart D(iv) allows for alternate concentration limits of uranium to be established, as described in 264.95 and 264.94(b)	Relevant and Appropriate	This requirement is for disposal areas at active uranium mill tailing sites, and is a relevant and appropriate requirement for the engineered disposal cell and capping systems.
LOW LEVEL RADIOACTIVE WASTE DISPOSAL			
Performance Objectives DOE Order 5820.2A, Chapter III (3)(a)	Performance objectives must: 1) Protect public health and safety in accordance with standards specified in applicable EH Orders and other DOE Orders. 2) Assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, groundwater, soil, plants and animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment ALARA. 3) Assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure. 4) Protect groundwater resources, consistent with federal, state, and local requirements.	TBC	Soils contain radioactive materials consistent with low level wastes. All alternatives contemplate leaving residual radioactivity at the site above background and could result in exposures to members of the public.
Disposal Methods DOE Order 5820.2A, Chapter III, (3)(i)(1)-(6)	Low level radioactive waste shall be disposed by methods appropriate to achieve the performance standard objectives in (3)(a) above, consistent with the radiation dose limits in paragraph (3)(b)	TBC	Alternatives involving on-site disposal facilities will handle materials consistent with low level waste.

000292

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
LOW LEVEL RADIOACTIVE WASTE DISPOSAL (Continued)			
Disposal Facility and Disposal Site Design DOE Order 5820.2A, Chapter III (3)(i)(8)	Design criteria shall be established prior to selection of new disposal facilities, new disposal sites, or both. These design criteria shall be based on analyses of physiographic, environmental, and hydrogeologic data to assure that the policy and requirements of this Order can be met. The criteria shall be also based on assessments of projected waste volumes, waste characterizations, and facility and disposal site performance.	TBC	Alternatives involving on-site disposal facilities will handle materials consistent with low level waste.
Disposal Facility Operations DOE Order 5820.2A, Chapter III (3)(i)(9)	Operating procedures shall: protect human health and the environment, security, minimum long-term control, closure/post-closure, identify markers for excavations, training, minimum voids between containers	TBC	Alternatives involving on-site disposal facilities will handle materials consistent with low level waste.
MANAGEMENT OF LOW LEVEL RADIOACTIVE WASTE			
Low Level Radioactive Waste Generation DOE Order 5828.2A, Chapter III (3)(c)	Technical and Administrative controls shall be directed to reducing the gross volume of waste generated and/or the amount of radioactivity requiring disposal. Waste reduction efforts shall include consideration of process modification, process optimization, materials substitution, and decontamination. All DOE low level waste generators shall establish auditable programs to assure that the amount of low level waste generated and/or shipped for disposal is minimized. Each DOE low level waste generator shall separate uncontaminated waste from low level waste to facilitate cost effective treatment and disposal. Each DOE low level waste generator preparing a design for a new process or process change shall incorporate principles into the design that will minimize the generation of low level waste.	TBC	Alternatives involving on-site disposal facilities will handle materials consistent with low level waste.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
MANAGEMENT OF LOW LEVEL RADIOACTIVE WASTE (Continued)			
Waste Characterization DOE Order 5820.2A, Chapter III (3)(d)	Low level waste shall be characterized with sufficient accuracy to permit proper segregation, treatment, storage, and disposal. This characterization shall ensure that, upon generation after processing, the actual physical and chemical characteristics and major radionuclide content are recorded and known during all stages of the waste management process. Waste characterization data shall be recorded on a waste manifest and shall include: - The physical and chemical characteristics of the waste; - Volume of the waste (total of waste and any solidification or absorbent media); - Weight of the waste (total of waste and any solidification or absorbent media); - Major radionuclides and their concentrations; and - Packaging date, package weight, and external volume.	TBC	Alternatives involving on-site disposal facilities will handle materials consistent with low level waste.
Waste Treatment DOE Order 5820.2A, Chapter III (3)(f)	Waste shall be treated by appropriate methods so that the disposal site can meet the performance objectives stated in DOE Order 5820.2A Chapter III (3)(a). Waste treatment techniques such as incineration, shredding, and compaction to reduce volume and provide more stable waste forms shall be implemented as necessary to meet performance requirements. Use of waste treatment techniques to increase the life of the disposal facility and improve the long-term facility performance, by improved site stability and reduction of infiltrating water, is required to the extent it is cost effective. The development of large scale waste treatment facilities shall be supported by the appropriate National Environmental Policy Act documentation. Operation of waste treatment facilities shall be supported by adequate documentation.	TBC	Alternatives using on-site disposal of low-level waste will meet these performance objectives.
Low Level Radioactive Waste Shipment DOE Order 5820.2A, Chapter III (3)(g)	The volume of waste and number of shipments of low level waste shall be minimized and the shipments conducted based on plans developed by field organizations. Generators must receive advance approval from the receiving facility and shall certify prior to shipment that waste meets the receiving facility waste acceptance criteria (WAC). The certification program shall be auditable and able to withstand independent review.	TBC	All alternatives requiring remedial action contemplate the off-site shipment of some contaminated soils, sludges, or treatment residues.
Long-Term Storage DOE Order 5820.2A, Chapter III (3)(h)	Requires achieving performance objectives of DOE 5820.2A III (3)(a); requires records and documentation be maintained for low level waste in storage, permits storage of waste until disposal by approved methods.	TBC	All alternatives requiring remedial action involve the staging of contaminated soils prior to treatment and/or disposal.

000639

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
MANAGEMENT OF LOW LEVEL RADIOACTIVE WASTE (Continued)			
Disposal Site Closure/Post Closure DOE Order 5820.2A, Chapter III (3)(j)	Site-specific comprehensive closure plans shall be developed for new and existing operating low level waste disposal sites. The plan shall address closure of disposal sites within a 5-year period after each is filled and shall conform to the requirements of the NEPA process. Performance objectives for existing disposal sites shall be developed on a case-by-case basis as part of the NEPA process. During closure and post closure, residual radioactivity levels for surface soils shall comply with existing DOE decommissioning guidelines. Corrective measures shall be applied to new disposal sites or individual disposal units if conditions occur or are forecasted that could jeopardize attainment of the performance objectives of this Order. Inactive disposal facilities, disposal sites, and disposal units shall be managed in conformance with RCRA, CERCLA, and the Superfund Amendments and Reauthorization Act (SARA). Closure Plans for new and existing operating low level waste disposal facilities shall be reviewed and approved by the appropriate field organization. Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	TBC	Alternatives using on-site disposal of low-level waste will meet these performance objectives.
Environmental Monitoring DOE Order 5820.2A, Chapter III (3)(k)	Each operational or non-operational low level waste disposal facility shall be monitored by an environmental monitoring program that conforms with DOE 5484.1 and, at a minimum, meets the requirements listed below: 1) The environmental program shall be designed to measure: a) Operational effluent releases; b) Migration of radionuclides; c) Disposal units subsidence; d) Changes in disposal facility and disposal site parameters which may affect long-term site performance. 2) Based on the character of the facility monitored, the environmental monitoring program may include, but not necessarily be limited to, monitoring surface soil, air, surface water, and in the subsurface, soil and water, both in the saturated and unsaturated zones. 3) The monitoring program shall be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives. The monitoring program shall be able to ascertain whether or not effluents from each treatment, storage, or disposal facility or disposal site meets the requirements of applicable DOE Orders.	TBC	Alternatives involving on-site disposal facilities will handle materials consistent with low level waste.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
UNDERGROUND STORAGE TANKS (USTs)			
UST CLOSURE			
General Requirements RCRA 40 CFR 280.61 through .66 Subpart F OAC 1301:7-7-36	Owners and operators of petroleum or hazardous substance UST systems must, in response to a confirmed release from the UST system, comply with abatement measures, site characterization, product removal, investigations for soil and groundwater cleanup, and corrective action plans, except for USTs excluded under 280.10(b) and UST systems subject to RCRA Subtitle C corrective action requirements under section 3004(u) of the RCRA, as amended.	Applicable	Petroleum USTs will be closed as part of sitewide remedial actions.
Ohio Petroleum Contaminated Soil Policy OPEA Policy PP 01 03 200 PP.01-03-200	The basis of the "contained in" policy is that environmental media, such as soil or groundwater, are not considered to be waste material. because they are not a solid waste, the mixture rule, as set forth in OAC 3745-51-03, does not apply when they become contaminated with a listed hazardous waste but only contains the waste. The result of this policy is that if the waste constituents can be removed, the soil is no longer considered to contain a hazardous waste. Therefore, since soil is not a waste material it does not have to be de-listed in order for it to be used for its intended purpose. However, as long as the soil contains the waste material, it must be managed as a hazardous waste. If we apply this concept to petroleum-contaminated soil, the soils containing a petroleum hydrocarbon would not need to be managed as a solid waste if the contaminants were removed.	TBC	This policy allows for treated/cleaned soil to be backfilled at the excavation site. Operable Unit 5 will consider this policy for all soils treated below PRGs or PRLs to be backfilled as clean soil.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
	BEST MANAGEMENT PRACTICES PROGRAM		
Best Management Practices Programs (BMP) Clean Water Act 40 CFR 125.104 Subpart K	BMP programs shall be developed in accordance with good engineering practices and: 1) Be documented in narrative form, and include any necessary plot plans, drawings or maps; 2) Establish specific objectives for the control of toxic and hazardous pollutants. (a) Each facility component or system shall be examined for its potential for causing a release of significant amounts of toxic or hazardous pollutants to waters of the United States due to equipment failure, improper operation, natural phenomena such as rain or snowfall, etc. (b) Where experience indicates a reasonable potential for equipment failure (e.g., a tank overflow or leakage), natural condition (e.g., precipitation), or other circumstances to result in significant amounts of toxic or hazardous pollutants reaching surface waters, the program should include a prediction of the direction, rate of flow and total quantity of toxic or hazardous pollutants which could be discharged from the facility as a result of each condition or circumstance; 3) Establish specific best management practices to meet the objectives identified in (2) above, addressing each component or system capable of causing a release of significant amounts of toxic or hazardous pollutants to the waters of the United States.	Applicable	Substantive requirements of this regulation are applicable to all alternatives requiring action. All action alternatives could release contaminants to waters of the United States if BMPs are not implemented.
AIR			
	AIR EMISSION STANDARDS FROM A STATIONARY SOURCE		
Air Emission Standards for Process Vents RCRA 40 CFR 264.1030, .1032 through .1034 Subpart AA	This subpart applies to process vents associated with distillation, fractionation, thin-film evaporation, solvent extraction, or air or steam stripping operations that manage hazardous wastes with organic concentrations of at least 10-ppm.	Applicable	This requirement is applicable for treating soils contaminated with RCRA waste.
Malfunction and Maintenance of Air Pollution Control Equipment OAC 3745-15-06 (A)(1) and (A)(2)	Scheduled maintenance must be established for pollution control equipment, as well as time periods when the pollution source must be shut-down during maintenance.	Applicable	This requirement is applicable for all alternatives that will utilize air pollution control equipment on-site.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
AIR EMISSION STANDARDS FROM A STATIONARY SOURCE (Continued)			
Stack Height Requirements OAC 3745-15-12 (B) and (C)	Stack height for air contaminant sources must be based on good engineering practices.	Applicable	All alternatives that include low-temperature thermal desorption must meet this requirement.
STATIONARY SOURCE AIR EMISSIONS			
General Provisions on Air Pollution Control OAC 3745-15-07 ORC 3704.01-.05	Measures shall be taken to adopt and maintain a program for the prevention, control, and abatement of air pollution in order to protect and enhance the quality of the state's air resource so as to promote the public health, welfare, and economic vitality of the people of the state. The emission or escape into open air from any source whatsoever of smoke ashes, dust, dirt, grime, acids, fumes, gases, vapors, odors and combinations of the above in such a manner or in such amounts as to endanger the health, safety, welfare of the public, or to cause unreasonable injury or damage to property shall be declared to be a public nuisance. It is unlawful for any person to cause, permit, or maintain any such public nuisance.	Applicable	During the remedial action, potential exists for emissions of radionuclides and toxic chemicals to air, which might endanger individuals or damage property.
Installation and Modification of Air Contaminant Sources OAC 3745-31-05(A)(3)	New or modified air contaminant sources are required to employ best available technology to control emissions	Applicable	This requirement is applicable to alternatives that involve the construction or modification of air contaminant sources.
Control of Emissions of Organic Materials form Stationary Sources OAC 3745-21-07(G)(2)	Discharges containing organic material must not exceed 40 pounds in any one day, nor eight pounds in any one hour, unless the discharge has been reduced by at least eight-five percent.	Applicable	This requirement is applicable to alternatives that involve the discharge of organic emissions.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
FUGITIVE AIR EMISSION STANDARDS			
Visible Particulates in Air EPA Regulations on National Primary and Secondary Ambient Air Quality Standards 40 CFR 50.6(a),(b),(c) Ohio Ambient Air Quality OAC 3745-17-07 (A)	The level of the national primary and secondary 24-hour ambient air quality standards for particulate matter is 150 micrograms per cubic meter, 24-hour average concentration. Visible particulate emissions from any stack may exceed 20% opacity, as a six-minute average, for not more than six consecutive minutes in any sixty minutes, but shall not exceed 60% opacity, as a six minute average at any time. The standards for national primary and secondary standards must be ≤50 micrograms per cubic meter, annual arithmetic average. Particulate matter shall be measured in the gradient air as PM_{10} (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers).	Applicable	The Federal standard at 40 CFR 50.6 for particulate matter in air is applicable to remedial actions at Operable Unit 5 because remedial activities may contribute, at least temporarily, to particulate matter in the air. Particulate emissions may be generated through fugitive emissions from excavations and disposal activities and point source discharges from wastewater sludge dewatering or soil treatment/stabilization. The Ohio standard for particulates in air is not an ARAR because it is not more stringent than the Federal standard at 40 CFR 50.6
Particulate Ambient Air Quality Standards OAC 3745-17-02 (C)(D)	The level of ambient air quality standards for total suspended particles is one hundred fifty micrograms per cubic meter, twenty-four-hour average concentration. The level of the primary and secondary annual standards for total suspended particulates is fifty micrograms per cubic meter.	Applicable	This requirement is applicable for all alternatives the omit or allow the escape of particulates. This includes all remedial activities that require excavation, demolition, cleaning and scrubbing.
Particulate Non-Degradation Policy OAC 3745-17-05	Degradation of Air Quality in any area where the air quality is better than required in 3745-27-02 (described above) is prohibited.	Applicable	See comment above.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
FUGITIVE AIR EMISSION STANDARDS (Continued)			
Control of Visible Particulate Emissions for Fugitive Dust OAC 3745-17-07 (B)(4),(5),(6)	There shall be no visible particulate emissions from any paved roadway or parking area except for a period of time not to exceed six minutes during any sixty-minute observation period. There shall be no visible particulate emissions from any unpaved roadway or parking area except for a period of time not to exceed thirteen minutes during any sixty-minute observation period. There shall be no visible particulate emissions from any material storage piles except for a period of time not to exceed thirteen minutes during any sixty-minute observation period.	Relevant and Appropriate	Paved and unpaved roadways, parking areas, and material storage piles will be in use during the remedial action. This requirement is not applicable as the FEMP is not located within a city or township subject to the rule, however, the requirement is relevant and appropriate for site activities during the remedial action. Grading, loading, and construction operations will occur during soil excavation, soil backfilling and during capping and construction of the disposal facility.
Ambient Air Quality Standards for Non-methane Hydrocarbons OAC 3745-21-02(C) and OAC 3745-21-03(D)	The ambient air quality guidelines for non-methane hydrocarbons is a maximum three hour arithmetic mean concentration of one hundred sixty micrograms per cubic meter not to be exceeded between the hours of six and nine am. Hourly and three-hour concentrations must be determined in accordance with prescribed methods.	Applicable	These requirements are applicable to alternatives that involve hydrocarbon emissions.
Restriction of Emission of Fugitive Dust OAC 3745-17-08 (B)	No person shall cause or permit any fugitive dust source to be operated; or any materials to be handled, transported, or stored; or a building or its appurtenances or a road to be used, constructed, altered, repaired, or demolished without taking or installing reasonably available control measures to prevent fugitive dust from becoming airborne. Such reasonably available control measures shall include, but not limited to, one or more of the following which are appropriate to minimize or eliminate visible particulate emissions of fugitive dust. - The use of water or other suitable dust suppression chemicals for the control of fugitive dust from the demolition of existing buildings or structures, construction operations, the grading of roads, or the clearing of land; or - The periodic application of asphalt, oil, water, or other suitable dust suppression chemicals on dirt or gravel roads and parking lots, and any other surfaces which may cause emissions of fugitive dust.	Relevant and Appropriate	This requirement is not applicable as the FEMP is not located within a city or township subject to the rule, however, the requirement is relevant and appropriate for site activities during the remedial action. Grading, loading, and construction operations will occur during soil excavation, soil backfilling and during capping and construction of the disposal facility.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
SOLID WASTES			
SOLID WASTE DISPOSAL			
Facility Design Criteria OAC 3745-27-08 (C)(1) through (9); (D) through (H) 40 CFR 258.40 Subpart D	Prescriptive engineering design specifications must be followed for the solid waste landfill facility, including requirements for liner specifications, leachate management systems, leachate storage, surface water control, benchmark location, access road grading, groundwater control, explosive gas monitoring systems and structures, composite and alternate cap systems, and the final cover.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility. The prescriptive requirements needed for construction of a solid waste landfill will be performed. The OAC requirements are more stringent than the Federal requirements, and therefore become the pertinent ARAR. Certification is not required as specified in OAC 3745-27-08 (A) and (B) because the FEMP is a CERCLA site. However the substantive requirements will be met.
SOLID WASTE DISPOSAL FACILITY OPERATIONS			
Facility Operations OAC 3745-27-09 (C), (D) through (F); (K) through (Q)	Sanitary landfill facility operations requirements.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility.
Daily Facility Operations OAC 3745-27-09 (C) through (E), (F)(2); (J) through (R) OAC 3745-27-19	This requirement specifies procedures for daily landfill operations maintenance and types of waste that is acceptable.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
SOLID WASTE DISPOSAL FACILITY OPERATIONS (Continued)			
Required Technical Information OAC 3745-7-06 (A)(B) and (C)	The minimum technical information is required of a solid waste permit to install. Included are a hydrogeologic investigation report, leachate production and migration information, surface water discharge information, design calculations, and plan drawings.	Applicable	This paragraph presents the substantive requirements of a solid waste permit to install. This requirement is applicable for all alternatives where siting a new solid waste landfill facility is considered. This requirement is also applicable to existing areas of contamination are capped per solid waste rules. This rule establishes the minimum information required during the remedial design stage.
Ohio Solid Waste Disposal Regulations OAC 3745-27-19(N)	Section 3745-27-19(N) states the permittee shall submit to the Director of the OEPA, upon every tenth anniversary of the effective date of a permit to install that approved the initial construction of the facility, an analysis demonstrating that the design, construction and final closure plan of the sanitary landfill facility continue to constitute best available technology. If the director of the OEPA determines that the design is no longer consistent with best available technology as being applied to the sanitary landfill industry in the state of Ohio, the permittee may be required to submit a permit to install application for necessary modifications to the landfill facilities. If a permit to install is required, the director of the OEPA shall not apply the siting criteria outlined in paragraph (H) of OAC 3745-27-07, when considering the permit to install application.	Relevant and Appropriate	Several remedial alternatives involve the on-property disposal of solid waste. A permit-to-install is not required for the siting of on-property landfill at the FEMP because it is a CERCLA site. However, the substantive requirements will be met through the CERCLA 5-year review process.
SOLID WASTE DISPOSAL FACILITY CLOSURE			
Final Closure of Sanitary Landfill Facilities OAC 3745-27-11 (A),(B); (G)(1) through (3), (7)	It is the responsibility of the permittee to complete final closure of the sanitary landfill facility in a manner that minimizes the need for further maintenance and minimizes post-closure formation and release of leachate and explosive gases to air, soil, groundwater, or surface water to the extent necessary to protect human health and the environment. The adequacy of closure methods must be approved by OEPA for cap design, soil barrier layer, granular drainage layer and vegetative cover.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
SOLID WASTE DISPOSAL FACILITY CLOSURE (Continued)			
Post-Closure Care of Sanitary Landfill Facilities OAC 3745-27-14 (A)(1),(2) RCRA Subtitle D	Following completion of final closure activities in accordance with rule 3745-27-11 of the Administrative Code, the owner or operator shall conduct post-closure care activities at the sanitary landfill facility for a minimum of thirty years. Post-closure care activities for all sanitary landfill facilities shall include, but are not limited to: (1) Continuing operation and maintenance of the leachate management system, the surface water management system, any explosive gas extraction and/or control system, any explosive gas monitoring system, and the ground water monitoring system; and (2) Maintaining the integrity and effectiveness of the cap system, including making repairs to the cap system as necessary to correct the effects of settling, dead vegetation, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cap system.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility.
Post-Closure Care EPA Criteria for Municipal Solid Waste Landfills 40 CFR §258.61	This requirement allows State Director to direct the owner or operator to stop managing leachate if the owner or operator demonstrates that leachate no longer poses a threat to human health and the environment.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility

WATER

SURFACE WATER			
Ohio NPDES Permits CWA OAC 3745-33-05 ORC 6111.042 40 CFR 122.41 Subpart C	That the point source must be equipped with instrumentation to monitor and record data and other information about the operation of the point source. The permittee shall maintain in good working order and operate at optimum levels in accordance with good engineering practices any wastewater treatment facilities or control systems regardless of the quality of the effluent. The permittee shall provide adequately trained and qualified personnel to operate the wastewater treatment facility.	Applicable	The Ohio NPDES permit is applicable because these requirements are more stringent than the federal regulations under the Clean Water Act. These requirements are applicable as all alternatives involve point source discharges to the Great Miami River.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
SURFACE WATER (Continued)			
Stormwater Discharges Associated with Industrial Activity 40 CFR 122.26(a)(l)(ii) 40 CFR 122.26(b)(4) and OAC 3745-38	A discharge composed entirely of stormwater associated with industrial activity must obtain a NPDES permit. These categories of facilities are considered to be engaging in "industrial activity": • landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection), including those that are subject to regulation under Subtitle D of RCRA and • construction activities including clearing, grading, and excavation that disturbs 5 acres more of total land area.	Applicable	The Ohio NPDES permit is applicable because these requirements are more stringent than the federal regulations under the Clean Water Act. These requirements are applicable as all alternatives involve point source discharges to the Great Miami River.
Antidegradation Policy OAC 3745-1-05 CWA 40 CFR 131.12	Existing instream water uses as defined in Rule 3745-1-07 of the Administrative Code and designated in Rules 3745-1-08 to 3745-1-32 of the Administrative Code, shall be maintained and protected. No further water quality degradation which would interfere with or become injurious to existing designated uses is allowable.	Applicable	This requirement is applicable for wastewater discharges to the Great Miami River. Under CERCLA, the State of Ohio has the overriding authority for the antidegradation of surface waters.
Analytical and Collection Procedures OAC 3745-01-03	Analytical methods and collection procedures for surface water discharge sampling are specified.	Applicable	This requirement is applicable to both discharges to surface waters as a result of remediation and any on-site surface waters affected by site conditions.
National Pollutant Discharge Elimination System; Wastewater Discharges Resulting From Clean-up of Response Action Sites Contaminated with Volatile Organic Compounds OEPA Policy #DSW-DERR 0100.027	Establishes response action guidelines for treatment technologies and discharge criteria for VOCs to be discharged to surface water.	TBC	This OEPA policy will provide guidance for alternatives involving wastewater discharges which contain VOCs.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
GROUNDWATER MONITORING			
Monitoring Well System OAC 3745-27-10 (A) and (B)	Ground water monitoring program requirements of new landfill facilities include background monitoring, detection monitoring and post-closure monitoring. The groundwater monitoring system will consist of a sufficient number of wells installed at appropriate locations and depths to yield ground water samples form both the uppermost aquifer system and any significant zones of saturation.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility.
Groundwater Monitoring Program OAC 3745-27-10 (C) and (D)	Sampling and analyses procedures must be designed to provide accurate representation of groundwater quality at the background and downgradient wells. Sampling and analysis procedures must be documented in a written plan. If the landfill facility owner deviates from the monitoring parameters listed in OAC 3745-27-10 (D)(3) to (D)(6), then an alternate list may be proposed to the Director. In addition, a written Quality Assessment Program must be prepared.	Applicable	These requirements are applicable to alternatives that include the on-site disposal cell. An alternate list of monitoring parameters will be required from those specified in OAC 3745-27-10(D)(3) to (D)(6).
Groundwater Quality Assessment Program OAC 3745-27-10 (E) and (P)	If a statistically significant change from background levels is identified for each parameter or constituent being monitored, then the landfill owner must submit a Quality Assessment program within 15 days. The plan must determine: (1) If leachate or leachate-derived constituents have entered the groundwater; (2) The rate and extent of migration of leachate or leachate-derived waste in the groundwater (3) The concentrations of leachate or leachate-derived waste in groundwater.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility.
Corrective Measures Study 3745-24-19(F)	After 180 days of determining that contaminants have leached from the landfill a corrective measures study must be submitted to OEPA. Remediation must include meeting MCLs in groundwater for a risk-level of 1×10^{-6} for a cumulative lifetime risk to an individual.	Applicable	These requirements are applicable to alternatives that include the on-site disposal facility.

GROUNDWATER WELLS

INSTALLATION			
Construction of New Wells OAC 3745-09-05 (A) and (B), 06 (A),(B),(D), and (E)	Specifies minimum construction requirements for new groundwater wells for casing material, casing diameters, casing depth, potable water, annular spaces, use of drive shoe, opening to allow water entry, contaminant entry.	Applicable	This requirement is applicable to all groundwater wells on the site that either will be installed or have been installed since February, 1975, when this regulation was promulgated.
Surface Design OAC 3745-09-07	Establish specific surface design requirements, such as height above ground, well vents, well pumps, etc.	Applicable	This requirement is applicable to all groundwater wells on the site that either will be installed or have been installed since February, 1975, when this regulation was promulgated.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
INSTALLATION (Continued)			
Start up and Operation of Groundwater Wells OAC 3745-09-08, (A) and (C)	This requirement describes procedures for disinfection/decontamination of new wells and use of potable water for priming pumps.	Applicable	This requirement is applicable to all groundwater wells on the site that either will be installed or have been installed since February, 1975, when this regulation was promulgated.
Maintenance and Operation of Groundwater Wells OAC 3745-09-09 (A-C), (B-1), and (E-6) OAC 3745-09-08, (A) and (C)	This requirement establishes specific maintenance and modification requirements for casing, pumps and wells.	Applicable	This requirement is applicable to all groundwater wells on the site that either will be installed or have been installed since February, 1975, when this regulation was promulgated.
INJECTION			
Underground Injection Control Program OAC 3745-34-01 OAC 3745-34-13	Injection into existing and new Class V wells is authorized by rule pursuant to section 6111.043 of the Ohio Revised Code until further requirements under future rules become applicable, unless injection is of sewage, industrial wastes or other wastes, as defined in Section 6111.01 of the Ohio Revised Code, into or above an Underground Source of Drinking Water (USDW).	Applicable	This requirement is applicable to all alternatives which involve the re-injection of treated groundwater into the GMA rather than discharging it to the Great Miami River.
Injection of Wastes into Wells ORC 6111.043 ORC 6111.044 to ORC 611.049	These sections of the Ohio Revised Code establish a program for regulations of the injection of sewage, industrial waste, hazardous waste, and other wastes into wells in order to control pollution of the waters of the state, to prevent contamination of underground sources of drinking water, and to satisfy all requirements of the "Safe Drinking Water Act", regarding injection wells as defined in regulations adopted under that act.	Applicable	This requirement is applicable to all alternatives which involve the re-injection of treated groundwater into the GMA rather than discharging it to the Great Miami River.
OEPA Policy 5X26 Aquifer Remediation Projects	This OEPA policy outlines requirements for groundwater remediation via subsurface injection of fluids.	TBC	This OEPA policy will provide guidance for alternatives contemplating the re-injection of treated groundwater into the GMA.

000811

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
WELL ABANDONMENT			
Abandonment of Test Holes and Wells OAC 3745-09-10	Upon completion of testing, a test hole shall be either completely filled with grout or such other material as will prevent contaminants from entering ground water.	Applicable	This requirement is applicable to all groundwater wells on the site that either will be installed or have been installed since February 15, 1975.
PCBs			
PCB DISPOSAL			
Disposal Requirements TSCA 40 CFR 761.60(a)(4) Subpart D	Any non-liquid PCBs at concentrations 50 ppm or greater in the form of contaminated soil, rags, or other debris shall be disposed of in an incinerator or in a chemical waste landfill.	Applicable	In the event soils containing PCBs above 50 ppm are excavated, this requirement is applicable. PCBs were detected in soil beneath the Fire Training Facility.
PCB TREATMENT			
TSCA 40 CFR 761.60(e) Subpart D	Any person who is required to incinerate any PCBs and PCB items under this subpart and who can demonstrate that an alternative method of destroying PCBs and PCB Items exists and that this alternative method can achieve a level of performance equivalent to 761.70 incinerators or high efficiency boilers as provided in paragraphs (a)(2)(iv) and (a)(3)(iv) of this section, may submit a written request to either the Regional Administrator or the Director, Exposure Evaluation Division for an exemption from the incineration requirements of 761.70 or 761.60. The applicant must show that his method of destroying PCBs will not present an unreasonable risk of injury to health or the environment.	Applicable	This requirement is applicable only if PCB contaminated soils are greater than 50 ppm and are treated on-property using a method besides incineration.
PCB STORAGE			
Storage for Disposal TSCA 40 CFR 761.65 Subpart D	This section applies to the design of storage areas to be used for later disposal of PCBs at concentrations of 50 ppm or greater.	Applicable	This requirement is applicable for storage of contaminated PCB soils at 50 ppm or greater.

TABLE ARAR B-3 (Continued)
OPERABLE UNIT 5 POTENTIAL ACTION-SPECIFIC REQUIREMENTS

Citation	Requirement	ARAR/TBC	Remarks
OTHER REGULATIONS			
NOISE CONTROL			
Noise Control Act, as amended 42 USC 4901, et seq. Noise Pollution and Abatement Act 42 USC 7641	The public must be protected from noises that jeopardize health and welfare.	Applicable	Because equipment and vehicles would be involved in certain aspects of the proposed action, all substantive requirements of the act are applicable. However, appropriate engineering controls and best management practices will be implemented to reduce nuisance noise to the maximum practicable extent during conduct of the proposed actions.
HAMILTON COUNTY EARTHWORK REGULATIONS			
Erosion Control Specifications Hamilton County Earthwork Regulations	Department of Public Works -- temporary and/or permanent erosion and sediment control features and devices shall be designed and constructed in accordance with the State of Ohio Temporary Erosion Control Specifications.	TBC	All alternatives involving excavation contemplate erosion and sediment control features.

000543

TABLE B.4

OPERABLE UNIT 5 OTHER REQUIREMENTS*

Citation	Requirement	Remarks
OSHA Worker Protection Requirements 29 CFR 1904 and 1910	These regulations establish requirements to protect workers who could be exposed to radiation, noise, hazardous wastes, or other contaminants or hazards at the remediation site.	This operable unit is a remediation site under CERCLA. Compliance with 29 CFR 1910.120 is required for all sites undergoing remediation by 40 CFR 300.150.
DOT Requirements for Transportation of Hazardous Materials 49 CFR 171-173, 177-179	No one may transport hazardous materials on public highways except in accordance with these regulations: Part 171 General requirements Part 172 This part establishes shipping papers, marking, labeling, placarding, and emergency response information requirements. Part 173 This part establishes packaging and other shipping requirements for hazardous materials, including radioactive materials. Part 177 Requirements of the transporter Part 178 Specifications for shipping containers	Applicable to those alternatives which involve transportation of the waste materials off site. Radioactive materials and materials sufficiently similar to hazardous wastes might be shipped off site.
Highway Improvement Act of 1982 23 USC 127	Establishes vehicle weight limits for interstate highways.	Applicable to those alternatives which involve transportation of the waste materials off site.
Hazardous Materials Transportation Act 49 USC §1801-1812	Establishes requirements for minimizing environmental impacts of spills or releases of hazardous materials.	Applicable to those alternatives which involve transportation of the waste materials off-site. Radioactive materials and materials sufficiently similar to hazardous wastes might be shipped off site.

TABLE B.4 (Continued)
OPERABLE UNIT 5 OTHER REQUIREMENTS

Citation	Requirement	Remarks
Transportation of Hazardous Waste Resource Conservation and Recovery Act 40 CFR §262.20, and .30 through .33. 40 CFR §263	A generator who transports, or offers for transportation, a hazardous waste for off site treatment, storage, or disposal must prepare a Manifest OMB control number 2050-0039 on EPA form 8700-22, and if necessary, EPA form 8700-22A, according to the instructions included in the Appendix to Part 262. Before transporting hazardous waste or offering hazardous waste for transportation off site, a generator must package, label, mark, and placard the waste in accordance with §§ 172, 173, 178, and 179 of the Department of Transportation regulations (49 cfr). Persons transporting hazardous waste within the United States must comply with the regulations of Part 263, including manifest requirements and management of accidental hazardous waste discharges.	Applicable to those alternatives which involve transportation of the waste materials off-site. Radioactive materials and materials sufficiently similar to hazardous wastes might be shipped off site.
Hazardous Waste Accumulation Time Resource Conservation and Recovery Act 40 CFR §262.34	A generator may accumulate hazardous waste on-site for 90 days or less without a permit or without having interim status, provided that it is stored according to the requirements of this section. A generator who accumulates hazardous waste for more than 90 days is an operator of a storage facility and is subject to the requirements of 40 CFR Parts 264 and 265 and the permit requirements of 40 CFR Part 270 unless he has been granted an extension to the 90-day period. Such an extension can be granted by EPA if hazardous wastes must remain on-site for longer than 90 days due to unforeseen, temporary, and uncontrollable circumstances.	Applicable to those alternatives which involve transportation of the waste materials off-site. Radioactive materials and materials sufficiently similar to hazardous wastes might be shipped off site.
NTS Waste Acceptance Criteria, Certification, and Transfer Requirements	Establishes the wastes that can be disposed at the facility.	NTS's acceptance criteria would be applicable to disposal at the NTS. NTS operates under DOE Order 5820.2A, "Radioactive Waste Management."
Envirocare Waste Acceptance Criteria Utah Bureau of Radiation Control, Radioactive Material License UT 2300249	Establishes the wastes that can be disposed at the facility.	Envirocare's acceptance criteria would be applicable to disposal at Envirocare.

TABLE B.4 (Continued)
OPERABLE UNIT 5 OTHER REQUIREMENTS*

Citation	Requirement	Remarks
National American Graves Protection and Repatriation Act 25 U.S.C. 3001	Provides for return of human remains and cultural objects from Native American graves to affiliated tribes.	Required as a matter of law for the alternatives affected.
Fish and Wildlife Coordination Act 16 U.S.C. 66 et seq.	Requires consultation with other state agencies for any activities which might affect any body of water for the purpose of conserving fish and wildlife resources.	Required as a matter of law for the alternatives affected.
Archaeological Resources Protection Act 16 USC 470 (a)	Requires permit for removal of any archaeological resources from federal lands.	Required as a matter of law for the alternatives affected.
Farmland Protection Policy Act 7 USC 4201 et. seq.	Requires protection and maintenance of farmland for its beneficial use as a national resource.	Required as a matter of law for the alternatives affected.
DOE 10 CFR 820 58 FR 43680 8/17/93	Procedural Rules for DOE Nuclear Activities	Required as a matter of law for the alternatives affected.
DOE 10 CFR 830 59 FR 15843 4/5/94	Nuclear Safety Management	Required as a matter of law for the alternatives affected.
DOE 10 CFR 835 58 FR 65458 12/14/93	Occupational Radiation Protection	Required as a matter of law for the alternatives affected.
DOE 10 CFR 860 58 FR 47984 9/14/93	Trespassing on Department of Energy Property	Required as a matter of law for the alternatives affected.
1540.1A	Materials Transportation and Traffic Management	Contractual obligation for activities at DOE facilities
5400.3	Hazardous and Radioactive Mixed Waste Program	Contractual obligation for activities at DOE facilities

000816

7069

TABLE B.4 (Continued)
OPERABLE UNIT 5 OTHER REQUIREMENTS*

Citation	Requirement	Remarks
5440.1E	NEPA Compliance Program	Contractual obligation for activities at DOE facilities
5480.1B	Environmental, Safety, and Health Program for DOE Operations	Contractual obligation for activities at DOE facilities
5480.3A	Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes	Contractual obligation for activities at DOE facilities
5480.4	Environmental Protection, Safety, and Health Protection Standards	Contractual obligation for activities at DOE facilities
5480.11	Radiation Protection for Occupational Workers	Contractual obligation for activities at DOE facilities
5483.1A	Occupational Safety and Health Programs for DOE Employees at Government-Owned, Contractor-Operated Facilities	Contractual obligation for activities at DOE facilities
5700.6C	Quality Assurance	Contractual obligation for activities at DOE facilities
6340.1A	General Design Criteria	Contractual obligation for activities at DOE facilities

* These other requirements are not ARARs or TBCs since they are not environmental regulations or guidance subject to waiver. These requirements must be complied with whenever they pertain to the location or activity.

TABLE B.5.A

COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH CHEMICAL-SPECIFIC ARARs

Chemical ARAR	Compliance Status	Alternatives That Must Meet Compliance
Applicable Chemical-Specific Federal ARARs		
EPA Regulations on National Emission Standards for Hazardous Air Pollutants 40 CFR 61 National Emission Standards for Emissions of Radionuclides other than Radon from DOE Facilities Subpart H	Existing site conditions currently attain compliance with this regulation through the application of active waste management and maintenance activities. Under the assumption of discontinuance of these active operations, conditions could deteriorate to cause these emission standards to be exceeded. Dust suppression techniques will be implemented during all phases of remedial action involving the handling of contaminated materials. Additionally, all soil treatment and wastewater treatment operations with a potential to emit radionuclides to the environment will be equipped with emission control devices (i.e. HEPA filters, etc.). Compliance will be maintained for all alternatives contemplating remedial action.	All
National Emission Standard for Radon Emissions from DOE Facilities 40 CFR 61 Subpart Q	The existing distribution of contaminants within the affected environmental media in Operable Unit 5 attains compliance with this requirement. For alternatives contemplating the consolidation of the contaminated media, the disposal facility design would need to accommodate sufficient barriers to ensure continued compliance. The conceptual design basis adopted for FS alternative evaluation includes the use of a radon barrier in the cell and multi-layered capping systems.	All, except No Action.
Lead in Air 40 CFR 50.12	Compliance will be met.	All, except No Action.

TABLE B.5.A (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH CHEMICAL-SPECIFIC ARARs

Chemical ARAR	Compliance Status	Alternatives That Must Meet Compliance
Relevant and Appropriate Chemical-Specific Federal ARARs		
National Primary Drinking Water Standards, Maximum Contaminant Levels and Proposed Maximum Contaminant Levels 40 CFR 141.11, 40 CFR 141.15 and 40 CFR 141.16	The existing conditions exhibit concentrations of contaminants in the aquifer exceeding MCL or proposed MCL concentrations. Affected groundwater in the glacial till (1 gpm sustained yield) and GMA exhibiting greater than MCL or proposed MCL concentrations will be extracted with recovery wells (or excavation) until asymptotic conditions are attained. The pumping/excavation operation is anticipated to reduce contaminant concentrations to less than the MCLs or proposed MCLs at all points in the aquifer system at and beyond the point of compliance. All water collected from Operable Unit 5 remedial activities will be treated in the AWWT and discharged. Compliance will be met.	All, except No Action. MCLs in the GMA for uranium proposed at (0.02 mg/L), antimony (0.006 mg/L), Chromium (0.05 mg/L), and radium 228 (20 pCi/L) will be met in 35 years. MCLs for arsenic (proposed at 0.05 mg/L) and radium-226 (20 pCi/L) are not anticipated to be achieved in the GMA due to technical constraints. Existing concentrations of these constituents in the GMA also exceed background concentrations. A waiver for technical impracticability under CERCLA may be required. Compliance with MCLs for COCs in perched groundwater are anticipated to be met over the course of remediation, within 22 years. Perched groundwater will be treated during excavation and consolidation.
Federal non-zero Maximum Contaminant Level Goals for Organic and Inorganic Chemicals 40 CFR 141.12, 40 CFR 141.50 and 40 CFR 141.51	See comment above	All, except No Action.

000829

TABLE B.5.A (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH CHEMICAL-SPECIFIC ARARs

Chemical ARAR	Compliance Status	Alternatives That Must Meet Compliance
Relevant and Appropriate Chemical-Specific Federal ARARs (Continued)		
The National Primary Drinking Water Standards, Maximum Contaminant Levels for Organic and Inorganic Chemicals 40 CFR 141.61 and 40 CFR 141.62	See comment above	All, except No Action. MCLs in the GMA for antimony (0.006 mg/L), arsenic (0.005 mg/L), chromium (0.05 mg/L), and radium 226-228 (5 pCi/L) are anticipated to be met in 35 years. MCLs for arsenic (proposed at 0.05 mg/L) and radium-226 (20 pCi/L) are not anticipated to be achieved in the GMA due to technical constraints. Existing concentrations of these constituents in the GMA also exceed background concentrations. A waiver for technical impracticability under CERCLA may be required. Compliance of MCLs for COCs in perched groundwater are anticipated to be met over the course of remediation, within 22 years. Perched groundwater will be treated during excavation and consolidation.
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR 192.02, Subpart A; 192.12(a), Subpart B; 192.20, Subpart C; 192.21(f) and 192.22(b), Subpart C; 192.32(b)(2), Subpart D; 192.40-192.42, Subpart E	Select portions of the site exhibit existing concentrations exceeding these requirements. Soil excavation efforts for radioactive environmental media will reduce the concentration of radium-226/radium-228/thorium-230 to required levels, in addition to reducing other residual radioactivity levels to be as low as reasonably achievable.	All, except No Action.
Chemicals in Drinking Water for a Solid Waste Disposal Facility 40 CFR 257.4	Waste generated from remedial activities may be disposed of in an on-property disposal facility. The disposal facility would be designed and the WAC established as to ensure the continued protection of the underlying regional aquifer system. Through the engineering design, complemented by the WAC, this standard would be attained.	2A, 3A, and 4A.

TABLE B.5.A (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH CHEMICAL-SPECIFIC ARARs

Chemical ARAR	Compliance Status	Alternatives That Must Meet Compliance
Relevant and Appropriate Chemical-Specific Federal ARARs (Continued)		
Chemicals in Drinking Water for a Hazardous Waste Disposal Facility 40 CFR 264.94	See comment above	2A, 3A, and 4A.
Lead Soil Cleanup Standards (Resource Conservation and Recovery Act) 40 CFR 268.41	The no action alternative would leave any soil exceeding these levels in place. Any soil or treatment sludges identified as exceeding this standard will be subjected to soil washing or cement stabilization prior to on-property or off-property disposal.	All, except No Action.
Applicable Chemical-Specific Ohio ARARs		
Ohio Water Quality Standards for Surface Water OAC 3745-1-04 and OAC 3745-1-07	All discharges to surface water will be controlled to the Great Miami River (permitted under NPDES) and to Paddys Run during the time period of active remediation. Stormwater, process wastewaters, sanitary sewage, and recovered groundwater will be managed for each remedial alternative to ensure the water quality standards are attained. The AWWT system and a new expansion of this facility will be employed to treat wastewater, stormwater, and recovered groundwater, as required, to ensure compliance with the standards. The no action alternative, which assumes discontinuance of site facilities maintenance and operation, would exceed these limitations.	All, except No Action.
Relevant and Appropriate Chemical-Specific Ohio ARARs		
General Radiation Protection Standards OAC 3701-38-15(A)(1),(B)	Compliance will be met.	All, except No Action.

TABLE B.5.B

COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH LOCATION-SPECIFIC ARARs

Location ARAR	Compliance Status	Alternatives That Must Meet Compliance
	Applicable Location-Specific Federal ARARs	
16 U.S.C. 470, National Historic Preservation Act and 36 CFR 60, 60.4, 63, 800	Prior to remedial activities, surveys will be conducted to determine the presence of any cultural resources. Identification of cultural resources identified will be either avoided or managed consistently with this requirement as agreed upon with DOE, SHPO, the Advisory Council in a signed programmatic agreement. Compliance will be met.	All, except no action
16 U.S.C. 1531, et seq., Endangered Species Act 50 CFR 402.01, 402.12, Interagency Cooperation-Endangered Species Act	Studies are being conducted to determine the presence of individuals and potential habitat of federally and state-listed animal and plant species. If habitat or individuals are found, appropriate mitigative measures would be implemented. Compliance will be met.	All
Archeological Resources Protection Act (16 USC § 47099 -47011) 43 CFR 7.4 (a), Protection of Archeological Resources	Compliance will be coordinated through Section 106 of the National Historic Preservation Act.	All, except no action
16 U.S.C. 431-433, Antiquities Act of 1906	Compliance will be coordinated through Section 106 of the National Historic Preservation Act.	All, except no action
16 U.S.C. 461-467, 469, and 470 Historic Sites Preservation Act	Compliance will be coordinated through Section 106 of the National Historic Preservation Act.	All, except no action
25 U.S.C. 3001, Native American Graves Protection and Repatriation Act	Compliance will be coordinated through Section 106 of the National Historic Preservation Act.	All, except no action
42 U.S.C. 1996, American Indian Religious Freedom Act	Prior to remedial activities, surveys will be conducted to determine the presence of these cultural resources. Cultural resources identified will be either avoided or managed consistently with this requirement. Compliance will be met.	All, except no action

TABLE B.5.B (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH LOCATION-SPECIFIC ARARs

Location ARAR	Compliance Status	Alternatives That Must Meet Compliance
Applicable Location-Specific Federal ARARs (Continued)		
42 U.S.C. 1424(e), Safe Drinking Water Act	Operable Unit 5 overlies a sole source aquifer (Great Miami Aquifer), which has been contaminated by site process activities. Contaminants will be removed during remedial activities. Compliance will be met.	All, except no action
DOE Compliance with Flood Plain/Wetlands Review Requirements 10 CFR 1022.3(a), (b)(1), (2), (3), (5), (6), (c), (d), (e): .5(b), (h), 11(a), (b), (c), .12(a), .15(a)	A wetland delineation has identified freshwater wetlands within the 1050 acre FEMP property boundary. Remedial activities relative to wetland impacts will be handled through the U.S. Army Corps of Engineers Nationwide Permit (NWP) Program where possible. When not covered by a NWP, the action will meet requirements mandated by individual permits per 33 CFR 323. Compliance will be met.	All, except no action
Dredge and Fill 33 CFR 323, 330, 40 CFR 230	See above comment.	All, except no action
Procedure for Implementing the National Environmental Policy Act 40 CFR 6.301(c)	Substantive requirements will be met through the revised secretarial policy on NEPA. Compliance will be met.	All
Executive Order 11990, Protection of Wetlands 40 CFR 6.302(a)	Remedial design will minimize impacts to wetlands. Any unavoidable impacts will be undertaken in accordance with 33 CFR 323 or 330. Any potentially impacted wetlands will be mitigated. Compliance will be met.	All
Executive Order 11988, Protection of Floodplains	Remedial activities will minimize impacts to Floodplains. Impacted Floodplain areas would be backfilled with clean soil and regraded to avoid alteration of flow patterns or uses of the Floodplain.	All
Procedure for Implementing the National Environmental Policy Act 40 CFR 6.302(h)	Substantive requirements will be met through the revised secretarial policy on NEPA. Compliance will be met.	All

TABLE B.5.B (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH LOCATION-SPECIFIC ARARs

Location ARAR	Compliance Status	Alternatives That Must Meet Compliance
Applicable Location-Specific Federal ARARs (Continued)		
Location of Solid Waste Disposal Facilities 40 CFR 257.3-2 40 CFR 258.12	Any planned disposal facility will be located so at to attain these statutory requirements.	2A, 3A, and 4A
Protection of Endangered and Threatened Wildlife and Plants 50 CFR 17.21, 17.31, 17.61, 17.71, and 17.94	All Federal agencies must ensure that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of the constituent elements essential to the conservation of a listed species within a defined critical habitat. Additional requirements apply if it is determined that a proposed activity could adversely affect these species or their habitat. Compliance will be met.	All
Protection and Enhancement of Cultural Environment Executive Order 11593 3 CFR 154	Compliance will be met for identification and preservation of cultural resources on Federal land, including natural landmarks.	All
Relevant and Appropriate Location-Specific Federal ARARs		
None Identified		
Applicable Location-Specific Ohio ARARs		
Ohio Endangered Species Regulations OAC 1501: 18-1 ORC 1518.02 and ORC 1531.25	Compliance will be met.	All

TABLE B.5.B (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH LOCATION-SPECIFIC ARARs

Location ARAR	Compliance Status	Alternatives That Must Meet Compliance
Applicable Location-Specific Ohio ARARs (Continued)		
Hazardous Waste Facility Environmental Impact OAC 3734.05 (D)(6)(c)	Compliance will be met.	All
Hazardous Waste Facility Minimum Risk OAC 3734.05 (D)(6)(d)	Compliance will be met.	All, except no action.
Water use for Southwestern Ohio Tributaries OAC 3745-01-17 and OAC 3745-01-21	Compliance will be met.	All, except no action.
Ohio Solid Waste Regulations OAC 3745-27-07(A) and (B) and OAC 3745-27-09(Y)	Any proposed disposal facility will be sited such that the facility and any associated leachate collection system will be located out of a floodway or floodplain.	2A, 3A, and 4A
State Water Quality Certifications OAC 3745-32-02	Required certifications would be attained prior to completing excavation or backfill operations within wetlands or waters of the United States. Compliance will be attained.	All
Relevant and Appropriate Location-Specific Ohio ARARs		
None Identified		

TABLE B.5.C

COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Applicable Action-Specific Federal ARARs		
Preparing and Transporting Hazardous Waste Off-site 40 CFR 262.20 through 262.23, .30 and .33 Subparts B and C OAC 3745-53-20 through 31 OAC 3745-52-30 and 33	Hazardous waste that will be disposed of off site will comply with all substantive and administrative requirements.	All except No Action.
Groundwater Monitoring Program 40 CFR 265.90(d) Subpart F OAC 3745-65-90(d)	This requirements is being and will be met via the September 10, 1993, Ohio EPA Director's Final Findings and Orders (DFOs).	All except No Action.
Corrective Action Management Unit 40 CFR 264.552 Subpart S	A CAMU will be designated at the FEMP to include areas undergoing remedial action. The CAMU will encompass the area of excavation, the on-property disposal facility, and consolidation areas.	All except No Action.
Air Emission Standards for Process Vents 40 CFR 264.1030, 264.1032 through 264.1034 Subpart AA	Units that will treat soils and wastes contaminated with organic compounds will comply with air emission standards by employing control devices and monitoring.	All except No Action.
Land Disposal Restrictions and Contaminated Debris 40 CFR 268.40 through 268.44, 268.45 Subpart D OAC 3745-59	Hazardous waste and associated debris will be treated to treatment standards for off-site disposal. On-property disposal will not require land-disposal treatment standards because of management under the CAMU Rule.	All except No Action.

TABLE B.5.C. (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Applicable Action-Specific Federal ARARs (Continued)		
Post Closure Care 40 CFR 265.117 Subpart G OAC 3745-66-17	Post-closure care requirements will be met for all alternatives which leave residual contaminants at the site which exceed risk-based cleanup values. The requirement will be satisfied by including such monitoring and maintenance requirements into the operations & maintenance phase of the CERCLA response action.	All except No Action and Alternative 1.
Underground Storage Tank (UST) Closure 40 CFR 280.60 through 280.66 Subpart F OAC 1301:7-7-36	All USTs and related petroleum-contaminated soils will undergo full closure per the requirements during the CERCLA remedial action.	All except No Action.
Best Management Practices Programs (BMP) 40 CFR 125.104 Subpart K	The BMP requirements will be met via conducting the FEMP's BMP. The BMP Plan will be progressively updated to accommodate changing site activities during the conduct of CERCLA remedial actions.	All except No Action.
PCB Disposal, Treatment, and Storage 40 CFR 761.60(a)(4), (e), and 761.65 Subpart D	In the event that soils contaminated by at least 50 ppm PCBs are encountered, PCB disposal, treatment, and storage requirements will be met. PCB-contaminated soil will be either treated on site at the source location or shipped off site for disposal. PCB-contaminated soils will be stored in facilities that meet PCB storage requirements.	All except No Action.
Noise Control 42 USC 4901 42 USC 7641	Engineering controls and best management practices will be implemented to reduce noise to the maximum extent practicable during the remedial action.	All except No Action.
Particulate Air Emissions 40 CFR 50.6 (a), (b), (c)	Compliance will be met.	All except No Action.

000857

TABLE B.5.C. (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Relevant and Appropriate Action-Specific Federal ARARs		
Empty Containers of Hazardous Waste 40 CFR 261.7 Subpart A OAC 3745-51-07	Containers that have held hazardous wastes will be considered empty if the requirements in the rule are met.	All except No Action.
Hazardous Waste Determination 40 CFR 262.11 Subpart A OAC 3745-52-11	Material such as soils and other environmental media and residues from soil treatment will be evaluated to determine if the material contains or is a hazardous waste.	All except No Action.
Groundwater Protection Standard 40 CFR 264.92 through 246.100 Subpart F OAC 3745-54-92 through 100	Groundwater monitoring for the on-property disposal facility will comply with the substantive requirements.	2A, 3A, and 4A.
Storage Area Closure 40 CFR 264.178 Subpart I OAC 3745-55-78	Substantive closure requirements for container storage areas will be met after the storage area is no longer needed for the CERCLA remedial action.	All except No Action.
Minimum RCRA Landfill Design Requirements for Closure 40 CFR 264.310 Subpart N OAC 3745-68-10	The final closure substantive requirements will be met in the on-property disposal facility design.	2A, 3A, and 4A.
Containment Building 40 CFR 264.1100 through .1102 Subpart DD	Design and operation of the containment building(s) (Central Storage Facility) will comply with the design, operation, and closure and post-closure care substantive requirements.	All except No Action.

TABLE B.5.C. (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Relevant and Appropriate Action-Specific Federal ARARs (Continued)		
Treatment, Storage, and Disposal General Facility Standards 40 CFR 265.13 through 265.16 Subpart B OAC 3745-65-13 through 16 Treatment, Storage, and Disposal Facility Preparedness and Prevention 40 CFR 265.31 through 265.35, 265.37 Subpart C OAC 3745-65-31 through 35, 37 Treatment, Storage, and Disposal Facility Contingency Plan and Emergency Procedures 40 CFR 265.51 and 265.52, 265.55 and 265.56 Subpart D OAC 3745-65-51 and 52, 55 and 56	All general RCRA facility standards will be met during the CERCLA remedial action.	All except No Action.
Closure Performance Standard for HWMUs 40 CFR 265.111, 265.114 Subpart G OAC 3745-66-11 and 14	All HWMUs will be closed clean or via a risk-based closure integrated with the CERCLA process. The HWMU structures and contaminated soils will be fully addressed by decontamination and dismantlement under OU3, and excavation, treatment, and on- or off-site disposal of soils under OU5.	All except No Action.
Condition of Containers 40 CFR 265.171 through 265.174, 265.175(a)-(c), 265.176, and 265.177 Subpart I OAC 3745-66-71 through 74, 76, 77 OAC 3745-55-75	Container storage requirements for hazardous wastes will be complied with by following the FEMP drum management plan as required by the SACD. Container storage areas will meet the requirements for containment systems.	All except No Action.

TABLE B.5.C. (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Relevant and Appropriate Action-Specific Federal ARARs (Continued)		
Closure of Tank Systems 40 CFR 265.197 Subpart J OAC 3745-66-97	Existing tank and container storage HWMUs are proposed to be closed through an integrated RCRA/CERCLA process. The affected soils associated with these HWMUs will be removed to attain risk-based cleanup values for each COC to fulfill RCRA closure requirements. Any new tank systems or container storage facilities installed to facilitate CERCLA remedial actions will be "closed" consistent with these substantive requirements.	All except No Action.
Control of Residual Radioactive Materials 40 CFR 192.02(a) Subpart A	The control standards will be met in the design and operation of the on-property disposal facility multi-layered capping system and consolidation area. Alternative 1 would comply by removing the residual radioactive material from the site.	All except No Action.
Implementation 40 CFR 192.20 Subpart C	Compliance with the implementation requirements is met through the use of a verification and certification sampling program and the use of groundwater models for evaluating the long-term effectiveness of residual alternatives.	All except No Action.
Management of Uranium Byproduct Materials 40 CFR 192.30 through 34 Subpart D	The design of the on-property disposal facility capping systems and consolidation concept will attain these standards. Alternatives involving soil washing would not adequately attain these requirements.	All except No Action.
Solid Waste Disposal Facility Design Criteria 40 CFR 258.40 Subpart D	The on-property disposal facility design will, at a minimum, comply with the federal design standards for municipal solid waste landfills.	2A, 3A, and 4A.
PCB Cleanup Policy 40 CFR 761.120, .125, .130 Subpart G	The PCB Cleanup Policy will be followed for addressing soil contaminated with PCBs.	All except No Action.

TABLE B.5.C. (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Applicable Action-Specific Ohio ARARs		
Analytical and Collection Procedures OAC 3745-01-03	The analytical methods and collection procedures specified in this requirement will be utilized for surface water discharges.	All except No Action.
Antidegradation Policy OAC 3745-01-05 40 CFR 131.12	The remedial action will ensure that existing in stream water uses of Paddys Run and the Great Miami River will be maintained.	All except No Action.
Abandonment of Test Holes and Wells OAC 3745-09-10	Existing FEMP water supply wells and all wells used in support of the RI/FS, removal actions, remedial actions, and RCRA groundwater monitoring will be properly plugged and abandoned in accordance with abandonment requirements after they are no longer needed.	All except No Action.
Malfunction and Maintenance of Air Pollution Control Equipment OAC 3745-15-06 (A)(1) and (A)(2)	Scheduled maintenance will be established for pollution control equipment, as well as time periods when the pollution source will be shut-down during maintenance.	All alternatives that involve air pollution control equipment.
General Provisions on Air Pollution Control OAC 3745-15-07	Air pollution nuisance prohibitions will be met by employing best management practices such as dust control and air monitoring during the CERCLA remedial action.	All except No Action.
Stack Height Requirements OAC 3745-15-12 (B) and (C)	The stack height requirements will be met for alternatives using low-temperature thermal desorption units.	All alternatives that involve low-temperature thermal desorption for RCRA hazardous organics removal.
Restriction on Particulate Emissions from Industrial Processes OAC 3745-17-11	Emission restrictions will be met during soil staging, stabilization, and treatment by using proper operations, maintenance, management, and monitoring.	All except No Action.

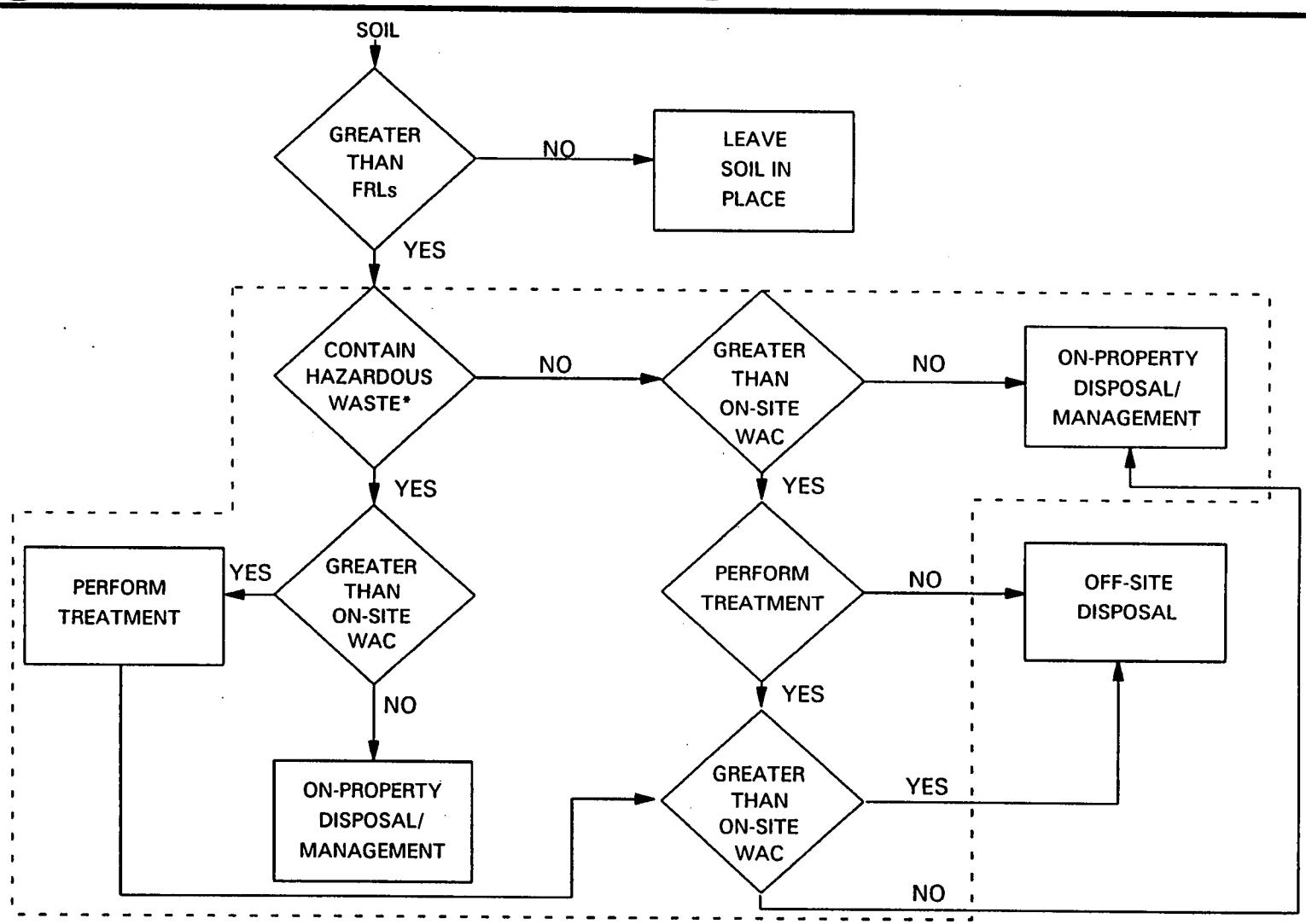
TABLE B.5.C. (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Applicable Action-Specific Ohio ARARs (Continued)		
Particulate Ambient Air Quality Standards OAC 3745-17-02 (C)(D)	Compliance will be met.	All except No Action.
Particulate Ambient Air Quality Standards OAC 3745-17-05	Compliance will be met.	All except No Action.
Solid Waste Disposal Facility Construction Requirements OAC 3745-27-08(C)(1) through (9), (D) through (H)	The on-property disposal facility construction design will meet the sanitary landfill substantive design requirements.	2A, 3A, and 4A.
Solid Waste Disposal Facility Operations OAC 3745-27-09(D) through (F), (K) through (Q) OAC 3745-27-19	The on-property disposal facility operations will meet these requirements.	2A, 3A, and 4A.
Groundwater Monitoring OAC 3745-27-10	Groundwater monitoring for the on-property disposal facility will fulfill these requirements.	2A, 3A, and 4A.
Solid Waste Disposal Facility Closure OAC 3745-27-11(B);(G)(1) through (3), (7)	Final "closure" of the on-property disposal facility will meet these requirements.	2A, 3A, and 4A.
Solid Waste Disposal Facility Post Closure OAC 3745-27-14	Substantive requirements for post-closure care of the on-property disposal facility will be included in the operations and maintenance phase of the CERCLA response action.	2A, 3A, and 4A.
Underground Injection Control Program OAC 3745-34-01 OAC 3745-34-13	The re-injection of treated groundwater into the GMA will comply with substantive requirements.	All alternatives that involve the re-injection of treated groundwater into the GMA.

TABLE B.5.C. (Continued)
COMPLIANCE STATUS OF OPERABLE UNIT 5 ALTERNATIVES WITH ACTION-SPECIFIC ARARs

Action-Specific ARAR	Compliance Status	Alternatives That Must Meet Requirement
Applicable Action-Specific Ohio ARARs (Continued)		
Injection of Wastes into Wells ORC 6111.043 ORC 6111.044 to ORC 6111.049	The re-injection of treated groundwater into the GMA will comply with substantive requirements.	All alternatives that involve the re-injection of treated groundwater into the GMA.
Relevant and Appropriate Action-Specific Ohio ARARs		
Abandonment of Test Holes and Wells OAC 3745-09-10	All monitoring wells, piezometers and lysimeters will be plugged and abandoned per these requirements after they are no longer needed.	All except No Action.
Quality Standards, Particulate in Air OAC 3745-17-07, (B)(4), (5), (6)	Appropriate mitigative measures will be applied to all excavations and material movement activities to reduce fugitive emissions. All point sources associated with a remedial alternative (i.e., sludge dewatering, etc) will employ best available emissions control technologies to mitigate particulates emissions. All alternatives will attain compliance with this requirement.	All except No Action.
Restriction of Emission of Fugitive Dust OAC 3745-17-08	Fugitive dust control will be achieved by employing control measures during grading, loading, and construction operations while soil is handled.	All except No Action.
Ohio NPDES Permits OAC 3745-33-05 40 CFR 122.41 Subpart C	Point-source discharges will have been treated by the AWWT. Compliance with general permit conditions for wastewater discharges will be met by employing proper operation and maintenance and monitoring during the operations and maintenance phase of the CERCLA response action.	All except No Action.

000833



NOTES: = WASTE TO BE MANAGED UNDER CORRECTIVE ACTION MANAGEMENT UNIT (CAMU) RULE

* RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) IS APPLICABLE FOR OFF-SITE DISPOSAL AND LAND DISPOSAL RESTRICTIONS (LDR) MUST BE MET

FRL - FINAL REMEDIATION LEVEL

WAC - WASTE ACCEPTANCE CRITERIA

FINAL

F:\FL4\FIGB-1.DRW - DAZ

FIGURE B-1. WASTE MANAGEMENT FLOW CHART

000834

- 2069

APPENDIX C

CALCULATIONS OF RISK-BASED PRELIMINARY REMEDIATION GOALS FOR THE OPERABLE UNIT 5 FEASIBILITY STUDY

TABLE OF CONTENTS

	Page
List of Tables	c-iii
List of Acronyms and Abbreviations	c-iv
C.1.0 Introduction	C-1-1
C.2.0 Risk-based PRG Development	C-2-1
C.2.1 Methods	C-2-1
C.2.2 Preliminary Remediation Goals for Soil	C-2-4
C.2.3 Preliminary Remediation Goals for Groundwater	C-2-7
C.2.4 Preliminary Remediation Goals for Surface Water	C-2-8
C.2.5 Preliminary Remediation Goals for Surface Soil for a Consumer of Milk and Meat Products	C-2-9
C.2.6 Preliminary Remediation Goals for Sediment	C-2-10
C.3.0 Calculation of Unit Risks	C-3-1
C.3.1 Air Exposures	C-3-1
C.3.1.1 Inhalation	C-3-1
C.3.1.2 Ingestion of Vegetables Contaminated by Aerial Deposition	C-3-3
C.3.1.3 Ingestion of Meat or Milk Produced Downwind of Source	C-3-6
C.3.1.4 Calculation of an ILCR from a Combination of All Airborne Exposure Pathways	C-3-10
C.3.2 Groundwater Exposures	C-3-11
C.3.2.1 Drinking Water Ingestion Pathway	C-3-12
C.3.2.2 Irrigation of Vegetables	C-3-13
C.3.2.3 Ingestion of Beef and Dairy Products Produced with Groundwater	C-3-15
C.3.2.4 Calculation of ILCR for Groundwater	C-3-19
C.3.3 Soil Exposures	C-3-19
C.3.3.1 Incidental Ingestion of Soil	C-3-20
C.3.3.2 Ingestion of Vegetables Grown in Contaminated Soil	C-3-21
C.3.3.3 Ingestion of Meat or Milk	C-3-23
C.3.3.4 Direct Radiation Exposure	C-3-26
C.3.3.5 Calculation of Aggregate Risks For On-Property Resident from All Soil Pathways	C-3-27
C.3.4 Surface Water Exposures Including Household Use	C-3-28
C.3.4.1 Drinking Water Ingestion Pathway	C-3-28
C.3.4.2 Incidental Ingestion of Surface Water While Swimming	C-3-29
C.3.4.3 Ingestion of Beef and Dairy Products Produced with River Water	C-3-29
C.3.5 Sediment Exposures	C-3-31

	Page
C.3.5.1 Incidental Ingestion of Sediment	C-3-31
C.3.5.2 Direct Radiation Exposure	C-3-32
C.3.5.3 Calculation of Aggregate Risks for Youth from All Sediment Pathways	C-3-32
C.3.6 Multiple Age Group Receptors	C-3-33
C.4.0 Toxicological Information	C-4-1
C.4.1 Introduction	C-4-1
C.4.2 Toxicity Criteria	C-4-1
C.4.2.1 Noncarcinogenic Toxic Effects	C-4-1
C.4.2.2 Chemical Carcinogen Risk	C-4-3
C.4.2.3 Radiocarcinogens	C-4-4
C.4.3 Quantifying Dermal Exposure Risks	C-4-6
C.4.4 Toxicity Equivalence Factors	C-4-7
C.4.5 Toxicological Profiles	C-4-9
C.4.5.1 Arsenic	C-4-9
C.4.5.2 Magnesium	C-4-11
C.4.5.3 Manganese	C-4-12
C.4.6 Assessing Background in the Derivation of PRGS/PRLS	C-4-15
List of References	C-4-23

000837

LIST OF TABLES

		Page
C.2-1a	Risk-Based PRGs for Surface Soil Based on Exposure to the On-property RME Farmer	C.2-11
C.2-1b	Risk-Based PRGs for Surface Soil Based on Exposure to the On-property Child	C.2-14
C.2-2	Risk-Based PRGs for Surface Soil Based on Commercial/Industrial Land Use	C.2-17
C.2-3	Risk-Based PRGs for Surface Soil Based on Exposure to the Recreational User - Developed Park.	C.2-20
C.2-4	Risk-Based PRGs for Surface Soil Based on Exposure to the Recreational User - Undeveloped Park.	C.2-23
C.2-5	Risk-Based PRGs for Surface Soil Based on Exposure to the Recreational User - Wildlife Reserve.	C.2-26
C.2-6	Risk-Based PRGs for Surface Soil Based on Exposure to the Expanded Trespasser	C.2-29
C.2-7	Risk-Based PRGs for the Great Miami Aquifer Based on Exposure to the On-property RME Farmer	C.2-32
C.2-8	Risk-Based PRGs for the Perched Groundwater Based on Household Use of Perched Groundwater	C.2-35
C.2-9	Risk-Based PRGs for Surface Water Based on Exposure to the Expanded Trespasser/Recreational.	C.2-38
C.2-10	Risk-Based PRGs for Surface Water Based on Exposure to the Consumer of Meat and Milk Products.	C.2-41
C.2-11	Risk-Based PRGs for Surface Soil Based on Exposure to the Consumer of Meat and Milk Products.	C.2-44
C.2-12	Risk-Based PRGs for Sediment Based on Exposure to the Expanded Trespasser/Recreational Receptors	C.2-47
C.3-1	Partitioning Coefficient and Biotransfer Factors for Constituents of Potential Concern for OU5	C.3-37
C.3-2	Summary of Parameters for Biouptake Models	C.3-45
C.4-1	Manganese Concentrations in Selected Foods	C.4-16
C.4-2	Toxicity Criteria for Operable Unit 5 Contaminants of Concern	C.4-17
C.4-3	Summary of Cancer Slope Factors Available for FEMP Radionuclide Contaminants	C.4-22

LIST OF ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable
ARAR	applicable relevant and appropriate requirement
ARL	acceptable risk level
AT	averaging time
BW	body weight
CDD	chlorinated dibenzo-p-dioxin
CDF	chlorinated dibenzofurans
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm^3	cubic centimeter
COC	contaminant of concern
CSF	cancer slope factor
d	day
DOE	U.S. Department of Energy
ED	exposure duration
EF	exposure frequency
EPA	U.S. Environmental Protection Agency
ET	exposure time
FEMP	Fernald Environmental Management Project
FI	fraction ingested
FS	feasibility study
g	gram
GI	gastrointestinal
h	hour
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
IR	inhalation rate
IRIS	Integrated Risk Information System
kg	kilogram
L	liter
LOAEL	lowest observable adverse effect level
m	meter
m^2	square meter
m^3	cubic meter
MCLG	maximum contaminant level goal
mg	milligram
ml	milliliter

LIST OF ACRONYMS
(Continued)

NCP	National Contingency Plan
NOAEL	no observable adverse effect level
NPL	National Priorities List
ORP	Office of Radiation Programs
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCi	picocuries
ppm	parts per million
PRG	preliminary remediation goal
PRL	preliminary remediation level
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
RSC	relative source contribution
SF	slope factor
TCDD	tetrachlorodibenzo-p-dioxin
TEF	toxicity equivalence factor
TF	transfer factor
U	uranium
UCL	upper confidence limit
UR	unit risk
V	velocity
y	year

C.1.0 INTRODUCTION

This appendix summarizes the calculation of risk-based preliminary remediation goals (PRGs) for the Operable Unit 5 Feasibility Study (FS). Risk-based PRGs are chemical-specific, medium-specific concentrations for individual contaminants that are calculated for target receptors that consider all contaminants and all pathways found to be of concern in the baseline risk assessment of the Operable Unit 5 Remedial Investigation (RI) Report.

Risk-based PRGs are only one consideration in the development of preliminary remediation levels, as discussed in Section C.2.0. PRGs must also comply with applicable relevant and appropriate requirements (ARARs) and be protective of human health and the environment via cross-media impacts. This appendix presents only the methods for calculation of risk-based PRGs. Risk-based PRGs are presented for groundwater, soil, surface water, and sediment. To illustrate PRG development, example calculations are provided for uranium-238 in this appendix. Section C.2.0 discusses the methods for developing risk-based PRGs using unit risks. Section C.3.0 presents the methods for calculating unit risks. Section C.4.0 presents a summary of the toxicological information used for this FS.

C.2.0 RISK-BASED PRG DEVELOPMENT

C.2.1 METHODS

Potential health effects resulting from exposures to radioactive and chemical contaminants are divided into two categories: carcinogenic and noncarcinogenic effects. For carcinogens, the U.S. Environmental Protection Agency (EPA) has identified in the National Contingency Plan (NCP) a target range for acceptable risk from 1 in 1,000,000 (10^{-6}) to 1 in 10,000 (10^{-4}) to limit the possibility that an individual will develop cancer due to exposures to residual contaminants at a National Priorities List (NPL) site (EPA 1991b, EPA 1989b). As part of cleanup at NPL sites, EPA strives to manage possible incremental cancer risks within the target range, with 10^{-6} generally serving as the point of departure. For sites where the total estimated incremental lifetime cancer risk (ILCR) for each receptor is less than 10^{-4} and the hazard index (HI) is less than 1, action may not be warranted. The HI represents the sum of hazard quotients (HQs) for multiple contaminants of concern (COCs) and/or multiple exposure pathways. The HQs are ratios of a single COC exposure level developed over a specified time period to a RfD developed over a similar time period. Therefore, a HI of less than 1 means the exposure to the toxicant is less than that which would cause a toxic health effect.

Although the upper end of the target range is generally used to make risk management decisions to determine whether or not remedial actions are necessary or warranted, EPA does not consider 10^{-4} a discrete limit. That is, risks above that level may be considered generally acceptable based on site-specific conditions (EPA 1991b). However, for purposes of PRG development, the range of 10^{-6} to 10^{-4} was used for calculation purposes.

The following general principles for carcinogenic and noncarcinogenic constituents were applied for development of risk-based PRGs:

- Exposures to radionuclides should be reduced to levels as low as reasonably achievable (ALARA) as limited by the natural presence of radionuclides in the soil and groundwater and/or result in an ILCR of less than 10^{-4}.
- Exposures to carcinogenic chemicals should not result in an ILCR of more than 10^{-4}.
- Exposures to noncarcinogenic constituents should not result in significant adverse health effects which is for a given target organ, indicated by a HI greater than 1.0.

In developing risk-based PRGs, target risk levels are established for carcinogens and target HIs are established for noncarcinogens. Once established, these target risk levels are used in calculating the PRGs.

One goal of the NCP is to manage total site-wide risks such that the sum of all risks does not exceed 10^{-4}. In keeping with the NCP, PRGs were calculated for 10^{-4}, 10^{-5}, and 10^{-6} risk levels to encompass the range of acceptable risk for remediation of sites with carcinogenic compounds.

EPA indicates that the cumulative site HI should be less that 1.0. However, no EPA guidance is available on apportioning the allowable level among the range of constituents in various environmental media. The most relevant guidance is provided by the Office of Drinking Water which, in calculating maximum contaminant level goals (MCLGs), uses a relative source contribution (RSC) factor to account for other sources of exposure (EPA 1989a). Because it is not known what additional sources are contributing to total exposure, this default RSC of 0.2 was used to develop chemical- and media-specific PRGs to ensure that the total HI does not exceed 1.0.

The EPA's methods under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which is set forth in recent guidance such as the Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual (Part A) (EPA 1989b) and its supporting documents, use a specific method to calculate human health effects. Exposures are first quantified using a set of equations and parameters that are unique to each exposure pathway. The exposure assessment process results in calculated daily intakes [expressed in milligram per kilogram day (mg/kg-day)] for hazardous chemical contaminants and radioactivity intakes [expressed in picocurie per lifetime (pCi)/lifetime] for radionuclide contaminants. The calculated intakes are then multiplied by an appropriate carcinogenic slope factor (SF) to calculate ILCR or divided by a constituent's reference dose (RfD) to yield a HQ. The calculation of a unit risk (risk per unit of concentration) involves merely the substitution of one for the concentration term in a standard intake equation. This unit intake is then either multiplied by a cancer SF to calculate a unit risk or divided by an RfD to calculate a unit toxicity value.

The slope factors cited in the Integrated Risk Information System (IRIS) (EPA 1994b) and Health Effects Assessment Summary Tables (HEAST) (EPA 1994a) are assumed to be linear below risk levels of 10^{-2}. Thus, because risks are linear within the acceptable risk range (10^{-6} to 10^{-4}), these exposure equations can be used to calculate risk-based acceptable concentrations or PRGs. The general procedures for rearranging these standard risk equations for PRG calculation is provided by EPA (1991b).

Risk-based PRGs were developed upon completion of the baseline risk assessment by considering applicable land use scenarios, receptors, exposure parameters, and COCs applicable for Operable Unit 5. These assumptions were also evaluated to determine whether refinements are required for the FS.

For purposes of providing additional information for use in decision making, PRGs were developed for all land uses (i.e., agricultural, commercial/industrial, and recreational) and included restricted access (trespassing). These land use scenarios consider future uses with and without the assumption of continued federal ownership. Within each land use scenario, critical receptors are identified for calculation of risk-based PRGs.

To develop the PRGs for the hypothetical future land use without continued federal ownership, an on-property resident farmer and an on-property child were adopted as the most conservative reference receptors. PRGs were also developed for a consumer of meat and milk products from cattle which graze on-property to give reference or comparison concentrations for a more limited agricultural land use than that assumed for the on-property farmer.

For the purposes of developing PRGs for the future land use with continued federal ownership scenario, a series of hypothetical on-property reference receptors were considered, which represent alternative land uses including:

- A groundskeeper, representing commercial/industrial land use
- Recreational receptors, including adults and children who would visit the site if developed as either a:
  - wildlife reserve
  - neighborhood park with open space (i.e., no development)
  - a neighborhood park with developed recreational facilities and organized sporting events
- Expanded trespasser assuming restricted access with institutional controls on land use.

The purpose of identifying a range of hypothetical receptors from agricultural to commercial or industrial, to recreational, to trespassing is to evaluate potential site land uses based on a tiered approach from least restrictive land use (agricultural) to most restrictive (trespassing). An overview of risk-based PRGs for soil, groundwater, surface water, and sediment is provided below.

For each of the receptors, the risk-based PRG was derived from standard risk equations from the Risk Assessment Guidance (EPA 1989b) as specified in the Fernald Environmental Management Project (FEMP) Risk Assessment Work Plan Addendum (DOE 1992). Generally, risk-based PRGs are derived independent of site concentrations and consider only the receptor's potential exposure (or contact rate) to a particular medium. This contact rate without regard to site concentration is the unit risk/unit toxicity approach previously defined.

For this FS, risk-based PRGs for a particular compound in a particular medium are evaluated using multiple exposure pathways. As a result, a single equation to calculate a risk-based PRG is too

unwieldy to present here in a concise manner. Therefore, to simplify the presentation of risk-based PRGs for this appendix, the presentation will first calculate the unit risk for a receptor exposed to a compound from individual exposure pathways and then calculate cumulative exposure by summing overall exposure pathways to provide a total unit risk value (i.e., unit risk or unit toxicity value). These unit risk values were derived using the exposure parameters and intake equations discussed in Section A.3 of the Operable Unit 5 Baseline Risk Assessment (DOE 1994b), the appropriate slope factor (SF) or reference dose (RfD), and of unit concentration of 1.0 for each constituent in each media evaluated. The relationship between unit risk (UR) or unit toxicity and a medium-specific PRG can be described with a standard PRG equation as follows:

$$PRG = \frac{ARL}{\sum UR} \qquad (C.2\text{-}1)$$

where

ARL	=	an acceptable risk level (target risk) or an acceptable unit toxicity value
UR	=	unit risk (total risk for a constituent in a media per unit concentration of 1.0 for that constituent)

Example calculations for deriving a UR are provide in section C.3.0.

C.2.2 PRELIMINARY REMEDIATION GOALS FOR SOIL

Risk-based PRGs for soil for full unrestricted land use were based on exposure pathways applicable for the on-property resident farmer via the inhalation of dusts, consumption of farm products contaminated by dust deposition, incidental ingestion of soil, dermal contact, and external radiation pathways associated with the soil. Risk-based PRGs for soil were calculated for the off-property farmer via inhalation of particulates and consumption of farm products contaminated by dust deposition. Risk-based PRGs for soil were calculated for continued government ownership based on the groundskeeper, recreational receptors, and expanded trespasser through the inhalation of dusts, incidental ingestion of soil, dermal contact, and external radiation pathways associated with the soil. These receptor exposure scenarios are more fully described in the Operable Unit 5 Baseline Risk Assessment (Appendix A) of the Operable Unit 5 RI Report (DOE 1994b) and in Appendix H of this document, including all exposure assumptions and exposure models used.

Tables C.2-1 to C.2-6 present health based PRGs for soil exposures for all applicable on-property land uses using the appropriate receptors. These PRGs also apply to off-property land uses and receptors where localized off-property contamination has occurred. The tables are:

- Table C.2-1a On-property Reasonable Maximum Exposure (RME) Farmer
- Table C.2-1b On-property RME Child
- Table C.2-2 Commercial or Industrial Worker (also referred to as a Groundskeeper)
- Table C.2-3 Recreational User of a Developed Park
- Table C.2-4 Recreational User of an Undeveloped Park
- Table C.2-5 Recreational User of a Wildlife Reserve
- Table C.2-6 Expanded Trespasser on a Government Reserve

PRGs are presented for three risk levels in these tables. They are 10^{-6}, 10^{-5}, and 10^{-4}. The PRGs for noncarcinogenic health effects are based on a HQ of 0.2. If the COC is a carcinogen and there are also RFDs available for noncarcinogenic effects, PRGs for both considerations were calculated. The smallest PRG (either the PRG based on an ILCR of 10^{-6}, 10^{-5}, or 10^{-4} or the PRG based on an HQ of 0.2) calculated was inserted in the table.

For the derivation of these risk-based PRGs, the short half-life progeny of radionuclides present at the FEMP site have been included within the results of the PRG calculation for the parent isotope by including the progeny risks in the parent SF.

To support the derivation of PRGs for soil, it is assumed that the receptors are exposed to the COCs from both direct and indirect exposure pathways. For example, risk-based PRGs for the on- and off-property farmer are exposed to constituents in soil from direct contact (i.e., incidental ingestion, dermal contact, and direct irradiation) as well as indirect contact through resuspension of dust from soil that is inhaled by the receptor and deposited on the crops and forage. Dust resuspension and transport modeling was performed for Operable Unit 5 to examine exposure point concentrations both on- and off-property as a result of baseline conditions for the RI and with implementation of various remedial alternatives in the FS. These modeling results were used to calculate a transport factor or resuspension factor which is ultimately used to calculate soil concentration-based PRGs. The soil to air transfer factor (TF) used for dust for Operable Unit 5 is 2.0×10^{-5} grams per cubic meter (g/m^3). Support for use of this particular transfer factor is provided in the Fate and Transport Modeling [Appendix F of the Operable Unit 5 RI Report (DOE 1994b)]. This TF is used to relate the concentration of a constituent in soil to that in the air as follows:

$$\textit{Air concentration } (pCi/m^3) = \textit{Soil Concentration } (pCi/g) \times TF\ (g/m^3) \qquad \text{(C.2-2)}$$

The on-property resident farmer is assumed to occupy a home and conduct agricultural activities on the residual soil within Operable Unit 5. The resident farmer is exposed to COCs in soil by incidental ingestion, dermal contact, consumption of meat, milk, and garden produce, and direct

external radiation. The meat, milk, and produce will accumulate COCs from root uptake and aerial deposition of particulates on plant surfaces. The UR for each of these pathways are calculated using a unit exposure concentration of 1.0 and then summed together to yield a total UR. For uranium (U)-38, these are summarized through the use of unit risks for air and soil exposure pathways as follows:

Air exposures:		
Unit risk for inhalation of dust	=	2.78×10^{-3} (pCi/m^3)$^{-1}$
Unit risk for ingestion of fruit and vegetables	=	1.49×10^{-5} (pCi/m^3)$^{-1}$
Unit risk for ingestion of meat	=	3.45×10^{-7} (pCi/m^3)$^{-1}$
Unit risk for ingestion of milk	=	4.14×10^{-6} (pCi/m^3)$^{-1}$
Sum of unit risk for air exposures (UR_a)	=	2.8×10^{-3} (pCi/m^3)$^{-1}$
Soil Exposures:		
Unit risk for incidental ingestion	=	8.8×10^{-8} (pCi/g)$^{-1}$
Unit risk for external radiation	=	2.12×10^{-6} (pCi/g)$^{-1}$
Unit risk for ingestion of fruit and vegetables	=	5.12×10^{-8} (pCi/g)$^{-1}$
Unit risk for ingestion of meat	=	6.8×10^{-9} (pCi/g)$^{-1}$
Unit risk for ingestion of milk products	=	8.16×10^{-8} (pCi/g)$^{-1}$
Sum of unit risk for soil exposures (UR_s)	=	2.35×10^{-6} (pCi/g)$^{-1}$

Development of URs is presented in Section C.3. Unit risks from these two source terms must be combined to arrive at a risk-based soil PRG with a modification to the standard PRG equation as follows:

$$PRG_s = \frac{TRL}{\sum UR_s + (\sum UR_a \times TF)} \qquad \text{(C.2-3)}$$

where
TRL = target risk level
URs = unit risk for soil pathways
URa = unit risk for air pathways
TF = soil-to-air transfer factor

Thus, by substituting the unit risks for air and soil pathways for U-238 into this equation and assuming a target risk level (TRL) of 10^{-6}, a risk-based PRG is calculated for soil as follows:

$$PRG_{U238_s} = \frac{10^{-6}}{\frac{2.35x10^{-6}}{pCi/g} + \left(\frac{2.8x10^{-3}}{pCi/m^3} \; x \; 2x10^{-5} \; g/m^3\right)} = 0.41 \; pCi/g \qquad \text{(C.2-4)}$$

Risk-based PRGs for carcinogens, assuming a target risk of 10^{-5} or 10^{-4}, are calculated in a similar manner but require the substitution of 10^{-5} or 10^{-4} for the acceptable risk level in the above equation. For systemic toxicants, an acceptable risk level of 0.2 was used in the above equation and the unit risk values were replaced with unit toxicity values.

The calculation of PRGs for other reference receptors representing alternative land uses is limited to soil, exposure pathways through incidental ingestion, dermal contact (chemicals), inhalation of particulates, and external irradiation (radionuclides). The PRG calculation for these receptors is performed in a manner analogous to that described above for the on-property farmer (i.e., agricultural land use) but is restricted to the exposure pathways that are applicable for those particular reference receptors.

C.2.3 PRELIMINARY REMEDIATION GOALS FOR GROUNDWATER

Tables C.2-7 and C.2-8 present risk-based PRGs for groundwater from the Great Miami Aquifer and perched groundwater. For groundwater from the Great Miami Aquifer, applicable land uses for development of PRGs consider both future land use with continued federal ownership (with an off-property farmer as the reference receptor) and future land use without continued federal ownership (with the on-property farmer as the reference receptor). However, the risk-based PRGs for groundwater for these two scenarios are the same since the only difference is the source of groundwater (i.e., on property versus off property) and the PRG applies to water at the tap. For agricultural land use, it is assumed that groundwater is used for all domestic water purposes and agricultural purposes, including irrigation of crops and ingestion by livestock. PRGs under this scenario provides a "preliminary goal" or a reference concentration that will be used in deciding levels of remediation in groundwater directly beneath the FEMP site.

Under other alternative land use scenarios, it is assumed that individuals outside the FEMP site use groundwater for agricultural and household purpose. Consistent with this scenario, it is assumed there will be no domestic use of groundwater on the FEMP site. Thus, the groundwater PRGs established under the continued federal ownership scenario provide a "preliminary goal concentration" for the FEMP site boundary.

Risk-based PRGs for perched groundwater, presented in Table C.2-8 were based on household use of perched groundwater, including ingestion, dermal contact while bathing, and inhalation of volatiles

and radon from indoor use of groundwater. Agricultural exposure pathways were not considered in the development of PRGs for perched groundwater because the yield of perched groundwater from the site is not of sufficient quantity to irrigate crops and water livestock under an agricultural scenario. The risk-based PRGs for perched groundwater represent more reasonable remediation goals than those based on agricultural use because they do not include the high level of uncertainty associated with the food pathway models.

The risk-based PRGs for groundwater were calculated using the equations and parameters presented in the Supplemental Guidance to the Risk Assessment Work Plan Addendum (DOE 1994a) and are consistent with Part B of EPA's Risk Assessment Guidance for Superfund (EPA 1991b). The risk-based PRG for U-238 in the Great Miami Aquifer was calculated as follows:

The off-property and on-property resident farmer are assumed to use groundwater from the Great Miami Aquifer for drinking and bathing and consumption of the farm produce contaminated by irrigation with the groundwater for a lifetime of 70 years.

Unit risk for water consumption	= 9.8×10^{-7} (pCi/L)$^{-1}$
Unit risk for irrigation of vegetables	= 1.46×10^{-7} (pCi/L)$^{-1}$
Unit risk for irrigation of forage; meat	= 2.76×10^{-8} (pCi/L)$^{-1}$
Unit risk for irrigation of forage; milk	= 2.2×10^{-9} (pCi/L)$^{-1}$
Sum of unit risks	1.16×10^{-6} (pCi/L)$^{-1}$

By substituting the UR for groundwater pathways for U-238 into the standard PRG equation and assuming an TRL of 10^{-6}, a risk-based PRG is calculated for groundwater as follows:

$$PRG_{U238_{GW}} = \frac{10^{-6}}{\frac{1.16 \times 10^{-6}}{pCi/L}} = 0.86\ pCi/L \qquad \text{(C.2-5)}$$

Example calculations for development of URs and PRGs for uranium in groundwater are presented in Section C.3.

C.2.4 PRELIMINARY REMEDIATION GOALS FOR SURFACE WATER

Table C.2-9 presents the health-based PRGs for surface water exposure for the youth portion of the expanded trespasser or any of the recreational receptors. The exposure scenarios for these receptors assumed only the youth portion (ages 7-18) are exposed to surface water and sediment. These scenarios also assume the same exposure parameters for the surface water and sediment pathways. Therefore the surface water and sediment PRGs, based on these receptors are identical. This table

could apply to both exposures from the surface water in Paddys Run and the Great Miami River. The pathways of exposure used in this table are incidental ingestion of surface water and dermal contact while wading.

Table C.2-10 presents the health-based PRGs for surface water based on consumption of meat and milk from livestock which ingest surface water. The livestock are assumed to graze on uncontaminated land, off-site.

A risk-based PRG for U-238 in surface water exposure for either Paddys Run or the Great Miami River was calculated based on UR for the youth portion of the expanded trespasser exposed via incidental ingestion as follows:

UR for incidental ingestion $= 4.4 \times 10^{-10}$ $(pCi/L)^{-1}$

For most metals and hence, most radionuclides in Operable Unit 5, dermal absorption is not a significant pathway because penetration through the skin is minimal. Therefore, the dermal pathway is not included in the calculation of the PRG for U-238. By substituting the unit risks for surface water pathways for U-238 into the standard PRG equation and assuming a target risk level of 10^{-6}, a risk-based PRG is calculated for surface water in Paddys Run as follows:

$$PRG_{U238_{SW}} = \frac{10^{-6}}{\frac{4.4x10^{-10}}{pCi/L}} = 2.3x10^{+3} pCi/L \qquad \text{(C.2-6)}$$

A risk-based PRG for U-238 in surface water applicable for a consumer of meat and milk products was calculated based on UR as follows:

Unit risk for ingestion of meat	$= 3.6 \times 10^{-10}$ $(pCi/L)^{-1}$
Unit risk for ingestion of milk products	$= 5.3 \times 10^{-9}$ $(pCi/L)^{-1}$
Sum of unit risks	$= 5.7 \times 10^{-9}$ $(pCi/L)^{-1}$

By substituting the UR for surface water pathways for U-238 into the standard PRG equation and assuming a target risk level of 10^{-6}, a risk-based PRG is calculated for surface water in Paddys Run based on exposures to a consumer of meat and milk products as follows:

$$PRG_{U238_{SW}} = \frac{10^{-6}}{\frac{5.7x10^{-9}}{pCi/L}} = 1.8x10^{2}\ pCi/L \qquad (C.2\text{-}7)$$

C.2.5 PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL FOR A USER OF MILK AND MEAT PRODUCTS

Table C.2-11 presents PRGs for surface soil which are based on the off-property use of meat and milk products from cattle grazing on property. The uptake of contaminants by the cattle is through consumption of forage and feed grown on property and in the intake of surface soil. Human receptors are then exposed to contaminants through consumption of meat and milk from these cattle. These PRGs were presented as additional reference remediation goals for purposes of comparison.

The PRG for U-238 in the surface soils for the user of meat and milk products was calculated by using URs as follows:

Unit risk for meat consumption	=	6.80×10^{-9} (pCi/g)$^{-1}$
Unit risk for milk consumption	=	8.20×10^{-8} (pCi/g)$^{-1}$
Sum of unit risks	=	8.80×10^{-8} (pCi/g)$^{-1}$

By substituting the UR for the user of meat and milk products into the standard equation and assuming a TRL of 10^{-6}, a PRG is calculated as follows:

$$PRG_{U238_{mm}} = \frac{10^{-6}}{8.8 \times 10^{-8}\ pCi/g} = 1.1 \times 10^{1}\ pCi/g \qquad (C.2\text{-}8)$$

C.2.6 PRELIMINARY REMEDIATION GOALS FOR SEDIMENT

Table C.2-12 presents PRGs for sediment. PRGs for stream sediment were based on the assumption of incidental contact by a youth playing or wading in the stream. This PRG applies to the sediment of Paddys Run and the Great Miami River. The pathways of concern include incidental ingestion, dermal contact (chemicals), and external exposure (radionuclides) while wading. As mentioned previously, in Section C.2.4, the exposure scenarios for the expanded trespasser, the recreational receptors and the trespassing youth, all included the same assumptions regarding exposures to surface water and sediment. Hence, the sediment PPGs based on any of these receptor scenarios are identical.

The risk-based PRG for U-238 in sediment and other on-site drainage was calculated based on URs for a youth as follows:

Unit risk for incidental ingestion	=	8.0×10^{-11} (pCi/g)$^{-1}$
Unit risk for external exposure	=	3.6×10^{-9} (pCi/g)$^{-1}$
Sum of unit risks	=	3.6×10^{-9} (pCi/g)$^{-1}$

By substituting the UR for sediment pathways for U-238 into the standard equation and assuming a TRL of 10^{-6}, a PRG is calculated as follows:

$$PRG_{U238_{sed}} = \frac{10^{-6}}{\frac{3.6 \times 10^{-9}}{pCi/g}} = 2.7 \times 10^{2}\ pCi/g \qquad \text{(C.2-9)}$$

TABLE C.2-1a

RISK-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL BASED ON EXPOSURES TO THE ON-PROPERTY RME FARMER

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Radionuclides (pCi/g)			
Cs_{137+1d}	1.1×10^{-2}	1.1×10^{-1}	1.1×10^{0}
Np_{237+1d}	4.9×10^{-2}	4.9×10^{-1}	4.9×10^{0}
Pb_{210+2d}	9.0×10^{-2}	9.0×10^{-1}	9.0×10^{0}
Pu_{238}	9.3×10^{-2}	9.3×10^{0}	9.3×10^{1}
$Pu_{239/240}$	9.0×10^{-1}	9.0×10^{0}	9.0×10^{1}
Ra_{226+8d}	3.9×10^{-3}	3.9×10^{-2}	3.9×10^{-1}
Ra_{228+1d}	8.2×10^{-3}	8.2×10^{-2}	8.2×10^{-1}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	1.7×10^{-2}	1.7×10^{-1}	1.7×10^{0}
Tc_{99}	1.8×10^{-2}	1.8×10^{-1}	1.8×10^{0}
Th_{228+7d}	4.3×10^{-3}	4.3×10^{-2}	4.3×10^{-1}
Th_{230}	7.8×10^{0}	7.8×10^{1}	7.8×10^{2}
$Th_{232+10d}$	2.8×10^{-3}	2.8×10^{-2}	2.8×10^{-1}
U_{234}	4.1×10^{0}	4.1×10^{1}	4.1×10^{2}
$U_{235/236}$	9.8×10^{-2}	9.8×10^{-1}	9.8×10^{0}
U_{238+2d}	4.2×10^{-1}	4.2×10^{0}	4.2×10^{1}
Inorganics (mg/kg)			
Antimony	2.4×10^{0} [a]	2.4×10^{0} [a]	2.4×10° [a]
Arsenic	5.5×10^{-2}	5.5×10^{-1}	5.5×10^{0}
Barium	6.3×10^{2} [a]	6.3×10^{2} [a]	6.3×10^{2} [a]
Beryllium	4.8×10^{-2}	4.8×10^{-1}	4.8×10^{0}
Boron	8.4×10^{0} [a]	8.4×10^{0} [a]	8.4×10^{0} [a]
Cadmium	9.8×10^{-1} [a]	9.8×10^{-1} [a]	9.8×10^{-1} [a]
Chromium vi	1.8×10^{1}	6.2×10^{1} [a]	6.2×10^{1} [a]
Cobalt	3.9×10^{1} [a]	3.9×10^{1} [a]	3.9×10^{1} [a]
Copper	1.7×10^{1} [a]	1.7×10^{1} [a]	1.7×10^{1} [a]
Cyanide	4.6×10^{-1} [a]	4.6×10^{-1} [a]	4.6×10^{-1} [a]
Fluoride	3.7×10^{3} [a]	3.7×10^{3} [a]	3.7×10^{3} [a]
Lead	ND	ND	ND
Manganese	3.4×10^{2} [a]	3.4×10^{2} [a]	3.4×10^{2} [a]
Mercury	5.1×10^{-3} [a]	5.1×10^{-3} [a]	5.1×10^{-3} [a]
Molybdenum	5.4×10^{0} [a]	5.4×10^{0} [a]	5.4×10^{0} [a]
Nickel	6.6×10^{1} [a]	6.6×10^{1} [a]	6.6×10^{1} [a]
Nitrate	1.3×10^{5} [a]	1.3×10^{5} [a]	1.3×10^{5} [a]
Selenium	1.5×10^{1} [a]	1.5×10^{1} [a]	1.5×10^{1} [a]

TABLE C.2-1a
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Inorganics (Continued)			
Silver	5.6×10^{-1} [a]	5.6×10^{-1} [a]	5.6×10^{-1} [a]
Thallium	3.7×10^{-1} [a]	3.7×10^{-1} [a]	3.7×10^{-1} [a]
Thorium-total	ND	ND	ND
Uranium-total	2.7×10^{1} [a]	2.7×10^{1} [a]	2.7×10^{1} [a]
Vanadium	1.9×10^{2} [a]	1.9×10^{2} [a]	1.9×10^{2} [a]
Zinc	5.3×10^{0} [a]	5.3×10^{0} [a]	5.3×10^{0} [a]
Organics (mg/kg)			
Acetone	1.7×10^{0} [a]	1.7×10^{0} [a]	1.7×10^{0} [a]
Aroclor-1254	1.5×10^{-3}	1.5×10^{-2}	1.5×10^{-1}
Aroclor-1260	2.4×10^{-4}	2.4×10^{-3}	2.4×10^{-2}
Benzene	4.3×10^{-2}	4.3×10^{-1}	4.3×10^{0}
Benzo(a)anthracene	1.6×10^{-2}	1.6×10^{-1}	1.6×10^{0}
Benzo(a)pyrene	1.6×10^{-3}	1.6×10^{-2}	1.6×10^{-1}
Benzo(b)fluoranthene	1.6×10^{-2}	1.6×10^{-1}	1.6×10^{0}
Benzo(k)fluoranthene	1.6×10^{-1}	1.6×10^{0}	1.6×10^{1}
Bis(2-chloroisopropyl)ether	1.3×10^{-2}	1.3×10^{-1}	1.3×10^{0}
Bis(2-ethylhexyl)phthalate	2.9×10^{0}	2.9×10^{1}	1.6×10^{2} [a]
Bromodichloromethane	1.8×10^{-2}	1.8×10^{-1}	1.8×10^{0}
Bromoform	2.1×10^{-1}	2.1×10^{0}	6.5×10^{0} [a]
Bromomethane	9.8×10^{-2} [a]	9.8×10^{-2} [a]	9.8×10^{-2} [a]
Butanone,2-	1.5×10^{1} [a]	1.5×10^{1} [a]	1.5×10^{1} [a]
Carbazole	3.1×10^{-1}	3.1×10^{0}	3.1×10^{1}
Carbon Disulfide	2.5×10^{1} [a]	2.5×10^{1} [a]	2.5×10^{1} [a]
Carbon Tetrachloride	1.9×10^{-2}	1.9×10^{-1}	3.6×10^{-1}
Chlordane	1.1×10^{-2}	1.1×10^{-1}	1.7×10^{-1}
Chlorobenzene	7.2×10^{0} [a]	7.2×10^{0} [a]	7.2×10^{0} [a]
Chloroform	1.6×10^{-1}	1.6×10^{0}	2.0×10^{0} [a]
Chrysene	1.6×10^{0}	1.6×10^{1}	1.6×10^{2}
Dibenzo(a,h)anthracene	1.6×10^{-3}	1.6×10^{-2}	1.6×10^{-1}
Dichlorobenzidene,3,3-	1.4×10^{-2}	1.4×10^{-1}	1.4×10^{0}
Dichloroethane,1,1-	NS	NS	NS
Dichloroethane,1,2-	1.3×10^{-2}	1.3×10^{-1}	1.3×10^{0}
Dichloroethene,1,1-	2.0×10^{-3}	2.0×10^{-2}	2.0×10^{-1}
Dichloroethene,1,1-	2.2×10^{0} [a]	2.2×10^{0} [a]	2.2×10^{0} [a]
Dieldrin	8.8×10^{-4}	8.8×10^{-3}	8.8×10^{-2}
Di-n-octylphthalate	8.6×10^{-2} [a]	8.6×10^{-2} [a]	8.6×10^{-2} [a]
Ethyl Ether	1.6×10^{2} [a]	1.6×10^{2} [a]	1.6×10^{2} [a]

TABLE C.2-1a
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Organics (Continued)			
Ethylbenzene	8.6×10^{1} [a]	8.6×10^{1} [a]	8.6×10^{1} [a]
Heptachlorodibenzofuran	2.7×10^{-7}	2.7×10^{-6}	2.7×10^{-5}
Heptachlorodibenzo-p-dioxin	1.4×10^{-7}	1.4×10^{-6}	1.4×10^{-5}
Indeno(1,2,3-cd)pyrene	1.6×10^{-2}	1.6×10^{-1}	1.6×10^{0}
Methanol	NA	NA	NA
Methyl-2-pentanone,4-	3.8×10^{0} [a]	3.8×10^{0} [a]	3.8×10^{0} [a]
Methylene Chloride	6.3×10^{-2}	6.3×10^{-1}	5.7×10^{0} [a]
Methylphenol,4-	1.1×10^{0} [a]	1.1×10^{0} [a]	1.1×10^{0} [a]
Nitroanaline,4-	2.7×10^{-1} [a]	2.7×10^{-1} [a]	2.7×10^{-1} [a]
Nitrophenol, 4	1.6×10^{1} [a]	1.6×10^{1} [a]	1.6×10^{1} [a]
N-Nitrosodiphenylamine	1.3×10^{0}	1.3×10^{1}	1.3×10^{2}
N-Nitrosodipropylamine	6.1×10^{-5}	6.1×10^{-4}	6.1×10^{-3}
Octachlorodibenzofuran	3.9×10^{-7}	3.9×10^{-6}	3.9×10^{-5}
Octachlorodibenzo-p-dioxin	5.9×10^{-7}	5.9×10^{-6}	5.9×10^{-5}
Pentachlorophenol	9.7×10^{-2}	9.7×10^{-1}	9.7×10^{0}
Phenanthrene	ND	ND	ND
Tetrachloroethane, 1, 1, 2, 2-	8.6×10^{-3}	8.6×10^{-2}	8.6×10^{-1}
Tetrachloroethene	1.0×10^{-1}	1.0×10^{0}	1.0×10^{1}
Tetrachlorodibenzo-p-dioxin	2.4×10^{-8}	2.4×10^{-7}	2.4×10^{-6}
Toluene	1.1×10^{2} [a]	1.1×10^{2} [a]	1.1×10^{2} [a]
Tributyl Phosphate	1.0×10^{1} [a]	1.0×10^{1} [a]	1.0×10^{1} [a]
Trichloroethane,1,1,1-	NS	NS	NS
Trichloroethane,1,1,2-	1.9×10^{-2}	1.9×10^{-1}	8.6×10^{-1} [a]
Trichloroethene	1.5×10^{-1}	1.5×10^{0}	1.5×10^{1}
Vinyl Chloride	2.3×10^{-4}	2.3×10^{-3}	2.3×10^{-2}
Xylenes	1.6×10^{3} [a]	1.6×10^{3} [a]	1.6×10^{3} [a]

NA - Not Applicable
ND - No toxicity data available for the development of risk-based PRGs
PRGs for PAHs are based on toxicity equivalent factors relative to benzo(a)pyrene
NS - Not significant for this receptor because of low order of toxicity and exposure - PRG > 1×10^{6} mg/kg
[a] - Value represents a PRG based on a HQ of 0.2.

TABLE C.2-1b

RISK-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL BASED ON EXPOSURES TO THE ON-PROPERTY CHILD

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Radionuclides (pCi/g)			
Cs_{137+1d}	1.3×10^{-1}	1.3×10^{0}	1.3×10^{1}
Np_{237+1d}	6.4×10^{-1}	6.4×10^{0}	6.4×10^{1}
Pb_{210+2d}	8.1×10^{-1}	8.1×10^{0}	8.1×10^{1}
Pu_{238}	1.1×10^{1}	1.1×10^{2}	1.1×10^{3}
$Pu_{239/240}$	1.0×10^{1}	1.0×10^{2}	1.0×10^{3}
Ra_{226+8d}	5.1×10^{-2}	5.1×10^{-1}	5.1×10^{0}
Ra_{228+1d}	1.1×10^{-1}	1.1×10^{0}	1.1×10^{1}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	9.8×10^{-2}	9.8×10^{-1}	9.8×10^{0}
Tc_{99}	1.1×10^{-1}	1.1×10^{0}	1.1×10^{1}
Th_{228+7d}	5.7×10^{-2}	5.7×10^{-1}	5.7×10^{0}
Th_{230}	1.4×10^{2}	1.4×10^{3}	1.4×10^{4}
$Th_{232+10d}$	3.8×10^{-2}	3.8×10^{-1}	3.8×10^{0}
U_{234}	4.2×10^{1}	4.2×10^{2}	4.2×10^{3}
$U_{235/236}$	1.3×10^{0}	1.3×10^{1}	1.3×10^{2}
U_{238+2d}	5.3×10^{0}	5.3×10^{1}	5.3×10^{2}
Inorganics (mg/kg)			
Antimony	6.1×10^{-1} [a]	6.1×10^{-1} [a]	6.1×10^{-1} [a]
Arsenic	1.8×10^{-1}	1.6×10^{0} [a]	1.6×10^{0} [a]
Barium	8.7×10^{1} [a]	8.7×10^{1} [a]	8.7×10^{1} [a]
Beryllium	1.5×10^{-1}	1.5×10^{0}	1.5×10^{1}
Boron	1.1×10^{0} [a]	1.1×10^{0} [a]	1.1×10^{0} [a]
Cadmium	1.3×10^{-1} [a]	1.3×10^{-1} [a]	1.3×10^{-1} [a]
Chromium vi	1.1×10^{1} [a]	1.1×10^{1} [a]	1.1×10^{1} [a]
Cobalt	2.6×10^{1} [a]	2.6×10^{1} [a]	2.6×10^{1} [a]
Copper	3.5×10^{0} [a]	3.5×10^{0} [a]	3.5×10^{0} [a]
Cyanide	1.1×10^{-1} [a]	1.1×10^{-1} [a]	1.1×10^{-1} [a]
Fluoride	8.5×10^{2} [a]	8.5×10^{2} [a]	8.5×10^{2} [a]
Lead	ND	ND	ND
Manganese	8.0×10^{1} [a]	8.0×10^{1} [a]	8.0×10^{1} [a]
Mercury	2.7×10^{-3} [a]	2.7×10^{-3} [a]	2.7×10^{-3} [a]
Molybdenum	9.1×10^{-1} [a]	9.1×10^{-1} [a]	9.1×10^{-1} [a]
Nickel	1.4×10^{1} [a]	1.4×10^{1} [a]	1.4×10^{1} [a]
Nitrate	2.5×10^{4} [a]	2.5×10^{4} [a]	2.5×10^{4} [a]
Selenium	2.5×10^{0} [a]	2.5×10^{0} [a]	2.5×10^{0} [a]

TABLE C.2-1b
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Inorganics (Continued)			
Silver	5.5×10^{-2} [a]	5.5×10^{-2} [a]	5.5×10^{-2} [a]
Thallium	1.1×10^{-1} [a]	1.1×10^{-1} [a]	1.1×10^{-1} [a]
Thorium-total	ND	ND	ND
Uranium-total	8.7×10^{0} [a]	8.7×10^{0} [a]	8.7×10^{0} [a]
Vanadium	5.8×10^{1} [a]	5.8×10^{1} [a]	5.8×10^{1} [a]
Zinc	1.2×10^{0} [a]	1.2×10^{0} [a]	1.2×10^{0} [a]
Organics (mg/kg)			
Acetone	4.3×10^{-1} [a]	4.3×10^{-1} [a]	4.3×10^{-1} [a]
Aroclor-1254	2.9×10^{-3}	2.9×10^{-2}	2.9×10^{-1}
Aroclor-1260	4.2×10^{-4}	4.2×10^{-3}	4.2×10^{-2}
Benzene	1.2×10^{-1}	1.2×10^{0}	1.2×10^{1}
Benzo(a)anthracene	2.8×10^{-2}	2.8×10^{-1}	2.8×10^{0}
Benzo(a)pyrene	2.8×10^{-3}	2.8×10^{-2}	2.8×10^{-1}
Benzo(b)fluoranthene	2.8×10^{-2}	2.8×10^{-1}	2.8×10^{0}
Benzo(k)fluoranthene	2.8×10^{-1}	2.8×10^{0}	2.8×10^{1}
Bis(2-chloroisopropyl)ether	3.7×10^{-2}	3.7×10^{-1}	1.8×10^{0} [a]
Bis(2-ethylhexyl)phthalate	5.5×10^{0}	2.6×10^{1} [a]	2.6×10^{1} [a]
Bromodichloromethane	5.3×10^{-2}	5.3×10^{-1}	1.1×10^{0} [a]
Bromoform	6.1×10^{-1}	1.6×10^{0} [a]	1.6×10^{0} [a]
Bromomethane	2.4×10^{-2} [a]	2.4×10^{-2} [a]	2.4×10^{-2} [a]
Butanone,2-	3.7×10^{0} [a]	3.7×10^{0} [a]	3.7×10^{0} [a]
Carbazole	9.7×10^{-1}	9.7×10^{0}	9.7×10^{1}
Carbon Disulfide	6.2×10^{0} [a]	6.2×10^{0} [a]	6.2×10^{0} [a]
Carbon Tetrachloride	5.8×10^{-2}	9.1×10^{-2} [a]	9.1×10^{-2} [a]
Chlordane	2.8×10^{-2}	3.8×10^{-2} [a]	3.8×10^{-2} [a]
Chlorobenzene	1.9×10^{0} [a]	1.9×10^{0} [a]	1.9×10^{0} [a]
Chloroform	4.8×10^{-1}	5.0×10^{-1} [a]	5.0×10^{-1} [a]
Chrysene	2.8×10^{0}	2.8×10^{1}	2.8×10^{2}
Dibenzo(a,h)anthracene	2.8×10^{-3}	2.8×10^{-2}	2.8×10^{-1}
Dichlorobenzidene,3,3-	4.3×10^{-2}	4.3×10^{-1}	4.3×10^{0}
Dichloroethane,1,1-	NS	NS	NS
Dichloroethane,1,2-	3.7×10^{-2}	3.7×10^{-1}	3.7×10^{0}
Dichloroethene,1,1-	5.9×10^{-3}	5.9×10^{-2}	5.6×10^{-1}
Dieldrin	2.9×10^{-3}	2.9×10^{-2}	3.9×10^{-2} [a]
Di-n-octylphthalate	1.3×10^{-2} [a]	1.3×10^{-2} [a]	1.3×10^{-2} [a]
Ethyl Ether	4.0×10^{1} [a]	4.1×10^{1} [a]	4.1×10^{1} [a]
Ethylbenzene	2.2×10^{1} [a]	2.2×10^{1} [a]	2.2×10^{1} [a]
Heptachlorodibenzofuran	4.5×10^{-7}	4.5×10^{-6}	4.5×10^{-5}

TABLE C.2-1b
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Organics (Continued)			
Heptachlorodibenzo-p-dioxin	2.4×10^{-7}	2.4×10^{-6}	2.4×10^{-5}
Indeno(1,2,3-cd)pyrene	2.8×10^{-2}	2.8×10^{-1}	2.8×10^{0}
Methanol	NA	NA	NA
Methyl-2-pentanone,4-	9.4×10^{-1} [a]	9.4×10^{-1} [a]	9.4×10^{-1} [a]
Methylene Chloride	1.8×10^{-1}	1.4×10^{0} [a]	1.4×10^{0} [a]
Methylphenol,4-	2.7×10^{-1} [a]	2.7×10^{-1} [a]	2.7×10^{-1} [a]
Nitroanaline,4-	6.7×10^{-2} [a]	6.7×10^{-2} [a]	6.7×10^{-2} [a]
Nitrophenol, 4-	4.0×10^{0} [a]	4.0×10^{0} [a]	4.0×10^{0} [a]
N-Nitrosodiphenylamine	4.1×10^{0}	4.1×10^{1}	4.1×10^{2}
N-Nitrosodipropylamine	1.8×10^{-4}	1.8×10^{-3}	1.8×10^{-2}
Octachlorodibenzofuran	6.5×10^{-7}	6.5×10^{-6}	6.5×10^{-5}
Octachlorodibenzo-p-dioxin	9.8×10^{-7}	9.8×10^{-6}	9.8×10^{-5}
Pentachlorophenol	2.2×10^{-1}	2.2×10^{0}	1.4×10^{1} [a]
Phenanthrene	ND	ND	ND
Tetrachloroethane, 1, 1, 2, 2-	2.5×10^{-2}	2.5×10^{-1}	2.5×10^{0}
Tetrachloroethene	3.2×10^{-1}	2.9×10^{0} [a]	2.9×10^{0} [a]
Tetrachlorodibenzo-p-dioxin	4.2×10^{-8}	4.2×10^{-7}	4.2×10^{-6}
Toluene	2.7×10^{1} [a]	2.7×10^{1} [a]	2.7×10^{1} [a]
Tributyl Phosphate	2.9×10^{0} [a]	2.9×10^{0} [a]	2.9×10^{0} [a]
Trichloroethane,1,1,1-	NS	NS	NS
Trichloroethane,1,1,2-	5.5×10^{-2}	2.1×10^{-1}	2.1×10^{-1}
Trichloroethene	4.5×10^{-1}	4.5×10^{0}	4.5×10^{1}
Vinyl Chloride	6.7×10^{-4}	6.7×10^{-3}	6.7×10^{-2}
Xylenes	4.0×10^{2} [a]	4.0×10^{2} [a]	4.0×10^{2} [a]

NA - Not Applicable
ND - No toxicity data available for the development of risk-based PRGs
PRGs for PAHs are based on toxicity equivalent factors relative to benzo(a)pyrene
NS - Not significant for this receptor because of low order of toxicity and exposure - PRG> 1×10^{6} mg/kg
[a] - Value represents a PRG based on a HQ of 0.2.

TABLE C.2-2

RISK-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL BASED ON COMMERCIAL/INDUSTRIAL USE EXPOSURES

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Radionuclides (pCi/g)			
Cs_{137+1d}	1.5×10^{-1}	1.5×10^{0}	1.5×10^{1}
Np_{237+1d}	5.9×10^{-1}	5.9×10^{0}	5.9×10^{1}
Pb_{210+2d}	2.4×10^{0}	2.4×10^{1}	2.4×10^{2}
Pu_{238}	4.3×10^{0}	4.3×10^{1}	4.3×10^{2}
$Pu_{239/240}$	4.2×10^{0}	4.2×10^{1}	4.2×10^{2}
Ra_{226+8d}	4.7×10^{-2}	4.7×10^{-1}	4.7×10^{0}
Ra_{228+1d}	1.0×10^{-1}	1.0×10^{0}	1.0×10^{1}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	4.4×10^{1}	4.4×10^{2}	4.4×10^{3}
Tc_{99}	1.2×10^{3}	1.2×10^{4}	1.2×10^{5}
Th_{228+7d}	5.2×10^{-2}	5.2×10^{-1}	5.2×10^{0}
Th_{230}	1.2×10^{1}	1.2×10^{2}	1.2×10^{3}
$Th_{232+10d}$	3.4×10^{-2}	3.4×10^{-1}	3.4×10^{0}
U_{234}	1.3×10^{1}	1.3×10^{2}	1.3×10^{3}
$U_{235/236}$	1.1×10^{0}	1.1×10^{1}	1.1×10^{2}
U_{238+2d}	4.0×10^{0}	4.0×10^{1}	4.0×10^{2}
Inorganics (mg/kg)			
Antimony	1.7×10^{1} [a]	1.7×10^{1} [a]	1.7×10^{1} [a]
Arsenic	1.5×10^{0}	1.5×10^{1}	5.8×10^{1}
Barium	4.0×10^{3} [a]	4.0×10^{3} [a]	4.0×10^{3} [a]
Beryllium	4.2×10^{-1}	4.2×10^{0}	4.2×10^{1}
Boron	1.5×10^{3} [a]	1.5×10^{3} [a]	1.5×10^{3} [a]
Cadmium	1.6×10^{1} [a]	1.6×10^{1} [a]	1.6×10^{1} [a]
Chromium vi	1.7×10^{1}	1.7×10^{2}	4.5×10^{2} [a]
Cobalt	1.5×10^{1} [a]	1.5×10^{1} [a]	1.5×10^{1} [a]
Copper	7.6×10^{3} [a]	7.6×10^{3} [a]	7.6×10^{3} [a]
Cyanide	4.1×10^{3} [a]	4.1×10^{3} [a]	4.1×10^{3} [a]
Fluoride	7.8×10^{3} [a]	7.8×10^{3} [a]	7.8×10^{3} [a]
Lead	ND	ND	ND
Manganese	4.8×10^{2} [a]	4.8×10^{2} [a]	4.8×10^{2} [a]
Mercury	3.0×10^{0} [a]	3.0×10^{0} [a]	3.0×10^{0} [a]
Molybdenum	4.1×10^{2} [a]	4.1×10^{2} [a]	4.1×10^{2} [a]
Nickel	8.5×10^{2}	3.2×10^{3} [a]	3.2×10^{3} [a]
Nitrate	3.3×10^{5} [a]	3.3×10^{5} [a]	3.3×10^{5} [a]
Selenium	5.9×10^{2} [a]	5.9×10^{2} [a]	5.9×10^{2} [a]

TABLE C.2-2
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Inorganics (Continued)			
Silver	1.0×10^{3} [a]	1.0×10^{3} [a]	1.0×10^{3} [a]
Thallium	9.1×10^{0} [a]	9.1×10^{0} [a]	9.1×10^{0} [a]
Thorium-total	ND	ND	ND
Uranium-total	4.9×10^{1} [a]	4.9×10^{1} [a]	4.9×10^{1} [a]
Vanadium	6.7×10^{2} [a]	6.7×10^{2} [a]	6.7×10^{2} [a]
Zinc	1.9×10^{4} [a]	1.9×10^{4} [a]	1.9×10^{4} [a]
Organics (mg/kg)			
Acetone	6.6×10^{3} [a]	6.6×10^{3} [a]	6.6×10^{3} [a]
Aroclor-1254	6.6×10^{-2}	6.6×10^{-1}	6.6×10^{0}
Aroclor-1260	6.6×10^{-2}	6.6×10^{-1}	6.6×10^{0}
Benzene	9.6×10^{1}	9.6×10^{2}	9.6×10^{3}
Benzo(a)anthracene	2.0×10^{0}	2.0×10^{1}	2.0×10^{2}
Benzo(a)pyrene	2.0×10^{-1}	2.0×10^{0}	2.0×10^{1}
Benzo(b)fluoranthene	2.0×10^{0}	2.0×10^{1}	2.0×10^{2}
Benzo(k)fluoranthene	2.0×10^{1}	2.0×10^{2}	2.0×10^{3}
Bis(2-chloroisopropyl)ether	4.1×10^{1}	4.1×10^{2}	4.1×10^{3}
Bis(2-ethylhexyl)phthalate	1.6×10^{2}	1.6×10^{3}	3.3×10^{3} [a]
Bromodichloromethane	2.3×10^{0}	2.3×10^{1}	2.0×10^{2}
Bromoform	1.8×10^{1}	1.8×10^{2}	2.0×10^{2} [a]
Bromomethane	2.9×10^{2} [a]	2.9×10^{2} [a]	2.9×10^{2} [a]
Butanone,2-	1.2×10^{5} [a]	1.2×10^{5} [a]	1.2×10^{5} [a]
Carbazole	7.1×10^{0}	7.1×10^{1}	7.1×10^{2}
Carbon Disulfide	1.0×10^{3} [a]	1.0×10^{3} [a]	1.0×10^{3} [a]
Carbon Tetrachloride	1.2×10^{0}	7.8×10^{0} [a]	7.8×10^{0} [a]
Chlordane	1.1×10^{-1}	6.1×10^{-1} [a]	6.1×10^{-1} [a]
Chlorobenzene	7.2×10^{1} [a]	7.2×10^{1} [a]	7.2×10^{1} [a]
Chloroform	2.6×10^{1}	1.1×10^{2} [a]	1.1×10^{2} [a]
Chrysene	2.0×10^{2}	2.0×10^{3}	2.0×10^{4}
Dibenzo(a,h)anthracene	2.0×10^{-1}	2.0×10^{0}	2.0×10^{1}
Dichlorobenzidene,3,3-	3.2×10^{-1}	3.2×10^{0}	3.2×10^{1}
Dichloroethane,1,1-	NS	NS	NS
Dichloroethane,1,2-	1.6×10^{0}	1.6×10^{1}	1.6×10^{2}
Dichloroethene,1,1-	2.3×10^{-1}	2.3×10^{0}	2.3×10^{1}
Dieldrin	8.9×10^{-3}	8.9×10^{-2}	5.1×10^{-1} [a]
Di-n-octylphthalate	2.2×10^{2} [a]	2.2×10^{2} [a]	2.2×10^{2} [a]
Ethyl Ether	1.0×10^{3} [a]	1.0×10^{3} [a]	1.0×10^{3} [a]
Ethylbenzene	3.0×10^{0} [a]	3.0×10^{0} [a]	3.0×10^{0} [a]
Heptachlorodibenzofuran	4.3×10^{-4}	4.3×10^{-3}	4.3×10^{-2}

TABLE C.2-2
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Organics (Continued)			
Heptachlorodibenzo-p-dioxin	4.3×10^{-4}	4.3×10^{-3}	4.3×10^{-2}
Indeno(1,2,3-cd)pyrene	2.0×10^{0}	2.0×10^{1}	2.0×10^{2}
Methanol	NA	NA	NA
Methyl-2-pentanone,4-	5.1×10^{0} [a]	5.1×10^{0} [a]	5.1×10^{0} [a]
Methylene Chloride	2.1×10^{1}	2.1×10^{2}	6.8×10^{2} [a]
Methylphenol,4-	5.1×10^{1} [a]	5.1×10^{1} [a]	5.1×10^{1} [a]
Nitroanaline,4-	3.0×10^{1} [a]	3.0×10^{1} [a]	3.0×10^{1} [a]
N-Nitrosodiphenylamine	2.9×10^{1}	2.9×10^{2}	2.9×10^{3}
N-Nitrosodipropylamine	2.0×10^{-2}	2.0×10^{-1}	2.0×10^{0}
Octachlorodibenzofuran	4.3×10^{-3}	4.3×10^{-2}	4.3×10^{-1}
Octachlorodibenzo-p-dioxin	4.3×10^{-3}	4.3×10^{-2}	4.3×10^{-1}
Pentachlorophenol	1.3×10^{0}	1.3×10^{1}	1.3×10^{2}
Phenanthrene	ND	ND	ND
Tetrachloroethane, 1, 1, 2, 2-	7.1×10^{-1}	7.1×10^{0}	7.1×10^{1}
Tetrachloroethene	2.1×10^{0}	2.1×10^{1}	7.7×10^{1}
Tetrachlorodibenzo-p-dioxin	4.3×10^{-6}	4.3×10^{-5}	4.3×10^{-4}
Toluene	1.5×10^{4} [a]	1.5×10^{4} [a]	1.5×10^{4} [a]
Tributyl Phosphate	5.1×10^{1} [a]	5.1×10^{1} [a]	5.1×10^{1} [a]
Trichloroethane,1,1,1-	NS	NS	NS
Trichloroethane,1,1,2-	2.5×10^{0}	2.5×10^{1}	4.1×10^{1} [a]
Trichloroethene	1.4×10^{1}	1.4×10^{2}	1.4×10^{3}
Vinyl Chloride	7.5×10^{-2}	7.5×10^{-1}	7.5×10^{0}
Xylenes	3.0×10^{-1} [a]	3.0×10^{-1} [a]	3.0×10^{-1} [a]

NA - Not Applicable
ND - No toxicity data available for the development of risk-based PRGs
PRGs for PCBs are based on toxicity equivalent factors relative to benzo(a)pyrene
NS - Not significant for this receptor because of low order of toxicity and exposure - PRG > 1×10^{6} mg/kg
[a] - Value represents a PRG based on a HQ of 0.2.

000861

TABLE C.2-3

RISK-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL BASED ON EXPOSURES TO THE RECREATIONAL USER DEVELOPED PARK

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Radionuclides (pCi/g)			
Cs_{137+1d}	3.2×10^{-1}	3.2×10^{0}	3.2×10^{1}
Np_{237+1d}	1.4×10^{0}	1.4×10^{1}	1.4×10^{2}
Pb_{210+2d}	1.6×10^{1}	1.6×10^{2}	1.6×10^{3}
Pu_{238}	3.3×10^{1}	3.3×10^{2}	3.3×10^{3}
$Pu_{239/240}$	3.3×10^{1}	3.3×10^{2}	3.3×10^{3}
Ra_{226+8d}	1.1×10^{-1}	1.1×10^{0}	1.1×10^{1}
Ra_{228+1d}	2.2×10^{-1}	2.2×10^{0}	2.2×10^{1}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	2.9×10^{2}	2.9×10^{3}	2.9×10^{4}
Tc_{99}	7.9×10^{3}	7.9×10^{4}	7.9×10^{5}
Th_{228+7d}	1.1×10^{-1}	1.1×10^{0}	1.1×10^{1}
Th_{230}	1.3×10^{2}	1.3×10^{3}	1.3×10^{4}
$Th_{232+10d}$	7.5×10^{-2}	7.5×10^{-1}	7.5×10^{0}
U_{234}	1.3×10^{2}	1.3×10^{3}	1.3×10^{4}
$U_{235/236}$	2.6×10^{0}	2.6×10^{1}	2.6×10^{2}
U_{238+2d}	1.1×10^{1}	1.1×10^{2}	1.1×10^{3}
Inorganics (mg/kg)			
Antimony	8.0×10^{1} [a]	8.0×10^{1} [a]	8.0×10^{1} [a]
Arsenic	4.8×10^{0}	4.8×10^{1}	4.8×10^{2}
Barium	4.0×10^{4} [a]	4.0×10^{4} [a]	4.0×10^{4} [a]
Beryllium	9.7×10^{-1}	9.7×10^{0}	9.7×10^{1}
Boron	6.4×10^{3} [a]	6.4×10^{3} [a]	6.4×10^{3} [a]
Cadmium	7.2×10^{1} [a]	7.2×10^{1} [a]	7.2×10^{1} [a]
Chromium vi	1.1×10^{2}	1.1×10^{3}	2.5×10^{3} [a]
Cobalt	2.8×10^{2} [a]	2.8×10^{2} [a]	2.8×10^{2} [a]
Copper	7.1×10^{4} [a]	7.1×10^{4} [a]	7.1×10^{4} [a]
Cyanide	3.9×10^{4} [a]	3.9×10^{4} [a]	3.9×10^{4} [a]
Fluoride	5.0×10^{4} [a]	5.0×10^{4} [a]	5.0×10^{4} [a]
Lead	ND	ND	ND
Manganese	4.2×10^{3} [a]	4.2×10^{3} [a]	4.2×10^{3} [a]
Mercury	1.3×10^{1} [a]	1.3×10^{1} [a]	1.3×10^{1} [a]
Molybdenum	2.2×10^{3} [a]	2.2×10^{3} [a]	2.2×10^{3} [a]
Nickel	5.7×10^{3}	2.3×10^{4} [a]	2.3×10^{4} [a]
Nitrate	NS	NS	NS
Selenium	3.7×10^{3} [a]	3.7×10^{3} [a]	3.7×10^{3} [a]

TABLE C.2-3
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Inorganics (Continued)			
Silver	9.6×10^{3} [a]	9.6×10^{3} [a]	9.6×10^{3} [a]
Thallium	5.9×10^{1} [a]	5.9×10^{1} [a]	5.9×10^{1} [a]
Thorium-total	ND	ND	ND
Uranium-total	2.1×10^{2} [a]	2.1×10^{2} [a]	2.1×10^{2} [a]
Vanadium	3.8×10^{3} [a]	3.8×10^{3} [a]	3.8×10^{3} [a]
Zinc	9.3×10^{4} [a]	9.3×10^{4} [a]	9.3×10^{4} [a]
Organics (mg/kg)			
Acetone	3.4×10^{4} [a]	3.4×10^{4} [a]	3.4×10^{4} [a]
Aroclor-1254	1.1×10^{-1}	1.1×10^{0}	1.1×10^{1}
Aroclor-1260	1.1×10^{-1}	1.1×10^{0}	1.1×10^{1}
Benzene	3.1×10^{2}	3.1×10^{3}	3.1×10^{4}
Benzo(a)anthracene	6.6×10^{0}	6.6×10^{1}	6.6×10^{2}
Benzo(a)pyrene	6.6×10^{-1}	6.6×10^{0}	6.6×10^{1}
Benzo(b)fluoranthene	6.6×10^{0}	6.6×10^{1}	6.6×10^{2}
Benzo(k)fluoranthene	6.6×10^{1}	6.6×10^{2}	6.6×10^{3}
Bis(2-chloroisopropyl)ether	1.4×10^{2}	1.4×10^{3}	1.4×10^{4}
Bis(2-ethylhexyl)phthalate	4.4×10^{2}	4.4×10^{3}	2.4×10^{4} [a]
Bromodichloromethane	3.5×10^{0}	3.5×10^{1}	3.5×10^{2}
Bromoform	2.8×10^{1}	2.8×10^{2}	8.7×10^{2} [a]
Bromomethane	2.7×10^{3} [a]	2.7×10^{3} [a]	2.7×10^{3} [a]
Butanone,2-	NS	NS	NS
Carbazole	1.1×10^{1}	1.1×10^{2}	1.1×10^{3}
Carbon Disulfide	4.3×10^{3} [a]	4.3×10^{3} [a]	4.3×10^{3} [a]
Carbon Tetrachloride	1.8×10^{0}	1.8×10^{1}	3.4×10^{1} [a]
Chlordane	1.7×10^{-1}	1.7×10^{0}	2.6×10^{0}
Chlorobenzene	3.1×10^{2} [a]	3.1×10^{2} [a]	3.1×10^{2} [a]
Chloroform	4.0×10^{1}	4.0×10^{2}	4.8×10^{2} [a]
Chrysene	6.6×10^{2}	6.6×10^{3}	6.6×10^{4}
Dibenzo(a,h)anthracene	6.6×10^{-1}	6.6×10^{0}	6.6×10^{1}
Dichlorobenzidene,3,3-	4.8×10^{-1}	4.8×10^{0}	4.8×10^{1}
Dichloroethane,1,1-	NS	NS	NS
Dichloroethane,1,2-	2.4×10^{0}	2.4×10^{1}	2.4×10^{2}
Dichloroethene,1,1-	3.6×10^{-1}	3.6×10^{0}	3.6×10^{1}
Dieldrin	1.4×10^{-2}	1.4×10^{-1}	1.4×10^{0}
Di-n-octylphthalate	9.7×10^{2} [a]	9.7×10^{2} [a]	9.7×10^{2} [a]
Ethyl Ether	7.2×10^{4} [a]	7.2×10^{4} [a]	7.2×10^{4} [a]
Ethylbenzene	4.5×10^{3} [a]	4.5×10^{3} [a]	4.5×10^{3} [a]
Heptachlorodibenzofuran	7.3×10^{-4}	7.3×10^{-3}	7.3×10^{-2}
Heptachlorodibenzo-p-dioxin	7.3×10^{-4}	7.3×10^{-3}	7.3×10^{-2}

TABLE C.2-3
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Organics (Continued)			
Indeno(1,2,3-cd)pyrene	6.6×10^{0}	6.6×10^{1}	6.6×10^{2}
Methanol	NA	NA	NA
Methyl-2-pentanone,4-	3.2×10^{1}	3.2×10^{2}	2.9×10^{3} [a]
Methylene Chloride	2.2×10^{3} [a]	2.2×10^{3} [a]	2.2×10^{3} [a]
Methylphenol,4-	2.2×10^{2} [a]	2.2×10^{2} [a]	2.2×10^{2} [a]
Nitroanaline,4-	1.3×10^{2} [a]	1.3×10^{2} [a]	1.3×10^{2} [a]
Nitrophenol, 4-	2.6×10^{3} [a]	2.6×10^{3} [a]	2.6×10^{3} [a]
N-Nitrosodiphenylamine	4.4×10^{1}	4.4×10^{2}	4.4×10^{3}
N-Nitrosodipropylamine	3.1×10^{-2}	3.1×10^{-1}	3.1×10^{0}
Octachlorodibenzofuran	7.3×10^{-3}	7.3×10^{-2}	7.3×10^{-1}
Octachlorodibenzo-p-dioxin	7.3×10^{-3}	7.3×10^{-2}	7.3×10^{-1}
Pentachlorophenol	2.0×10^{0}	2.0×10^{1}	2.0×10^{2}
Phenanthrene	ND	ND	ND
Tetrachloroethene	3.2×10^{0}	3.2×10^{1}	3.2×10^{2}
Tetrachlorodibenzo-p-dioxin	7.3×10^{-6}	7.3×10^{-5}	7.3×10^{-4}
Toluene	7.9×10^{4} [a]	7.9×10^{4} [a]	7.9×10^{4} [a]
Tributyl Phosphate	2.2×10^{2} [a]	2.2×10^{2} [a]	2.2×10^{2} [a]
Trichloroethane,1,1,1-	NS	NS	NS
Trichloroethane,1,1,2-	3.8×10^{0}	3.8×10^{1}	1.7×10^{2} [a]
Trichloroethene	2.2×10^{1}	2.2×10^{2}	2.2×10^{3}
Vinyl Chloride	1.1×10^{-1}	1.1×10^{0}	1.1×10^{1}
Xylenes	7.2×10^{5} [a]	7.2×10^{5} [a]	7.2×10^{5} [a]

NA - Not Applicable
ND - No toxicity data available for the development of risk-based PRGs
PRGs for PAHs are based on toxicity equivalent factors relative to benzo(a)pyrene
NS - Not significant for the receptor because of low order of toxicity and exposure - PRG > 1×10^{6} mg/kg
[a] - Value represents a PRG based on a HQ of 0.2.

TABLE C.2-4

RISK-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL BASED ON EXPOSURES TO THE RECREATIONAL USER UNDEVELOPED PARK

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Radionuclides (pCi/g)			
Cs_{137+1d}	7.1×10^{-1}	7.1×10^{0}	7.1×10^{1}
Np_{237+1d}	3.2×10^{0}	3.2×10^{1}	3.2×10^{2}
Pb_{210+2d}	3.7×10^{1}	3.7×10^{2}	3.7×10^{3}
Pu_{238}	7.8×10^{1}	7.8×10^{2}	7.8×10^{3}
$Pu_{239/240}$	7.7×10^{1}	7.7×10^{2}	7.7×10^{3}
Ra_{226+8d}	2.4×10^{-1}	2.4×10^{0}	2.4×10^{1}
Ra_{228+1d}	4.9×10^{-1}	4.9×10^{0}	4.9×10^{1}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	6.9×10^{2}	6.9×10^{3}	6.9×10^{4}
Tc_{99}	1.9×10^{4}	1.9×10^{5}	1.9×10^{6}
Th_{228+7d}	2.5×10^{-1}	2.5×10^{0}	2.5×10^{1}
Th_{230}	2.8×10^{2}	2.8×10^{3}	2.8×10^{4}
$Th_{232+10d}$	1.7×10^{-1}	1.7×10^{0}	1.7×10^{1}
U_{234}	3.0×10^{2}	3.0×10^{3}	3.0×10^{4}
$U_{235/236}$	5.8×10^{0}	5.8×10^{1}	5.8×10^{2}
U_{238+2d}	2.6×10^{1}	2.6×10^{2}	2.6×10^{3}
Inorganics (mg/kg)			
Antimony	9.6×10^{1} [a]	9.6×10^{1} [a]	9.6×10^{1} [a]
Arsenic	1.2×10^{1}	1.2×10^{2}	1.2×10^{3}
Barium	6.8×10^{4} [a]	6.8×10^{4} [a]	6.8×10^{4} [a]
Beryllium	1.5×10^{0}	1.5×10^{1}	1.5×10^{2}
Boron	7.4×10^{3} [a]	7.4×10^{3} [a]	7.4×10^{3} [a]
Cadmium	8.2×10^{1} [a]	8.2×10^{1} [a]	8.2×10^{1} [a]
Chromium vi	3.0×10^{2}	3.0×10^{3}	3.3×10^{3} [a]
Cobalt	7.4×10^{2} [a]	7.4×10^{2} [a]	7.4×10^{2} [a]
Copper	2.2×10^{5} [a]	2.2×10^{5} [a]	2.2×10^{5} [a]
Cyanide	1.2×10^{5} [a]	1.2×10^{5} [a]	1.2×10^{5} [a]
Fluoride	7.8×10^{4} [a]	7.8×10^{4} [a]	7.8×10^{4} [a]
Lead	ND	ND	ND
Manganese	4.6×10^{3} [a]	4.6×10^{3} [a]	4.6×10^{3} [a]
Mercury	1.5×10^{1} [a]	1.5×10^{1} [a]	1.5×10^{1} [a]
Molybdenum	2.9×10^{3} [a]	2.9×10^{3} [a]	2.9×10^{3} [a]
Nickel	1.5×10^{4}	4.3×10^{4} [a]	4.3×10^{4} [a]
Nitrate	NS	NS	NS
Selenium	5.4×10^{3} [a]	5.4×10^{3} [a]	5.4×10^{3} [a]

TABLE C.2-4
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Inorganics (Continued)			
Silver	2.9×10^{4} [a]	2.9×10^{4} [a]	2.9×10^{4} [a]
Thallium	9.1×10^{1} [a]	9.1×10^{1} [a]	9.1×10^{1} [a]
Thorium-total	ND	ND	ND
Uranium-total	2.5×10^{2} [a]	2.5×10^{2} [a]	2.5×10^{2} [a]
Vanadium	5.1×10^{3} [a]	5.1×10^{3} [a]	5.1×10^{3} [a]
Zinc	1.2×10^{5} [a]	1.2×10^{5} [a]	1.2×10^{5} [a]
Organics (mg/kg)			
Acetone	4.3×10^{4} [a]	4.3×10^{4} [a]	4.3×10^{4} [a]
Aroclor-1254	1.3×10^{-1}	1.3×10^{0}	1.3×10^{1}
Aroclor-1260	1.3×10^{-1}	1.3×10^{0}	1.3×10^{1}
Benzene	8.5×10^{2}	8.5×10^{3}	8.5×10^{4}
Benzo(a)anthracene	2.0×10^{1}	2.0×10^{2}	2.0×10^{3}
Benzo(a)pyrene	2.0×10^{0}	2.0×10^{1}	2.0×10^{2}
Benzo(b)fluoranthene	2.0×10^{1}	2.0×10^{2}	2.0×10^{3}
Benzo(k)fluoranthene	2.0×10^{2}	2.0×10^{3}	2.0×10^{4}
Bis(2-chloroisopropyl)ether	4.2×10^{2}	4.2×10^{3}	4.2×10^{4}
Bis(2-ethylhexyl)phthalate	8.2×10^{2}	8.2×10^{3}	4.6×10^{4}
Bromodichloromethane	4.0×10^{0}	4.0×10^{1}	4.0×10^{2}
Bromoform	3.1×10^{1}	3.1×10^{2}	9.9×10^{2} [a]
Bromomethane	8.2×10^{3}	8.2×10^{3}	8.2×10^{3}
Butanone,2-	NS	NS	NS
Carbazole	1.2×10^{1}	1.2×10^{2}	1.2×10^{3}
Carbon Disulfide	5.0×10^{3}	5.0×10^{3}	5.0×10^{3}
Carbon Tetrachloride	2.1×10^{0}	2.1×10^{1}	3.8×10^{1} [a]
Chlordane	1.9×10^{-1}	1.9×10^{0}	3.0×10^{0} [a]
Chlorobenzene	3.4×10^{2}	3.4×10^{2}	3.4×10^{2} [a]
Chloroform	4.5×10^{1}	4.5×10^{2}	5.5×10^{2} [a]
Chrysene	2.0×10^{3}	2.0×10^{4}	2.0×10^{5}
Dibenzo(a,h)anthracene	2.0×10^{0}	2.0×10^{1}	2.0×10^{2}
Dichlorobenzidene,3,3-	5.5×10^{-1}	5.5×10^{0}	5.5×10^{1}
Dichloroethane,1,1-	NS	NS	NS
Dichloroethane,1,2-	2.7×10^{0}	2.7×10^{1}	2.7×10^{2}
Dichloroethene,1,1-	4.1×10^{-1}	4.1×10^{0}	4.1×10^{1}
Dieldrin	1.5×10^{-2}	1.5×10^{-1}	1.5×10^{0}
Di-n-octylphthalate	1.1×10^{3} [a]	1.1×10^{3} [a]	1.1×10^{3} [a]
Ethyl Ether	9.2×10^{4} [a]	9.2×10^{4} [a]	9.2×10^{4} [a]
Ethylbenzene	5.1×10^{3} [a]	5.1×10^{3} [a]	5.1×10^{3} [a]
Heptachlorodibenzofuran	8.8×10^{-4}	8.8×10^{-3}	8.8×10^{-2}

TABLE C.2-4
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Organics (Continued)			
Heptachlorodibenzo-p-dioxin	8.8×10^{-4}	8.8×10^{-3}	8.8×10^{-2}
Indeno(1,2,3-cd)pyrene	2.0×10^{1}	2.0×10^{2}	2.0×10^{3}
Methanol	ND	ND	ND
Methyl-2-pentanone,4-	2.5×10^{3} [a]	2.5×10^{3} [a]	2.5×10^{3} [a]
Methylene Chloride	3.7×10^{1}	3.7×10^{2}	3.4×10^{3}
Methylphenol,4-	2.5×10^{2} [a]	2.5×10^{2} [a]	2.5×10^{2} [a]
Nitroanaline,4-	1.5×10^{2} [a]	1.5×10^{2} [a]	1.5×10^{2} [a]
N-Nitrosodiphenylamine	5.1×10^{1}	5.1×10^{2}	5.1×10^{3}
N-Nitrosodipropylamine	3.5×10^{-2}	3.5×10^{-1}	3.5×10^{0}
Octachlorodibenzofuran	8.8×10^{-3}	8.8×10^{-2}	8.8×10^{-1}
Octachlorodibenzo-p-dioxin	8.8×10^{-3}	8.8×10^{-2}	8.8×10^{-1}
Pentachlorophenol	2.3×10^{0}	2.3×10^{1}	2.3×10^{2}
Phenanthrene	ND	ND	ND
Tetrachloroethene	3.6×10^{0}	3.6×10^{1}	3.6×10^{2}
Toluene	1.0×10^{5} [a]	1.0×10^{5} [a]	1.0×10^{5} [a]
Tributyl Phosphate	2.5×10^{2} [a]	2.5×10^{2} [a]	2.5×10^{2} [a]
Trichloroethane,1,1,1-	NS	NS	NS
Trichloroethane,1,1,2-	4.3×10^{0}	4.3×10^{1}	2.0×10^{2} [a]
Trichloroethene	2.5×10^{1}	2.5×10^{2}	2.5×10^{3}
Vinyl Chloride	1.3×10^{-1}	1.3×10^{0}	1.3×10^{1}
Xylenes	9.2×10^{5} [a]	9.2×10^{5} [a]	9.2×10^{5} [a]

NA - Not Applicable
ND - No toxicity data available for the development of risk-based PRGs
PRGs for PAHs are based on toxicity equivalent factors relative to benzo(a)pyrene
NS - Not significant for this receptor because of low order of toxicity and exposure - PRG> 1×10^{6} mg/kg
[a] - Value represents a PRG based on a HQ of 0.2.

TABLE C.2-5

RISK-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL BASED ON EXPOSURES TO THE RECREATIONAL USER WILDLIFE RESERVE

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Radionuclides (pCi/g)			
Cs_{137+1d}	8.1×10^{-1}	8.1×10^{0}	8.1×10^{1}
Np_{237+1d}	3.6×10^{0}	3.6×10^{1}	3.6×10^{2}
Pb_{210+2d}	4.3×10^{-1}	4.3×10^{0}	4.3×10^{1}
Pu_{238}	9.0×10^{1}	9.0×10^{2}	9.0×10^{3}
$Pu_{239/240}$	8.8×10^{1}	8.8×10^{2}	8.8×10^{3}
Ra_{226+8d}	2.7×10^{-1}	2.7×10^{0}	2.7×10^{1}
Ra_{228+1d}	5.6×10^{-1}	5.6×10^{0}	5.6×10^{1}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	8.0×10^{2}	8.0×10^{3}	8.0×10^{4}
Tc_{99}	2.2×10^{4}	2.2×10^{5}	2.2×10^{6}
Th_{228+7d}	2.9×10^{-1}	2.9×10^{0}	2.9×10^{1}
Th_{230}	3.2×10^{2}	3.2×10^{3}	3.2×10^{4}
$Th_{232+10d}$	1.9×10^{-1}	1.9×10^{0}	1.9×10^{1}
U_{234}	3.4×10^{2}	3.4×10^{3}	3.4×10^{4}
$U_{235/236}$	6.6×10^{0}	6.6×10^{1}	6.6×10^{2}
U_{238+2d}	2.9×10^{1}	2.9×10^{2}	2.9×10^{3}
Inorganics (mg/kg)			
Antimony	1.1×10^{2} [a]	1.1×10^{2} [a]	1.1×10^{2} [a]
Arsenic	1.6×10^{1}	1.6×10^{2}	1.6×10^{3}
Barium	8.4×10^{4} [a]	8.4×10^{4} [a]	8.4×10^{4} [a]
Beryllium	1.8×10^{0}	1.8×10^{1}	1.8×10^{2}
Boron	8.8×10^{3} [a]	8.8×10^{3} [a]	8.8×10^{3} [a]
Cadmium	9.8×10^{1} [a]	9.8×10^{1} [a]	9.8×10^{1} [a]
Chromium vi	3.9×10^{2}	3.9×10^{3}	4.0×10^{3} [a]
Cobalt	9.6×10^{2} [a]	9.6×10^{2} [a]	9.6×10^{2} [a]
Copper	2.9×10^{5} [a]	2.9×10^{5} [a]	2.9×10^{5} [a]
Cyanide	1.6×10^{5} [a]	1.6×10^{5} [a]	1.6×10^{5} [a]
Fluoride	9.5×10^{4}	9.5×10^{4} [a]	9.5×10^{4} [a]
Lead	ND	ND	ND
Manganese	5.4×10^{3} [a]	5.4×10^{3} [a]	5.4×10^{3} [a]
Mercury	1.8×10^{1} [a]	1.8×10^{1} [a]	1.8×10^{1} [a]
Molybdenum	3.4×10^{3} [a]	3.4×10^{3} [a]	3.4×10^{3} [a]
Nickel	2.0×10^{4}	5.3×10^{4} [a]	5.3×10^{4} [a]
Nitrate	NS	NS	NS
Selenium	6.6×10^{3} [a]	6.6×10^{3} [a]	6.6×10^{3} [a]
Silver	3.9×10^{4} [a]	3.9×10^{4} [a]	3.9×10^{4} [a]

TABLE C.2-5
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Inorganics (Continued)			
Thallium	1.1×10^{2} [a]	1.1×10^{2} [a]	1.1×10^{2} [a]
Thorium-total	ND	ND	ND
Uranium-total	2.9×10^{2} [a]	2.9×10^{2} [a]	2.9×10^{2} [a]
Vanadium	6.1×10^{3} [a]	6.1×10^{3} [a]	6.1×10^{3} [a]
Zinc	1.4×10^{5} [a]	1.4×10^{5} [a]	1.4×10^{5} [a]
Organics (mg/kg)			
Acetone	5.1×10^{4} [a]	5.1×10^{4} [a]	5.1×10^{4} [a]
Aroclor-1254	1.6×10^{-1}	1.6×10^{0}	1.6×10^{1} [a]
Aroclor-1260	1.6×10^{-1}	1.6×10^{0}	1.6×10^{1}
Benzene	1.1×10^{3}	1.1×10^{4}	1.1×10^{5}
Benzo(a)anthracene	2.7×10^{1}	2.7×10^{2}	2.7×10^{3}
Benzo(a)pyrene	2.7×10^{0}	2.7×10^{1}	2.7×10^{2}
Benzo(b)fluoranthene	2.7×10^{1}	2.7×10^{2}	2.7×10^{3}
Benzo(k)fluoranthene	2.7×10^{2}	2.7×10^{3}	2.7×10^{4}
Bis(2-chloroisopropyl)ether	5.6×10^{2}	5.6×10^{3}	5.6×10^{4}
Bis(2-ethylhexyl)phthalate	1.0×10^{3}	1.0×10^{4}	5.7×10^{4} [a]
Bromodichloromethane	4.7×10^{0}	4.7×10^{1}	4.7×10^{2}
Bromoform	3.7×10^{1}	3.7×10^{2}	1.2×10^{3} [a]
Bromomethane	1.1×10^{4} [a]	1.1×10^{4} [a]	1.1×10^{4} [a]
Butanone,2-	NS	NS	NS
Carbazole	1.5×10^{1}	1.5×10^{2}	1.5×10^{3}
Carbon Disulfide	5.9×10^{3} [a]	5.9×10^{3} [a]	5.9×10^{3} [a]
Carbon Tetrachloride	2.5×10^{0}	2.5×10^{1}	4.6×10^{1} [a]
Chlordane	2.3×10^{-1}	2.3×10^{0}	3.5×10^{0} [a]
Chlorobenzene	4.1×10^{2} [a]	4.1×10^{2} [a]	4.1×10^{2} [a]
Chloroform	5.4×10^{1}	5.4×10^{2}	6.5×10^{2} [a]
Chrysene	2.7×10^{3}	2.7×10^{4}	2.7×10^{5}
Dibenzo(a,h)anthracene	2.7×10^{0}	2.7×10^{1}	2.7×10^{2}
Dichlorobenzidene,3,3-	6.5×10^{-1}	6.5×10^{0}	6.5×10^{1}
Dichloroethane,1,1-	NS	NS	NS
Dichloroethane,1,2-	3.2×10^{0}	3.2×10^{1}	3.2×10^{2}
Dichloroethene,1,1-	4.8×10^{-1}	4.8×10^{0}	4.8×10^{1}
Dieldrin	1.8×10^{-2}	1.8×10^{-1}	1.8×10^{0}
Di-n-octylphthalate	1.3×10^{3} [a]	1.3×10^{3} [a]	1.3×10^{3} [a]
Ethyl Ether	9.0×10^{4} [a]	9.0×10^{4} [a]	9.0×10^{4} [a]
Ethylbenzene	4.7×10^{3} [a]	4.7×10^{3} [a]	4.7×10^{3} [a]
Heptachlorodibenzofuran	1.1×10^{-3}	1.1×10^{-2}	1.1×10^{-1}
Heptachlorodibenzo-p-dioxin	1.1×10^{-3}	1.1×10^{-2}	1.1×10^{-1}

000869

TABLE C.2-5
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Organics (Continued)			
Indeno(1,2,3-cd)pyrene	2.7×10^{1}	2.7×10^{2}	2.7×10^{3}
Methanol	ND	ND	ND
Methyl-2-pentanone,4-	2.9×10^{3} [a]	2.9×10^{3} [a]	2.9×10^{3} [a]
Methylene Chloride	4.4×10^{1}	4.4×10^{2}	4.0×10^{3}
Methylphenol,4-	2.9×10^{2} [a]	2.9×10^{2} [a]	2.9×10^{2} [a]
Nitroanaline,4-	1.8×10^{2} [a]	1.8×10^{2} [a]	1.8×10^{2} [a]
N-Nitrosodiphenylamine	6.0×10^{1}	6.0×10^{2}	6.0×10^{3}
N-Nitrosodipropylamine	4.2×10^{-2}	4.2×10^{-1}	4.2×10^{0}
Octachlorodibenzofuran	1.1×10^{-2}	1.1×10^{-1}	1.1×10^{0}
Octachlorodibenzo-p-dioxin	1.1×10^{-2}	1.1×10^{-1}	1.1×10^{0}
Pentachlorophenol	2.7×10^{0}	2.7×10^{1}	2.7×10^{2}
Phenanthrene	ND	ND	ND
Tetrachloroethene	4.2×10^{0}	4.2×10^{1}	4.2×10^{2}
Toluene	1.2×10^{5} [a]	1.2×10^{5} [a]	1.2×10^{5} [a]
Tributyl Phosphate	2.9×10^{2} [a]	2.9×10^{2} [a]	2.9×10^{2} [a]
Trichloroethane,1,1,1-	NS	NS	NS
Trichloroethane,1,1,2-	5.2×10^{0}	5.2×10^{1}	2.4×10^{2} [a]
Trichloroethene	2.9×10^{1}	2.9×10^{2}	2.9×10^{3}
Vinyl Chloride	1.5×10^{-1}	1.5×10^{0}	1.5×10^{1}
Xylenes	NS	NS	NS

NA - Not Applicable
ND - No toxicity data available for the development of risk-based PRGs
PRGs for PAHs are based on toxicity equivalent factors relative to benzo(a)pyrene
NS - Not significant for this receptor because of low order of toxicity and exposure - PRG $> 1 \times 10^{6}$ mg/kg
[a] - Value represents a PRG based on a HQ of 0.2.

TABLE C.2-6
RISK-BASED PRELIMINARY REMEDIATION GOALS FOR SURFACE SOIL BASED ON EXPOSURES TO THE EXPANDED TRESPASSER

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Radionuclides (pCi/g)			
Cs_{137+1d}	1.1×10^{0}	1.1×10^{1}	1.1×10^{2}
Np_{237+1d}	5.0×10^{0}	5.0×10^{1}	5.0×10^{2}
Pb_{210+2d}	4.6×10^{1}	4.6×10^{2}	4.6×10^{3}
Pu_{238}	1.0×10^{2}	1.0×10^{3}	1.0×10^{4}
$Pu_{239/240}$	1.0×10^{2}	1.0×10^{3}	1.0×10^{4}
Ra_{226+8d}	3.7×10^{-1}	3.7×10^{0}	3.7×10^{1}
Ra_{228+1d}	7.7×10^{-1}	7.7×10^{0}	7.7×10^{1}
Rn_{222+4d}	NA	NA	NA
Sr_{90+1d}	8.5×10^{2}	8.5×10^{3}	8.5×10^{4}
Tc_{99}	2.3×10^{4}	2.3×10^{5}	2.3×10^{6}
Th_{228+7d}	4.0×10^{-1}	4.0×10^{0}	4.0×10^{1}
Th_{230}	4.3×10^{2}	4.3×10^{3}	4.3×10^{4}
$Th_{232+10d}$	2.6×10^{-1}	2.6×10^{0}	2.6×10^{1}
U_{234}	4.5×10^{2}	4.5×10^{3}	4.5×10^{4}
$U_{235/236}$	9.1×10^{0}	9.1×10^{1}	9.1×10^{2}
U_{238+2d}	4.0×10^{1}	4.0×10^{2}	4.0×10^{3}
Inorganics (mg/kg)			
Antimony	7.9×10^{1} [a]	7.9×10^{1} [a]	7.9×10^{1} [a]
Arsenic	1.7×10^{1}	1.7×10^{2}	1.1×10^{3} [a]
Barium	5.9×10^{4} [a]	5.9×10^{4} [a]	5.9×10^{4} [a]
Beryllium	2.0×10^{0}	2.0×10^{1}	2.0×10^{2}
Boron	6.1×10^{3} [a]	6.1×10^{3} [a]	6.1×10^{3} [a]
Cadmium	6.8×10^{1} [a]	6.8×10^{1} [a]	6.8×10^{1} [a]
Chromium vi	4.6×10^{2}	2.8×10^{3} [a]	2.8×10^{3} [a]
Cobalt	7.1×10^{2} [a]	7.1×10^{2} [a]	7.1×10^{2} [a]
Copper	1.9×10^{5} [a]	1.9×10^{5} [a]	1.9×10^{5} [a]
Cyanide	1.0×10^{5} [a]	1.0×10^{5} [a]	1.0×10^{5} [a]
Fluoride	6.5×10^{4} [a]	6.5×10^{4} [a]	6.5×10^{4} [a]
Lead	ND	ND	ND
Manganese	2.0×10^{2} [a]	2.0×10^{2} [a]	2.0×10^{2} [a]
Mercury	1.2×10^{1} [a]	1.2×10^{1} [a]	1.2×10^{1} [a]
Molybdenum	2.4×10^{3} [a]	2.4×10^{3} [a]	2.4×10^{3} [a]
Nickel	2.3×10^{4}	3.6×10^{4} [a]	3.6×10^{4} [a]
Nitrate	NS	NS	NS
Selenium	4.5×10^{3} [a]	4.5×10^{3} [a]	4.5×10^{3} [a]
Silver	2.6×10^{4} [a]	2.6×10^{4} [a]	2.6×10^{4} [a]

TABLE C.2-6
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Inorganics (Continued)			
Thallium	7.6×10^{1} [a]	7.6×10^{1} [a]	7.6×10^{1} [a]
Thorium-total	ND	ND	ND
Uranium-total	2.0×10^{2} [a]	2.0×10^{2} [a]	2.0×10^{2} [a]
Vanadium	4.2×10^{3} [a]	4.2×10^{3} [a]	4.2×10^{3} [a]
Zinc	9.7×10^{4} [a]	9.7×10^{4} [a]	9.7×10^{4} [a]
Organics (mg/kg)			
Acetone	3.5×10^{4} [a]	3.5×10^{4} [a]	3.5×10^{4} [a]
Aroclor-1254	1.7×10^{-1}	1.7×10^{0}	1.7×10^{1}
Aroclor-1260	1.7×10^{-1}	1.7×10^{0}	1.7×10^{1}
Benzene	1.2×10^{3}	1.2×10^{4}	1.2×10^{5}
Benzo(a)anthracene	2.9×10^{1}	2.9×10^{2}	2.9×10^{3}
Benzo(a)pyrene	2.9×10^{0}	2.9×10^{1}	2.9×10^{2}
Benzo(b)fluoranthene	2.9×10^{1}	2.9×10^{2}	2.9×10^{3}
Benzo(k)fluoranthene	2.9×10^{2}	2.9×10^{3}	2.9×10^{4}
Bis(2-chloroisopropyl)ether	6.0×10^{2}	6.0×10^{3}	6.0×10^{4}
Bis(2-ethylhexyl)phthalate	1.1×10^{3}	1.1×10^{4}	3.9×10^{4} [a]
Bromodichloromethane	5.2×10^{0}	5.2×10^{1}	5.2×10^{2}
Bromoform	4.1×10^{1}	4.1×10^{2}	8.2×10^{2} [a]
Bromomethane	7.3×10^{3} [a]	7.3×10^{3} [a]	7.3×10^{3} [a]
Butanone,2-	NS	NS	NS
Carbazole	1.6×10^{1}	1.6×10^{2}	1.6×10^{3}
Carbon Disulfide	4.1×10^{3} [a]	4.1×10^{3} [a]	4.1×10^{3} [a]
Carbon Tetrachloride	2.8×10^{0}	2.8×10^{1}	3.2×10^{1} [a]
Chlordane	2.5×10^{-1}	2.5×10^{0}	2.5×10^{1}
Chlorobenzene	9.2×10^{2}	9.2×10^{2}	9.2×10^{2}
Chloroform	5.9×10^{1}	4.5×10^{2} [a]	4.5×10^{2} [a]
Chrysene	2.9×10^{3}	2.9×10^{4}	2.9×10^{5}
Dibenzo(a,h)anthracene	2.9×10^{0}	2.9×10^{1}	2.9×10^{2}
Dichlorobenzidene,3,3-	7.2×10^{-1}	7.2×10^{0}	7.2×10^{1}
Dichloroethane,1,1-	NS	NS	NS
Dichloroethane,1,2-	3.6×10^{0}	3.6×10^{1}	3.6×10^{2}
Dichloroethene,1,1-	5.3×10^{-1}	5.3×10^{0}	5.3×10^{1}
Dieldrin	2.0×10^{-2}	2.0×10^{-1}	2.0×10^{0}
Di-n-octylphthalate	9.1×10^{2} [a]	9.1×10^{2} [a]	9.1×10^{2} [a]
Ethyl Ether	7.0×10^{4} [a]	7.0×10^{4} [a]	7.0×10^{4} [a]
Ethylbenzene	4.2×10^{3} [a]	4.2×10^{3} [a]	4.2×10^{3} [a]
Heptachlorodibenzofuran	1.2×10^{-3}	1.2×10^{-2}	1.2×10^{-1}
Heptachlorodibenzo-p-dioxin	1.2×10^{-3}	1.2×10^{-2}	1.2×10^{-1}

TABLE C.2-6
(Continued)

Contaminant	Risk-Based Soil PRGs CR = 10^{-6} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-5} or HQ = 0.2	Risk-Based Soil PRGs CR = 10^{-4} or HQ = 0.2
Organics (Continued)			
Indeno(1,2,3-cd)pyrene	2.9×10^{1}	2.9×10^{2}	2.9×10^{3}
Methanol	NA	NA	NA
Methyl-2-pentanone,4-	2.0×10^{3}	2.0×10^{3}	2.0×10^{3}
Methylene Chloride	4.8×10^{1}	4.8×10^{2}	2.8×10^{3} [a]
Methylphenol,4-	2.0×10^{2}	2.0×10^{2}	2.0×10^{2}
Nitroanaline,4-	1.2×10^{2}	1.2×10^{2}	1.2×10^{2}
N-Nitrosodiphenylamine	6.6×10^{1}	6.6×10^{2}	6.6×10^{3}
N-Nitrosodipropylamine	4.6×10^{-2}	4.6×10^{-1}	4.6×10^{0}
Octachlorodibenzofuran	1.2×10^{-2}	1.2×10^{-1}	1.2×10^{0}
Octachlorodibenzo-p-dioxin	1.2×10^{-2}	1.2×10^{-1}	1.2×10^{0}
Pentachlorophenol	3.0×10^{0}	3.0×10^{1}	3.0×10^{2}
Phenanthrene	ND	ND	ND
Tetrachloroethene	4.7×10^{0}	4.7×10^{1}	3.1×10^{2} [a]
Toluene	8.4×10^{4} [a]	8.4×10^{4} [a]	8.4×10^{4} [a]
Tributyl Phosphate	2.0×10^{2} [a]	2.0×10^{2} [a]	2.0×10^{2} [a]
Trichloroethane,1,1,1-	NS	NS	NS
Trichloroethane,1,1,2-	5.7×10^{0}	5.7×10^{1}	1.6×10^{2} [a]
Trichloroethene	3.2×10^{1}	3.2×10^{2}	3.2×10^{3}
Vinyl Chloride	1.7×10^{-1}	1.7×10^{0}	1.7×10^{1}
Xylenes	7.0×10^{5} [a]	7.0×10^{5} [a]	7.0×10^{5} [a]

NA - Not Applicable
ND - No toxicity data available for the development of risk-based PRGs
PRGs for PAHs are based on toxicity equivalent factors relative to benzo(a)pyrene
NS - Not signficant for this receptor because of low order of toxicity and exposure - PRG $> 1 \times 10^{6}$ mg/kg
[a] - Value represents a PRG based on a HQ of 0.2.

C.3.0 CALCULATION OF UNIT RISKS

This section presents the methods for calculating unit risk (UR) and unit toxicity for exposure pathways for determination of risk-based PRGs. The constituent selected for the continued example calculation is U-238. This radionuclide is chosen for illustration because it is present in all media, and uranium contributes to both risk and toxic effects calculated for the operable unit. All parameters and equations are drawn from the FEMP Risk Assessment Work Plan Addendum (DOE 1992) and the Supplemental Guidance to the FEMP Risk Assessment Work Plan Addendum (DOE 1994a) unless noted otherwise. All receptor exposure parameters are listed in Tables H.III-8 and H.III-9.

For convenience, the equations used to quantify risk are grouped together according to exposure media. The exposure media considered are air (Section C.3.1), soil (Section C.3.2), groundwater (Section C.3.3), surface water (Section C.3.4), and sediment (Section C.3.5). Section C.3.6 presents the PRG calculations for the multiple age group receptors. The calculation of unit risk factors is identical to calculating an ILCR or an HI; however, a unit value of 1.0 is used in place of an exposure point concentration.

C.3.1 AIR EXPOSURES

Risk-based PRGs are not calculated directly for air but they must be considered in the calculation of PRGs for soil. Risk-based PRGs for soil are calculated for four receptor types based on four land use scenarios including the on-property RME farmer (agricultural), groundskeeper (commercial or industrial), and recreational receptors, and the expanded trespasser (no land use). The on-property RME farmer is used for this example to illustrate the calculation of UR for U-238 from air pathways. The pathways of concern for U-238 in air for this receptor include inhalation, deposition onto plants and ingestion of fruits and vegetables, and biouptake from plants into livestock and ingestion of meat and milk products. The inhalation portion of this example applies to receptors associated with alternative land uses. However, appropriate exposure parameters for these target individuals would be substituted where applicable.

C.3.1.1 Inhalation

Equations 7-5 and 7-6 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992) are used to quantify intake from the inhalation pathway:

$$\text{(radionuclides)}\ I_{ai} = (C_{ai})(IR)(ET)(EF)(ED) \qquad \text{(C.3-1)}$$

$$\text{(chemicals)}\ I_{ai} = (C_{ai})(IR)(ET)(EF)(ED)/(BW)(AT) \qquad \text{(C.3-2)}$$

where

I_{ai}	=	intake from inhalation (picocuries, radionuclides) [milligram per kilogram day (mg/kg-d, chemicals)]
C_{ai}	=	concentration in air (pCi/m^3, radionuclides) (mg/m^3, chemicals)
IR	=	inhalation rate [m^3/hour (h)]
ET	=	exposure time [h/day (d)]
EF	=	exposure frequency [d/year (y)]
ED	=	exposure duration (y)
BW	=	body weight (kg)
AT	=	averaging time (d); for noncarcinogens, AT equals ED (365 d/y); for chemical carcinogens, AT equals 70 y/ILCR (365 d/y)

Intakes resulting from inhaling air containing a unit concentration of 1 pCi/m^3 of U-238 have been selected for the example calculation. The inhalation rate for an adult is 0.83 m^3/h. The exposure duration is 70 years (ED = 70 y/lifetime) and the exposure frequency is 350 days out of every year (EF = 350 d/y). The exposure time (ET) is 5.7 h/d for outdoor exposure. Substituting these values into Equation C.3-1 yields:

$$I_{a\ U238} = (1\ pCi/m^3)(0.83\ m^3/h)(5.7\ h/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{a\ U238} = 115{,}910\ pCi/lifetime \qquad \text{(C.3-3)}$$

The exposure model used in this scenario responds linearly to changes in concentration. The UR to this receptor for this pathway from this radionuclide is:

$$ILCR_{a\ U238} = SF_{inh\ U238} \times I_{a\ U238} \qquad \text{(C.3-4)}$$

where

$ILCR_{a\ U238}$	=	incremental lifetime cancer risk from breathing air
$SF_{inh\ i}$	=	slope factor for inhalation of constituent "i" (risk/pCi)
$I_{a\ U238}$	=	intake if U-238 from inhalation of air containing 1 pCi/m^3

The relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 calculated in Equation C.3-3 and the inhalation slope factor for U-238, 2.4 x 10^{-8} (pCi)$^{-1}$, for $SF_{inh\ i}$ into Equation C.3-4. This yields:

$$ILCR_{a\ U238} = (2.4 \times 10^{-8}\ risk/pCi)\ (115910\ pCi/lifetime)$$
$$ILCR_{a\ U238} = 2.78 \times 10^{-3} \qquad \text{(C.3-5)}$$

Because a unit concentration of 1.0 was used in the intake equation and the exposure model used responds linearly to changes in concentration, 2.8 x 10^{-3} represents a UR factor. In other words, each additional pCi/m^3 of U-238 in air is predicted to result in a calculated ILCR of 2.8 x 10^{-3}.

C.3.1.2 Ingestion of Vegetables Contaminated by Aerial Deposition

Eating vegetables contaminated by aerial deposition of contaminated dust can contribute to the total intake of contaminants by humans. Estimating the magnitude of this intake is a two-step process. First, the concentration in the vegetables is estimated, then the lifetime intake is calculated. If measured values are not available (e.g., future exposures), this concentration is estimated using Equation 7-10 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The intake equation is:

$$C_{avi} = d_d \left[\frac{r_d \, (1-e^{-\lambda_w t_e})}{Y \, \lambda_w} + \frac{f_d \, B_{iv(n)} \, CF_p \, (1-e^{-\lambda_{di} t_{bd}})}{\rho \, \lambda_{di}} \right] e^{-\lambda_{di} t_h} \qquad \text{(C.3-6)}$$

where

C_{avi}	=	concentration of the ith contaminant in/on vegetables and fruit (pCi/g, radionuclides) (mg/kg, chemicals)
λ_{di}	=	effective depletion constant of ith contaminant in surface soil due to radioactive decay, chemical degradation, and leaching (h^{-1})
λ_w	=	effective depletion constant of ith contaminant on the surface plants also known as the weathering removal rate (h^{-1})
λ_{ri}	=	radioactive or chemical decay constant of ith contaminant (h^{-1})
$B_{iv(n)}$	=	dry soil to wet plant partitioning coefficient of ith contaminant in feed and forage (n=1) or food crops (n=2) (C_{iv}/C_s)
CF_p	=	dry to wet weight conversion factor [0.428 for vegetables and fruits (Baes et al., 1984) 1.0 for feed and forage]
d_d	=	constituent's deposition rate (pCi/m^2-h, radionuclides) (mg/m^2-h, chemicals)
f_d	=	fraction of year plant is downwind (unitless)
r_d	=	fraction of airborne material retained on plant surface (unitless)
t_e	=	growing season (h)
t_{bd}	=	duration soil is exposed to airborne emissions (h)
t_h	=	duration of period between harvest and consumption (h)
Y	=	agricultural yield (g/m^2) (kg/m^2)
ρ	=	effective dry surface soil density (g/m^2) (kg/m^2)

Chemical-specific biotransfer factors are provided in Table C.3-1. Site-specific parameter values are given in Table C.3-2. The soil depletion coefficient is calculated by:

$$\lambda_{di} = \lambda_{ri} + \lambda_{Li} \qquad \text{(C.3.-7)}$$

where the leaching coefficient (λ_{Li}) is calculated using the relationship (Baes et al., 1984):

$$\lambda_{Li} = \frac{V_w}{z\,\theta\left[1+\sigma\,\frac{K_d}{\theta}\right]} \qquad \text{(C.3-8)}$$

where

λ_{Li} = leach rate (h^{-1})
V_w = percolation rate (nominally 0.00177 cm/h through Operable Unit 5 soil)
z = depth of surface soil [15 centimeters (cm)]
σ = density of soil in root zone [nominally 1.5 g/cubic centimeters (cm^3)]
K_d = water to soil partitioning coefficient (cm^3/g)
θ = moisture fraction of surface soil (measured at 0.17)

When measured air concentration data are available, the aerial deposition rate of a constituent per unit area (d_d) is estimated by multiplying the concentration in air by the mean deposition velocity meters per hour (V m/h):

$$d_d = (C_{a\,U238}\ pCi/m^3)(V\ m/h) \qquad \text{(C.3-9)}$$

Vegetables grown in air containing particles of U-238 have been selected for the example calculation. Concentration in air has been estimated using a unit soil concentration of 1 pCi/g for the example calculation. Assuming that the mean deposition velocity for dust in the study area (V) is about 0.0018 m/s (DOE 1992) or 6.48 m/hr, the aerial deposition rate of U-238 (d_d) per unit area calculated by Equation C.3-9 is 6.48 $pCi/m^2/h$. Assuming the vegetables are centered in the study area, they will always be downwind, so (f_d) is unity (1). The duration of time which the vegetable plot is exposed to aerial deposition during the study period (t_{bd}) is 1000 years (8.76×10^6 h). The fraction of airborne material retained on the plant surface (r_d) is 0.25. The weathering removal rate (λ_w) is 0.0021 h^{-1}. The dry soil to dry plant partitioning coefficient of U-238 in the reproductive portions of vegetables ($B_{iv(2)}$) is 4×10^{-3}. The dry plant mass to wet plant mass ratio is 0.428 (CF_p). The effective dry surface density of the soil (ρ) is 225,000 g/m^2. The agricultural yield is 1500 g/m^2 (Y), and the growing season (t_e) is 1440 hours. The period between harvest and consumption (t_h) is 24 hours. The radiological decay constant of U-238 (λ_{ri}) is 1.77×10^{-14} h^{-1}. This value is so small that the $\exp(-\lambda_{ri}\ t_h)$ term approaches unity (1) (i.e., no significant decay). A value of 6.49×10^{-6} is calculated for λ_{Li} using Equation C.3-8 and a K_d of 12 cm^3/g from Appendix F of this FS. The effective depletion constant (λ_{di}) is calculated from Equation C.3-7 to be 1.61×10^{-5}. Substituting these parameter values into Equation C.3-5 and simplifying yields:

$$C_{avi} = (6.48 pCi/m^2/h)\left[\frac{(0.25)(1-e^{-(0.0021\,h^{-1})(1440\,h)})}{(1500\,g/m^2)(0.0021\,h^{-1})} + \frac{(1)(0.004)(0.483)(1-e^{-((6.49\,x\,10^{-6}h^{-1})(8760000\,h))})}{(225000\,g/m^2)(6.49\,x\,10^{-6}h^{-1})}\right]$$

(C.3.-10)

then

$$C_{av\ U238} = 0.490\ pCi/g$$

Once the constituent's concentration in the vegetables and fruit is estimated, the resulting unit intake by humans can be estimated using Equations 7-15 and 7-16 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992):

$$(radionuclides)\ I_{avi} = (C_{avi})(IR)(FI)(EF)(ED) \quad \text{(C.3-11)}$$
$$(chemicals)\ I_{avi} = (C_{avi})(IR)(FI)(EF)(ED)/(BW)(AT) \quad \text{(C.3.12)}$$

where

I_{avi}	=	intake from vegetation (pCi, radionuclides) (mg/kg-d, chemicals)
C_{avi}	=	total concentration of contaminants in vegetable (pCi/g, radionuclides) (mg/kg, chemicals)
IR	=	ingestion rate (g/d) (kg/d)
FI	=	fraction ingested from contaminated source (unitless)
EF	=	exposure frequency (d/y)
ED	=	exposure duration (y)
BW	=	body weight (kg)
AT	=	averaging time (d); for noncarcinogens, AT equals ED (365 d/y); for chemical carcinogens, AT equals 70 y/ILCR (365 d/y)

Continuing the example begun in Equation C.3-10, ingestion of vegetables and fruit containing a U-238 concentration of C_{avi} of 0.490 pCi/g for a 70-year lifetime has been selected to illustrate the method used to calculate human intake of constituents from plants. The exposure frequency is 350 days per year (EF = 350 d/y). The combined consumption rate of fruit and vegetables grown in the study area is 122 grams per day. The fraction of time that crops are consumed from the contaminated source is assumed to be 0.5. The exposure duration (ED) is 70 y/ILCR. The lifetime intake of U-238 from this food supply is given by Equation C.3-11. Using the presented parameter values, this becomes:

$$I_{av\ U238} = (0.490\ pCi/g)(122\ g/d)(0.5)(350 d/y)(70\ y/lifetime)$$
$$I_{av\ U238} = 7.31\ x\ 10^{+5}\ pCi/lifetime \quad \text{(C.3-13)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/m^3 of U-238 in air will produce an incremental lifetime intake of about 7.31 x 10^{+5} pCi U-238 via this pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{av\ U238} = SF_{ing\ i} \times I_{av\ U238} \qquad \text{(C.3-14)}$$

where

$ILCR_{av\ U238}$ = incremental lifetime cancer risk from ingestion of vegetables contaminated by aerial deposition (risk/lifetime)

$SF_{ing\ i}$ = slope factor for ingestion of constituent "i" (risk/pCi)

The linear relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake from fruit and vegetable consumption calculation in Equation C.3-13 and the ingestion slope factor for U-238 ($SF_{ing\ U238} = 2.0 \times 10^{-11}$ pCi) for Equation C.3-14. This yields:

$$ILCR_{av\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)(7.31 \times 10^{+5}\ pCi/lifetime)$$
$$ILCR_{av\ U238} = 1.46 \times 10^{-5}\ (risk/lifetime) \qquad \text{(C.3-15)}$$

Because the exposure model used in this scenario responds linearly to changes in concentration and an unit concentration of 1.0 was used in the intake calculation, each additional pCi/m^3 of U-238 in air is predicted to result in unit risk factor of 1.46×10^{-5}.

C.3.1.3 Ingestion of Meat or Milk Produced Downwind of Source

Forage, feed, and soil downwind of a potential source of contaminated dust can have contamination deposited on them by settling dust. Ingestion of these plants by livestock contributes to the body burden of these contaminants in livestock. Consumption of meat or milk from these animals contributes to the total intake of these contaminants by humans.

The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g., future exposures), this concentration can be calculated using the method set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The concentration of a contaminant in animal products such as beef or milk is estimated using the following equation:

$$C_{Ai} = F_{Ai}[(C_{afi})(Q_f) + (C_{agi})(Q_g) + (C_{asi})(Q_s)]\, e^{-\lambda_i t_h} \qquad \text{(C.3-16)}$$

where

C_{Ai} = concentration of ith contaminant in the animal product (pCi/mL for milk, pCi/g for beef for radionuclides) (mg/L for milk, mg/g for beef for chemicals)

C_{afi} = concentration of ith contaminant in feed (pCi/g, radionuclides) (mg/kg, chemicals)

C_{agi} = concentration of ith contaminant in forage (pCi/g, radionuclides) (mg/kg, chemicals)

C_{asi} = concentration of ith contaminant in soil (pCi/g, radionuclides) (mg/kg, chemicals)
F_{Ai} = elemental transfer coefficient that relates the daily intake by an animal to the concentration of ith contaminant in an edible portion of the animal product (d/L for milk, d/g for meat)
Q_f = consumption rate of contaminated feed by livestock (g/d) (kg/d)
Q_g = consumption rate of contaminated forage by livestock (g/d) (kg/d)
Q_s = consumption rate of contaminated soil by livestock (g/d) (kg/d)
λ_{ri} = radioactive or chemical decay constant of ith contaminant (h^{-1})
t_h = duration of period between harvest and consumption (h)

Estimating the magnitude of this intake is a two-step process. First, the concentration in the soil, feed, and forage is estimated. If measured values are not available (e.g., future exposures), this concentration is estimated. The amount attributable to dust deposition on feed and forage is calculated using Equation C.3-6. In the second step, the concentrations in animal products (meat and milk) are calculated.

Uptake of contaminants by feed and forage grown downwind of air emissions containing a unit concentration 1 pCi/m^3 have been selected as an example calculation for this pathway. Assuming that the mean deposition velocity for dust in the study area is about 0.0018 m/s (DOE 1992), the aerial deposition rate of U-238 (d_d) per unit area calculated by Equation C.3-9 is 6.48 pCi/m^2/h. Assuming the plants are centered in the study area, they will always be downwind, so (f_d) is unity (1). The duration of time in which the plants and surrounding soil are exposed to aerial deposition during the study period is 1,000 years (t_{bd} = 8,760,000 h). The fraction of airborne material retained on the plant surface (r_d) is 0.25. The weathering removal rate (λ_w) is 0.0021 h^{-1}. The dry soil to dry plant partitioning coefficient of U-238 in the feed and forage ($B_{iv(1)}$) is 8.5 x 10^{-3}. The dry plant mass to wet plant mass ratio for this case is 1.0. The effective dry surface density of the soil (ρ) is 225,000 g/m^2. The agricultural yield (Y) is 800 g/m^2 and the growing season (t_e) is 3312 hours for feed and 720 hours for forage. The period between harvest and consumption (t_h) is 6160 hours for feed and 720 hours for forage. The radiological decay constant of U-238 (λ_{ri}) is 1.77 x 10^{-14} h^{-1}. This value is so small that the $\exp(-\lambda_{ri}\ t_h)$ term approaches a value of 1 (i.e., no significant decay) for both the forage and the feed calculations.* A value of 6.49 x 10^{-6} is calculated for $\lambda_{d\ U238}$ using a K_d of 12 cm^3/g obtained from Appendix F of this FS. Chemical degradation does not apply and is set equal to zero (0). Substituting the parameter values for forage into Equation C.3-6 and simplifying yields:

$$C_{avi} = (6.48 pCi/m^2/h)\left[\frac{(0.25)(1-e^{-(0.0021\,h^{-1})(720\,h)})}{(800\,g/m^2)(0.0021)} + \frac{(1)(0.0085)(1)(1-e^{-(6.49\ x\ 10^{-6}h^{-1})(8760000\,h)})}{(225000\,g/m^2)(6.49\ x\ 10^{-6})}\right]$$

$$C_{ag\ U238} = 0.789\ pCi/g \qquad \text{(C.3-17)}$$

Substituting the parameter values for feed into Equation C.3-6 and simplifying yields:

$$C_{avi} = (6.48 pCi/m^2/h)\left[\frac{(0.25)(1-e^{-(0.0021\,h^{-1})(3312\,h)})}{(800\,g/m^2)(0.0021\,h^{-1})} + \frac{(1)(0.0085)(1)(1-e^{-(6.49\ x\ 10^{-6})(8760000\,h)})}{(225000\,g/m^2)(6.49\ x\ 10^{-6})}\right]$$

$$C_{af\,U238} = 1.000\ pCi/g \qquad \text{(C.3-18)}$$

Cows also consume soil while grazing. Concentrations in the soil attributable to aerial deposition can be calculated by multiplying the aerial deposition rate by the second term in parentheses in Equation C.3-6. Since the medium of interest is the soil itself and not a plant growing in the soil, the $B_{iv(2)}$ term is removed leaving:

$$C_{si} = d_d\left[\frac{f_d(1-e^{-\lambda_d t_w})}{\rho\lambda_d}\right] e^{-\lambda_{ri} t_h} \qquad \text{(C.3-19)}$$

Substituting previously described variables in Section C.3.3 into this equation produces an estimated soil concentration of:

$$C_{si} = 6.48 pCi/m^2/h\,\frac{(1)(1-e^{-(6.49 x 10^{-6})(8760000\,h)})}{(225000\,g/m^2)(6.49 x 10^{-6})}(1)$$

$$C_{as\,U238} = 4.44\ pCi/g \qquad \text{(C.3-20)}$$

Once the concentrations in feed, forage, and soil have been estimated, concentrations in the animal products can be calculated using Equation C.3-16. Continuing the example begun in Equation C.3-17, the concentrations of U-238 in feed, forage, and soil attributable to dust deposition are about 0.789 pCi/g, 1.000 pCi/g, and 4.44 pCi/g, respectively. In this study, a cow is assumed to consume 25,000 g/d of stored feed (Q_f), 25,000 g/d of forage (Q_g);*and 500 g/d of soil (Q_s). The food-to-beef biotransfer factor ($F_{m\,U238}$) is 2.0 x 10^{-7} d/g and the food-to-milk biotransfer factor ($F_{d\,U238}$) is 6.0 x 10^{-7} d/mL. The period between harvest and consumption (t_h) is 480 hours for beef and is 24 hours for milk. The radiological decay constant of U-238 λ_{ri} is 1.77 x 10^{-10} y^{-1}. This value is so small that the exp($-\lambda_{ri}\ t_h$) term approaches a value of 1 (i.e., no significant decay) for both the beef

and milk calculations. Substituting the presented parameter values for beef into Equation C.3-16 yields a meat concentration ($C_{Ai} = C_{m\ U238}$) of:

$$C_{am\ U238} = (2.0 \times 10^{-7}\ d/g)[(0.789\ pCi/g)(25000\ g/d) + (1.000\ pCi/g)(25000\ g/d) + (4.44\ pCi/g)(500\ g/d)]$$

$$C_{am\ U238} = 9.39 \times 10^{-3}\ pCi/g \qquad \text{(C.3-21)}$$

Using the presented parameter values for milk yields a U-238 concentration in milk ($C_{Ai} = C_{d\ U238}$) of:

$$C_{ad\ U238} = (6.0 \times 10^{-4}\ d/mL)[(0.789\ pCi/g)(25000\ g/d) + (1.000\ pCi/g)(25000\ g/d) + (4.44\ pCi/g)(500\ g/d)]$$

$$C_{ad\ U238} = 2.82 \times 10^{-2}\ pCi/mL \qquad \text{(C.3-22)}$$

Once the constituent's concentration in the animal product is estimated, the resulting unit intake by humans can be estimated using Equations 7-17 and 7-18 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992):

$$\text{(radionuclides)}\ I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED) \qquad \text{(C.3-23)}$$

$$\text{(chemicals)}\ I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED)/(BW)(AT) \qquad \text{(C.3-24)}$$

where

I_{Ai}	=	intake of ith constituent from animal product (pCi, radionuclides) (mg/kg-d, chemicals)
C_{Ai}	=	concentration of ith contaminant in animal product (pCi/g beef or pCi/mL milk, radionuclides) (mg/kg beef or mg/L milk, chemicals)
IR	=	ingestion rate (g beef/d or mL milk/d, radionuclides) (kg beef/d or L milk/d, chemicals)
FI	=	fraction ingested from contaminated source (unitless)
EF	=	exposure frequency (d/y)
ED	=	exposure duration (y)
BW	=	body weight (kg)
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) x (365 d/y); for chemical carcinogens, AT equals (70 y) x (365 d/y)

The calculated concentration of U-238 in beef and milk in the example scenario is about 9.39×10^{-3} pCi/g and 2.82×10^{-2} pCi/mL, respectively. The exposure frequency is 350 days per year (EF = 350 d/y). The fraction ingested from the contaminated source (FI x IR) is 75 g/d for beef and 300 mL/d for milk. The exposure duration (ED) is 70 years in days. After substituting the appropriate parameter values for beef ingestion into Equation C.3-24, the lifetime intake of U-238 from eating beef ($I_{Ai} = I_{am\ U238}$) is estimated as:

$$I_{am\ U238} = (9.396 \times 10^{-3} pCi/g)(75\ g/d)[(350\ d/y)(70\ y/lifetime)$$

$$I_{am\ U238} = 1.73 \times 10^{+4}\ pCi/lifetime \qquad \text{(C.3-25)}$$

After substituting the appropriate parameter values for milk ingestion into Equation C.3-23, the lifetime intake of U-238 from consuming dairy products ($I_{Ai} = I_{ad\ U238}$) is calculated as:

$$I_{ad\ U238} = (2.82 \times 10^{-2}\ pCi/mL)(300\ mL/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{ad\ U238} = 2.07 \times 10^{+5}\ pCi/lifetime \qquad \text{(C.3-26)}$$

The total intake from ingesting meat and dairy products raised on feed and forage grown in air containing U-238 ($I_{aA\ U238}$) is:

$$I_{aA\ U238} = I_{am\ U238} + I_{ad\ U238}$$
$$I_{aA\ U238} = (1.73 \times 10^{+4}\ pCi/lifetime) + (2.07 \times 10^{+5}\ pCi/lifetime)$$
$$I_{aA\ U238} = 2.24 \times 10^{+5}\ pCi/lifetime \qquad \text{(C.3-27)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, it is estimated that each additional pCi/m^3 of U-238 in air produces an unit intake of about $2.24 \times 10^{+5}$ pCi of U-238 via these pathways.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{aA\ U238} = SF_{ing\ i} \times I_{aA\ U238} \qquad \text{(C.3-28)}$$

where

$ILCR_{aA\ U238}$	=	unit risk from ingestion of meat or milk produced downwind of source (risk/lifetime)
$SF_{ing\ i}$	=	slope factor for ingestion of constituent "i" (risk/pCi)
$I_{aA\ U238}$	=	total intake of U-238 from ingestion of meat and milk products

The relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by the lifetime intake of U-238 from animal products calculated in Equation C.3-27 and substituting the ingestion slope factor for U-238, 2.0×10^{-11} pCi^{-1}, for $SF_{ing\ i}$ into Equation C.3-28. This yields:

$$ILCR_{aA\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)(2.24 \times 10^{+5}\ pCi/lifetime)$$
$$ILCR_{aA\ U238} = 4.49 \times 10^{-6}\ risk/lifetime \qquad \text{(C.3-29)}$$

Because a unit concentration of 1.0 was use to develope the unit concetration in the animal product and the exposure models respond linearly to changes in concentration, the ILCR of 4.5×10^{-6} represents a unit risk factor (UR).

C.3.1.4 Calculation of an ILCR from a Combination of All Airborne Exposure Pathways

In some situations, a hypothetical resident inhales air containing suspended material and ingests crops grown in areas experiencing aerial deposition. The total risks to the same receptor from these two pathways may be calculated as:

$$ILCR_{air\ i} = (I_{ai})(SF_{inh\ i}) + (I_{avi} + I_{aAi})(SF_{ing\ i}) \qquad \text{(C.3-30)}$$

where

$ILCR_{air\ i}$	=	incremental lifetime cancer risk
I_{ai}	=	intake from inhaling constituent "i" (pCi/lifetime)
I_{avi}	=	intake of constituent "i" in food crops from aerial deposition (pCi/lifetime)
I_{aAi}	=	intake of constituent "i" in animal products from aerial deposition (pCi/lifetime)
$SF_{ing\ i}$	=	slope factor for ingestion of constituent "i" (risk/pCi)
$SF_{inh\ i}$	=	slope factor for inhalation of constituent "i" (risk/pCi)

A farmer living downwind of a plume of resuspended U-238 particles has been selected as the example for this calculation. The total intake by inhalation for this hypothetical receptor for each pCi of U-238 per m^3 of air is calculated in Section C.3.1. Similarly, the intakes from each pCi of U-238 per m^3 of air from eating vegetables and animal products grown downwind of air emissions are calculated in Sections C.3.1.2 and C.3.1.3. Substituting these values into Equation C.3-30, along with the appropriate HEAST slope factors for inhalation and ingestion of uranium, yields:

$$ILCR_{air\ U238} = (115{,}910\ pCi/lifetime)(2.4 \times 10^{-8}\ risk\backslash pCi) + [(7.31 \times 10^{+5}\ pCi/lifetime) + (2.24 \times 10^{+5}\ pCi/lifetime)](2.0 \times 10^{-11}\ (risk/pCi)$$

$$ILCR_{air\ U238} = 2.8 \times 10^{-3}\ ILCR \qquad \text{(C.3-31)}$$

The exposure models used in this scenario respond linearly to changes in concentration. Therefore the ILCR of 2.8×10^{-3} represent a total UR factor for all air pathways applicable for this receptor, which can then be used in the calculation of the PRG.

Because the risk from the air pathways result from the resuspension of soil, the contribution of risk from air must be calculated into the soil PRGs. This can be done by multiplying the total unit risk from air by the soil to air transfer factor (TF), 2×10^{-5} g/m^3, as explained in Section C.2.2, equation (C.2-3).

C.3.2 GROUNDWATER EXPOSURES

The on-property RME farmer is the only receptor for calculation of risk-based PRGs for groundwater. Therefore, this receptor will be used to demonstrate the calculation of intakes and risks for determining unit risks associated with using groundwater containing U-238. The pathways of

concern for U-238 in groundwater from the Great Miami Aquifer for this receptor include ingestion; irrigation of food crops and ingestion of fruits and vegetables; and irrigation of feed crops, uptake into livestock, and ingestion of meat and milk products. In addition to these exposure pathways, intake from dermal contact while bathing would be included in the calculation of PRGs for chemicals. However, for most metals and hence, most radionuclides in Operable Unit 5, dermal absorption is not a significant pathway because penetration through the skin is minimal. Therefore, the dermal contact pathway is not included in the calculation of the PRG for U-238. Risk-based PRGs for U-238 in perched groundwater are calculated in a similar manner as those for the Great Miami Aquifer with the exception that it is assumed there is insufficient yield of perched groundwater for agricultural use but adequate yield for household use. Therefore, risk-based PRGs for perched groundwater consider only household use of groundwater. The example calculation provided here is for U-238 in the Great Miami Aquifer but could be altered for U-238 in the perched groundwater zone by considering only household use exposure pathways. A summary of these pathways is provided below.

C.3.2.1 Drinking Water Ingestion Pathway

Ingestion of contaminated drinking water can be a major contributor to environmental intakes of a COC. An estimate of intake from drinking water is calculated from Equations 7-3 and 7-4 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The intake equations are:

$$\text{(radionuclides)}\quad I_{wi} = (C_{wi})(IR)(ED)(EF) \qquad \text{(C.3-32)}$$

$$\text{(chemicals)}\quad I_{wi} = (C_{wi})(IR)(ED)(EF)/(BW)(AT) \qquad \text{(C.3-33)}$$

where

I_{wi} = intake of ith contaminant from drinking water (pCi, radionuclides) (mg/kg-d, chemicals)
C_{wi} = i^{th} concentration in water (pCi/L, radionuclides) (mg/L, chemicals)
IR = ingestion rate (L/d)
EF = exposure frequency (d/y)
ED = exposure duration (y)
BW = body weight (kg)
AT = averaging time (d); for noncarcinogens, AT equals (ED) x (365 d/y [EPA 1991a]); for chemical carcinogens, AT equals (70 y) x (365 d/y)

Intakes resulting from ingesting drinking water containing 1 pCi/L of U-238 have been selected for the example calculation. The ingestion rate (IR) is 2 L/d. The exposure frequency is 350 days per year (EF = 350 d/y) and exposure duration (ED) is 70 years. The lifetime intake is given by Equation C.3-32. Using the presented parameter values, this becomes:

$$I_{w\,U238} = (1\ pCi/L)(2\ L/d)(70\ y)(350\ d/y)$$
$$I_{w\,U238} = 49{,}000\ pCi/lifetime \qquad \text{(C.3-34)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each pCi/L of U-238 in water will produce a lifetime intake of 49,000 pCi of U-238 via this one pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{w\ U238} = SF_{ing\ i} \times I_{w\ U238} \qquad \text{(C.3-35)}$$

where

$ILCR_{w\ U238}$ = incremental lifetime cancer risk from ingestion of drinking water (risk/lifetime)
$SF_{ing\ i}$ = slope factor for ingestion of constituent "i" (risk/pCi)

The relationship between water concentration and risk for this receptor, pathway, and radionuclide is determined by combining Equations C.3-34 and C.3-35 and substituting the ingestion slope factor for U-238, 2.0 x 10^{-11} risk/pCi, for $SF_{ing\ i}$. This yields:

$$ILCR_{w\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)^{-1})(49{,}000\ pCi/lifetime)$$
$$ILCR_{w\ U238} = 9.8 \times 10^{-7}\ risk/lifetime \qquad \text{(C.3-36)}$$

Because a unit concentration of 1.0 was used in calculation, the value, 9.8 x 10^{-7}, represents a unit risk factor. Therefore, hypothetically, each additional pCi/L of U-238 in water will produce a risk of about 9.8 x 10^{-7} via this one pathway.

C.3.2.2 Irrigation of Vegetables

Eating vegetables irrigated with contaminated water can contribute to the total intake of contaminants by humans. Estimating the magnitude of this intake is a two-step process. First, the concentration in the vegetables is estimated. In the second step, the human intake of the constituent is calculated. If the measured constituent concentration in plants are not available (e.g., future exposures), this concentration is estimated using Equation 7-9 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The equation is:

$$C_{vwi} = d_w \left[\frac{r_w(1-e^{-\lambda_w t_r})}{Y\lambda_w} + \frac{f_w B_{iv(2)} CF_p (1-e^{-\lambda_{di} t_w})}{\rho \lambda_{di}} \right] e^{-\lambda_{di} t_h} \qquad \text{(C.3-37)}$$

where

C_{vwi} = concentration of ith contaminant in plants as a result of irrigating plants with contaminated water (pCi/g) (mg/kg)
λ_{di} = effective depletion constant of ith contaminant from the first 15 cm inches of soil; this includes radioactive decay, chemical degradation, and leaching (h^{-1}).

λ_w	=	effective depletion constant of ith contaminant on the surface plants also known as the weathering removal rate (h^{-1})
λ_{ri}	=	radioactive or chemical decay constant of ith contaminant (h^{-1})
$B_{iv(2)}$	=	dry soil to wet plant partitioning coefficient of ith contaminant in food crops (C_{iv}/C_s)
CF_p	=	dry plant mass to wet plant mass ratio (0.428 for food crops)
d_w	=	C_w x irrigation rate when C_w = 1 pCi/L
f_w	=	fraction of year plant is irrigated (unitless)
ρ	=	effective dry surface density of the soil (g/m^2) (kg/m^2)
r_w	=	fraction of waterborne material retained on plant surface (unitless)
t_e	=	growing season (h)
t_{bw}	=	duration of irrigation use (h)
t_h	=	duration of period between harvest and consumption (h)
Y	=	agricultural yield (g/m^2) (kg/m^2)
IR	=	.081 L/m^2/h

Vegetables irrigated with water containing 1 pCi/L of U-238 ($C_{w\ U238}$) have been selected for the example calculation. The mean irrigation rate (d_w) per unit area is 0.081 L/m^2-h, so the rate of constituent deposition by irrigation (d_wx C_w) is ($C_{w\ U238}$ pCi/L) (0.081 L/m^2-h) or 0.081 pCi/m^2-h, and the fraction of the growing season that the plant is irrigated (f_w) is 1. The duration of the study period is 1,000 years (t_{bw} = 8.76 x 10^6 h). The fraction of waterborne material retained on the plant surface (r_w) is 0.2. The weathering removal rate (λ_w) is 0.0021 h^{-1}. The dry soil to wet plant partitioning coefficient of U-238 in the reproductive portions of vegetables ($B_{iv(2)}$) is 4 x 10^{-3}. The dry plant mass to wet plant mass ratio (CFp) is 0.428. The effective dry surface density of the soil is (ρ) 225,000 g/m^2. The agricultural yield is (Y) 1,500 g/m^2. The growing season t_e is 1,440 hours. The period between harvest and consumption (t_h) is 24 hours. The radiological decay constant of U-238 λ_{ri} is 1.77 x 10^{-14} h^{-1}. This value is so small that the exp($-\lambda_{ri}\ t_h$) term approaches a value of 1 (i.e., no significant decay). A value of 6.49 x 10^{-6} is calculated for λ_{Li} using Equation C.3-8 and a K_d of 12 cm^3/g from Appendix F of this FS. The effective depletion coefficient (λ_{di}) is calculated from Equation C.3-7 to be 6.49 x 10^{-6}. Substituting these parameter values into Equation C.3-37 and simplifying yields:

$$C_{avi} = (0.081 pCi/m^2/h)\left[\frac{(0.2)(1-e^{-(0.0021\,h^{-1})(1440\,h)})}{(1500\,g/m^2)(0.0021\,h^{-1})} + \frac{(1)(0.004)(0.428)(1-e^{-((6.49x10^{-6}h^{-1})(8760000\,h))})}{(225000\,g/m^2)(6.49x10^{-6}h^{-1})}\right]$$

$$C_{wv\ U238} = 4.98 \times 10^{-3}\ \text{pCi/g} \qquad \text{(C.3-38)}$$

Once the constituent's concentration in the vegetables is estimated, the resulting intake by humans can be estimated using Equations C.3-11 or C.3-12. Continuing the example begun in Equation C.3-38, humans ingest vegetables from the study area for a 70-year lifetime. The calculated concentration of U-238 in vegetables and fruit is about 0.00498 pCi/g. The exposure frequency is 350 days per year

(EF = 350 d/y). The consumption rate of vegetables and fruit grown in the study area is 122 grams per day and the fraction of time that crops are consumed from the contaminated source is assumed to be 0.5. The exposure duration (ED) is 70 years per lifetime. The lifetime intake of U-238 from this food supply may be estimated by Equation C.3-11. Using the presented parameter values, this becomes:

$$I_{v\,U238} = (4.98 \times 10^{-3}\ pCi/g)(122\ g/d)(0.5)(350\ d/y)(70\ y/lifetime)$$
$$I_{v\,U238} = 7.44 \times 10^{3}\ pCi/lifetime \qquad \text{(C.3-39)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/L of U-238 in water will produce an unit incremental lifetime intake of 7.44×10^{-3} pCi of U-238 via this one pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{v\,U238} = SF_{ing\,i} \times I_{v\,U238} \qquad \text{(C.3-40)}$$

where

$ILCR_{v\,U238}$ = incremental lifetime cancer risk from irrigation of vegetables (risk/lifetime)
$SF_{ing\,i}$ = slope factor for ingestion of constituent "i" (risk/pCi)

The relationship between water concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 from eating vegetables and fruit calculated in Equation C.3-39 and the ingestion slope factor for U-238, 2.0×10^{-11} (risk/pCi), for $SF_{ing\,i}$ into Equation C.3-40. This yields:

$$ILCR_{v\,U238} = (2.0 \times 10^{-11}\ (risk/pCi)(7.44 \times 10^{3}\ pCi/lifetime)$$
$$ILCR_{v\,U238} = 1.48 \times 10^{-7}\ (risk/lifetime) \qquad \text{(C.3-41)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an unit risk factor of about 1.48×10^{-7} via this one pathway.

C.3.2.3 Ingestion of Beef and Dairy Products Produced with Groundwater

This scenario assumes that groundwater is used for stock water and irrigation of feed plants. Animals drinking the water ingest contaminants directly. Plants irrigated with water take up constituents via root uptake and direct deposition onto exposed surfaces by irrigation water. Ingestion of these plants by livestock also contributes to the body burden of these contaminants in the animals. Humans using products from these animals can ingest the contamination contained in them as well.

The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g., future exposures), this concentration can be calculated using the method set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The concentration of a contaminant in animal products such as beef or milk is estimated using the following equation:

$$C_{Ai} = F_{Ai}[(C_{fi})(Q_f) + (C_{wi})(Q_w)]\, e^{-\lambda_{ri} t_h} \qquad \text{(C.3-42)}$$

where

C_{Ai} = concentration of ith contaminant in the animal product (pCi/L) for milk, pCi/g for beef, radionuclides) (mg/L for milk, mg/kg for beef, chemicals)

C_{fi} = concentration of ith contaminant in feed (pCi/g, radionuclides) (mg/kg, chemicals)

C_{wi} = concentration of contaminant in water (pCi/L, radionuclides) (mg/L, chemicals)

F_{Ai} = element (stable) transfer coefficient that relates the daily intake by an animal to the concentration of ith contaminant in an edible portion of the animal product (d/L for milk, d/g for meat)

Q_f = consumption rate of contaminated feed by livestock (g/d) (kg/d)

Q_w = consumption rate of contaminated water by livestock (L/d)

λ_{ri} = radioactive or chemical decay constant of ith contaminant (h^{-1})

t_h = duration of period between harvest and consumption (h)

If measured values for the concentrations of constituents in stored feed are not available (e.g., future exposures), this concentration is estimated using Equation 7-9 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The equation is:

$$C_{vwi} = d_w \left[\frac{r_w(1-e^{-\lambda_w t_e})}{Y\lambda_w} + \frac{f_w CF_p B_{iv(1)}(1-e^{-\lambda_{di} t_{bw}})}{\rho\lambda_{di}} \right] e^{-\lambda_{ri} t_h} \qquad \text{(C.3-43)}$$

where

C_{vwi} = concentration of ith contaminant in plants as a result of irrigating plants with contaminated water (pCi/g) (mg/kg)

λ_{di} = effective depletion constant of ith contaminant in surface soil due to radioactive decay, chemical degradation, and leaching (h^{-1})

λ_w = effective depletion constant of ith contaminant on the surface plants also known as the weathering removal rate (h^{-1})

λ_{ri} = radioactive or chemical decay constant of ith contaminant (h^{-1})

$B_{iv(1)}$	=	dry soil to wet plant partitioning coefficient of ith contaminant (C_{iv}/C_s) in animal feed
CF_p	=	dry plant mass to wet plant mass ratio for feed and forage (1.0)
d_w	=	irrigation deposition rate (pCi/m^2-h) (mg/m^2-h)
f_w	=	fraction of year plant is irrigated (unitless)
ρ	=	effective dry surface density of the soil (g/m^2)
r_w	=	fraction of water-borne material retained on plant surface (unitless)
t_e	=	growing season (h)
t_{bw}	=	duration of irrigation use (h)
t_h	=	duration of period between harvest and consumption (h)
Y	=	agricultural yield (g/m^2)

The soil depletion coefficient is calculated by using Equations C.3-7 and C.3-8.

This example assumes that stored feed is irrigated with groundwater containing 1 pCi/L of U-238. The mean irrigation rate per unit area is 0.081 L/m^2-h, so the rate of constituent deposition by irrigation (d_w) is (C_w U-238 pCi/L)(0.081 L/m^2-h) or 0.081 pCi/m^2-h and the fraction of the growing season the plant is irrigated (f_w) is 1. The duration of the study period (t_{bw}) is 1,000 years (8,760,000 h). The fraction of waterborne material retained on the plant surface (r_w) is 0.2. The weathering removal rate (λ_w) is 0.0021 h^{-1}. The dry soil to wet plant partitioning coefficient of U-238 in feed plants ($B_{iv(2)}$) is 8.5 x 10^{-3}. The effective dry surface density of the soil (ρ) is 225,000 g/m^2. The agricultural yield (Y) is 800 g/m^2. The growing season (t_e) is 3,312 hours. The period between harvest and consumption (t_h) is 2,160 hours. The radiological decay constant (λ_{ri}) for U-238 is 1.77 x 10^{-14} h^{-1}. This value is so small that the exp($-\lambda_{ri}\ t_h$) term approaches a value of 1 (i.e., no significant decay). A value of 6.49 x 10^{-6} is calculated for λ_{Li} using Equation C.3-8 and a K_d of 12 cm^3/g from Appendix F of this FS. Substituting these parameter values into Equation C.3-43 and simplifying yields:

$$C_{wvU238}=(0.081\,pCi/m^2/h)\left[\frac{(0.2)(1-e^{-(0.0021\,h^{-1})(3312\,h)})}{(800\,g/m^2)(0.0021\,h^{-1})}+\frac{(1)(0.0085)(1)(1-e^{-(6.49x10^{-6}h^{-1})(8760000\,h)})}{(225000\,g/m^2)(6.49x10^{-6}h^{-1})}\right]$$

$$C_{wvU238} = 1.01 \times 10^{-2}\ pCi/g \qquad \text{(C.3-44)}$$

Once the concentration in stored feed has been estimated, its contribution to constituent levels in beef and dairy products can be calculated using Equation C.3-42. The calculated concentration of U-238 in stored feed attributable to irrigation is about 1.01 x 10^{-2} pCi/g. In this study, a cow is assumed to consume 25,000 g/d of potentially contaminated feed (Q_f). The plant to beef and plant to milk biotransfer factors for U-238 in cows are 2 x 10^{-7} d/g ($F_{m\ U238}$) and 6 x 10^{-7} d/mL ($F_{d\ U238}$), respectively. The time between harvesting and consumption of stored feed is 2160 hours. The radiological decay constant of U-238 λ_{ri} is 1.77 x 10^{-14} h^{-1}. This value is so small that the exp

$\exp(-\lambda_{ri}\ t_h)$ term approaches a value of 1 (i.e., no significant decay) for both meat and milk calculations. Beef cows ingest about 50 L/d of water (Q_{Aw}), while milk cows ingest about 60 L/d.

Substituting parameter values for the beef ingestion scenario in Equation C.3-42 ($C_{Ai} = C_{wm\ U238}$) yields the concentration of U-238 in beef:

$$C_{wm\ U238} = (2.0 \times 10^{-7}\ d/g)[(25000\ g/d)(1.01 \times 10^{-2}\ pCi/g) + (50\ L/d)(1\ pCi/L)]$$
$$C_{wm\ U238} = 6.05 \times 10^{-5}\ pCi/g \qquad \text{(C.3-45)}$$

Substituting parameter values for the milk ingestion scenario in Equation C.3-42 ($C_{Ai} = C_{wd\ U238}$) yields the concentration of U-238 in milk:

$$C_{wd\ U238} = (6.0 \times 10^{-7}\ d/mL)[(25000\ g/d)(1.01 \times 10^{-2}\ pCi/g) + (60\ L/d)(1\ pCi/L)]$$
$$C_{wd\ U238} = 1.88 \times 10^{-4}\ pCi/g \qquad \text{(C.3-46)}$$

Once the constituent's concentration in the animal product is estimated, the resulting intake by humans can be estimated using Equations C.3-23 and C.3-24. Continuing the example calculation, the farmer ingests beef containing 6.05 x 10^{-5} pCi/g of U-238 ($C_{wm\ U238}$ in Equation C.3-45) and dairy products containing 1.88 x 10^{-4} pCi/mL of U-238 ($C_{wd\ U238}$ in Equation C.3-46) for each pCi/L of U-238 in water during a 70-year lifetime. The exposure frequency is 350 days per year (EF=350 d/y). The fractions of beef and dairy products ingested from the contaminated source (FI x IR) are 75 g/d and 300 mL/d, respectively. The exposure duration (ED) is 70 years. The lifetime intake of U-238 from this supply of animal products is given by Equation C.3-23. Substituting the selected parameter values for the beef ingestion scenario, this becomes:

$$I_{wm\ U238} = (6.05 \times 10^{-5}\ pCi/g)(75\ g/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{wm\ U238} = 1.11 \times 10^{2}\ pCi/lifetime \qquad \text{(C.3-47)}$$

Substituting the selected parameter values for the dairy products ingestion scenario, this becomes:

$$I_{wd\ U238} = (1.88 \times 10^{-4}\ pCi/mL)(300\ mL/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{wd\ U238} = 1.38 \times 10^{3}\ pCi/lifetime \qquad \text{(C.3-48)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each pCi/L of U-238 in water will produce an incremental lifetime intake of 1.11 x 10^2 pCi U-238 via the beef ingestion pathway and 1.38 x 10^3 pCi of U-238 via the milk ingestion pathway.

The ILCR to this receptor for these pathways from this radionuclide is:

$$ILCR_{m\ U238} = SF_{ing\ i} \times I_{m\ U238}\ (beef)$$
$$or$$
$$ILCR_{d\ U238} = SF_{ing\ i} \times I_{d\ U238}\ (dairy) \qquad \text{(C.3-49)}$$

where

$ILCR_{m\ U238}$ or $ILCR_{d\ U238}$	=	ILCR from ingestion of beef or milk products produced with groundwater (risk/lifetime)
$SF_{ing\ i}$	=	slope factor for ingestion of constituent "i" (risk/pCi)

The relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 calculated in Equations C.3-47 and C.3-48 and the ingestion slope factor for U-238, 2.0×10^{-11} (risk/pCi), for $SF_{ing\ i}$ into Equation C.3-49. This yields:

Beef:

$$ILCR_{m\ U238} = (2.0 \times 10^{-11}\ risk/pCi)(111\ pCi/lifetime)$$
$$ILCR_{m\ U238} = 2.2 \times 10^{-9}\ risk/lifetime \qquad \text{(C.3-50)}$$

Dairy:

$$ILCR_{d\ U238} = (2.0 \times 10^{-11}\ risk/pCi)(1380\ pCi/lifetime)$$
$$ILCR_{d\ U238} = 2.8 \times 10^{-8}\ risk/lifetime \qquad \text{(C.3-51)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in groundwater will produce an risk of 2.2×10^{-9} via the beef pathway, and 2.8×10^{-8} via the milk pathway.

C.3.2.4 Calculation of Total Unit Risk for Groundwater

In this scenario, a hypothetical farmer uses groundwater for domestic and agricultural purposes. The total ILCR or UR for this receptor from exposure to U-238 from these exposure pathways may be calculated as:

$$ILCR_{gw\ i} = (I_{wi} + I_{wmi} + I_{wdi} + I_{wvi}) \times SF_{ing\ i} \qquad \text{(C.3-52)}$$

where

$ILCR_{gw\ i}$	=	total ILCR or UR from for groundwater
I_{wi}	=	intake from drinking water (pCi)
I_{wvi}	=	intake from ingesting vegetables and fruit (pCi)
I_{wmi}	=	intake from ingesting meat (pCi)
I_{wdi}	=	intake from ingesting dairy products (pCi)
$SF_{ing\ i}$	=	slope factor for ingestion of constituent "i" (risk/pCi)

An on-property farmer has been selected as the example for this calculation. The total intake for this hypothetical receptor for each pCi/L of U-238 in water from these pathways have been calculated in Sections C.3.2.1 though C.3.2.3. Substituting these values into Equation C.3-52, along with the appropriate HEAST slope factors for ingestion and inhalation of uranium, yields:

$$ILCR_{gw\ U238} = [(4.90x10^4\ pCi/lifetime) + (7.45x10^3\ pCi/lifetime) + (1.11x10^2\ pCi/lifetime) + (1.38x10^3\ pCi/lifetime)]x2.0x10^{-11}\ (risk/pCi)$$

$$ILCR_{gw\ U238} = 1.16 \times 10^{-6}\ ILCR \qquad \text{(C.3-53)}$$

The exposure models used in this combined pathway scenario respond linearly to changes in concentration. Therefore, each additional pCi/L of U-238 present in groundwater will produce an UR of 1.16×10^{-6} from the exposure pathways investigated. This UR factor can then be used to calculate PRGs for groundwater based on the on-property farmer scenario.

C.3.3 SOIL EXPOSURES

The on-property resident RME is used to calculate PRGs for U-238 in soil based on agricultural land use. Other receptors for which PRGs are calculated for soil include groundskeeper (i.e., industrial/commercial land use), recreational receptors (recreational land use) and expanded trespasser (no land use). The procedures used to calculate URs for these receptors is similar to the method provided here for the on-property RME farmer; however, the exposure pathways and parameters used for these other receptors would be specific to the particular land use. The pathways of concern for U-238 in soil for the on-property farmer include incidental ingestion, external radiation, ingestion of fruits and vegetables, and ingestion of meat and milk products. The pathways of concern for exposure to U-238 for industrial/commercial, recreational, and expanded trespasser would be incidental ingestion and external exposure.

C.3.3.1 Incidental Ingestion of Soil

Evaluation of the soil/sediment ingestion pathway is performed using Equations 7-7 and 7-8 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992):

$$\text{(radionuclides)}\ I_{si} = (C_{si})(IR)(ED)(EF)(FI) \qquad \text{(C.3-54)}$$

$$\text{(chemicals)}\ I_{si} = (C_{si})(IR)(CF)(FI)(EF)(ED)/(BW)(AT) \qquad \text{(C.3-55)}$$

where

I_{si}	=	intake from soil or sediment for constituent "i" (pCi, radionclides) (mg/kg-d, chemicals)
C_{si}	=	concentration of constituent "i" in soil or sediment (pCi/g, radionclides) (mg/kg, chemicals)
IR	=	ingestion rate (g/d) (kg/d)
CF	=	conversion factor 10^{-6} (kg/mg)

FI	=	fraction ingested from contaminated source (unitless)
EF	=	exposure frequency (d/y)
ED	=	exposure duration (y)
BW	=	body weight (kg)
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) x (365 d/y); for chemical carcinogens, AT equals (70 y) x (365 d/y)

Intakes resulting from ingesting soil containing a unit concentration of 1 pCi/g of U-238 have been selected for the example calculation. The time weighted average annual ingestion rate of soil over a 70-year lifetime from the study area (IR x FI) is about 0.18 g/d. The exposure frequency is 350 days per year (EF = 350 d/y), and the exposure duration (ED) is 70 y/lifetime. Substituting these parameter values into Equation C.3-54 yields:

$$I_{s\ U238} = (1\ pCi/g)(0.18\ g/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{s\ U238} = 4{,}410\ pCi/lifetime \qquad \text{(C.3-56)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/g of U-238 in soil will produce an unit intake of about 4,410 pCi of U-238 via this pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{s\ U238} = SF_{ing\ i} \times I_{s\ U238} \qquad \text{(C.3-57)}$$

where

$ILCR_{s\ U238}$	= unit risk from incidental ingestion of soil or sediment (risk/lifetime)
$SF_{ing\ i}$	= slope factor for ingestion of constituent "i" (risk/pCi)

The risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 calculated in Equation C.3-56 and the ingestion slope factor for U-238, 2.0×10^{-11} risk/pCi, for $SF_{ing\ i}$ into Equation C.3-57. This yields:

$$ILCR_{s\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)(4.41 \times 10^{3}\ pCi/lifetime)$$
$$ILCR_{s\ U238} = 8.82 \times 10^{-8}\ risk/lifetime \qquad \text{(C.3-58)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/g of U-238 in soil will produce an UR of about 8.8×10^{-8} via this pathway.

C.3.3.2 Ingestion of Vegetables Grown in Contaminated Soil

Plants grown in contaminated soil take up contaminants via root uptake. Ingestion of these plants by humans contributes to their total intake of contaminants. Estimating the magnitude of this intake is a two-step process. First, concentrations in the plants are estimated. Human intake of constituents in vegetables is then estimated in the second step. If measured plant concentrations are not available (e.g., future exposures), concentrations in the plants are estimated using Equation 7-11 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The equation is:

$$C_{svi} = (C_{si}) B_{iv(2)} CF_p e^{-\lambda_{ri} t_h} \qquad \text{(C.3-59)}$$

where

C_{svi}	=	concentration of ith contaminant in food crops (pCi/g) (mg/kg)
C_{si}	=	concentration of ith contaminant in soil (pCi/g) (mg/kg)
$B_{iv(2)}$	=	dry soil to dry plant partitioning coefficient of ith contaminant in food crops (C_{iv}/C_s)
CF_p	=	dry plant mass to wet plant mass ratio (unitless)
λ_{ri}	=	radioactive or chemical decay constant of ith contaminant (h^{-1})
t_h	=	duration of period between harvest and consumption (h)

Vegetables and fruits grown in soil containing 1 pCi/g of U-238 are selected to illustrate how contaminant concentrations in plants can be estimated from contaminant concentrations in soil. The dry soil to dry plant partitioning coefficient of U-238 in the reproductive portions of vegetables and fruits ($B_{iv(2)}$) is 4×10^{-3}. The dry plant mass to wet plant mass ratio is 0.428 (Baes et al., 1984). The period between harvest and consumption (t_h) for vegetables is 24 hours and 720 hours for fruit. The radiological decay constant of U-238 (λ_{ri}) is 1.77×10^{-14} y^{-1}. This value is so small that the $\exp(-\lambda_{ri}\ t_h)$ term approaches a value of 1 (i.e., no significant decay). Substituting these parameter values into Equation C.3-59 and simplifying yields:

$$C_{sv\ U238} = (1\ pCi/g_{soil})(0.428)(4 \times 10^{-3}\ g_{soil}/g_{plant})(1)$$
$$C_{sv\ U238} = 1.71 \times 10^{-3}\ pCi/g_{plant} \qquad \text{(C.3-60)}$$

Once the concentration in crops has been estimated, the quantity ingested by the on-property resident can be calculated using Equations C.3-11 or C.3-12. Continuing the previous example, the calculated concentration of U-238 in crops ($C_{sv\ U238}$ in Equation C.3-60) is 1.71×10^{-3} pCi/g. The exposure frequency is 350 days per year (EF = 350 d/y). The consumption rate of vegetables and fruit grown in the study area is 122 grams per day and the fraction of time vegetables and fruits are consumed from the contaminated source is estimated to be 0.5. The exposure duration (ED) is 70 years.

Substituting these parameter values into Equation C.3-11 produces a lifetime ingestion via vegetables ($I_{sv\ U238}$) of:

$$I_{sv\ U238} = (0.00171\ pCi/g_{plant})(122\ g_{plant}/d)(0.5)(70\ y/lifetime)(350d/y)$$
$$I_{sv\ U238} = 2.56 \times 10^{3}\ pCi/lifetime \qquad \text{(C.3-61)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/L of U-238 in water will produce an unit intake of $2.56 \times 10^{+3}$ pCi of U-238 via this pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{sv\ U238} = SF_{ing\ i} \times I_{sv\ U238} \qquad \text{(C.3-62)}$$

where

$ILCR_{sv\ U238}$	=	incremental lifetime risk (or UR) from ingestion of vegetables grown in contaminated soil (r/lifetime)
$SF_{ing\ i}$	=	slope factor for ingestion of constituent "i" (risk/pCi)

The unit risk factor for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 from eating vegetables and fruit calculated in Equation C.3-60 and the ingestion slope factor for U-238, 2.0×10^{-11} (risk/pCi), for $SF_{ing\ i}$ into Equation C.3-61. This yields:

$$ILCR_{sv\ U238} = (2.0 \times 10^{-11}\ risk/pCi)(2.56 \times 10^{3}\ pCi/lifetime)$$
$$ILCR_{sv\ U238} = 5.12 \times 10^{-8}\ risk/lifetime \qquad \text{(C.3-63)}$$

Because a unit soil concentration of 1.0 was used to derive the concentration in vegetables and fruit, and the exposure models respond linearly to changes in concentration, they predict that each additional pCi/g of U-238 in soil will produce an UR of 5.12×10^{-8} via this pathway.

C.3.3.3 Ingestion of Meat or Milk

This scenario assumes that livestock is raised on contaminated soil. Feed and forage grown on contaminated soil take up constituents via their root systems. Ingestion of these plants by livestock contributes to the body burden of these contaminants in the animals. In addition to intake from contaminated feed and forage, cows may receive a significant intake from soil ingestion if the soil is also a source of contamination (Zach and Mayoh 1984). Humans using products from these animals can be exposed to the contamination contained in them.

The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g., future exposures) this

concentration can be calculated using the method set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The concentration of a contaminant in animal products such as beef or milk is estimated using the following equation:

$$C_{Ai} = F_{Ai}[(C_{fi})(Q_f) + (C_{gi})(Q_g) + (C_{si})(Q_s)]\, e^{-\lambda_{ri} t_h} \qquad \text{(C.3-64)}$$

where:

C_{Ai}	=	concentration of ith contaminant in the animal product, (pCi/L for milk, pCi/g for beef) (mg/L for milk, mg/kg for beef)
C_{si}	=	concentration of contaminant in soil (pCi/g) (mg/kg)
C_{gi}	=	concentration of ith contaminant in forage (pCi/g) (mg/kg)
C_{fi}	=	concentration of ith contaminant in feed (pCi/g) (mg/kg)
F_{Ai}	=	element (stable) transfer coefficient that relates the daily intake by an animal to the concentration of ith contaminant in an edible portion of the animal product (d/L for milk, d/g for beef) (d/L for milk, d/kg for beef)
Q_g	=	consumption rate of contaminated forage (pasture grass) (g/d) (kg/d)
Q_s	=	consumption rate of soil by livestock (g/d) (kg/d)
Q_f	=	consumption rate of contaminated feed by an animal (g/d) (kg/d)
λ_{ri}	=	radioactive or chemical decay constant of ith contaminant (h^{-1})
t_h	=	duration of period between harvest and consumption (h)

If measured values for feed and forage are not available (e.g., future exposures), the concentration in these plants that is attributable to direct uptake from soil is estimated using Equation 7-11 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The equation is:

$$C_{s(p)i} = (C_{Si})\, B_{iv(1)}\, CF_p\, e^{-\lambda_{ri} t_h} \qquad \text{(C.3-65)}$$

where

$C_{s(p)i}$	=	concentration of ith contaminant in the plant (for both forage and stored feed), (pCi/g, radionuclides) (mg/kg, chemicals)
C_{si}	=	concentration of ith contaminant in soil (pCi/g, radionuclides) (mg/kg, chemicals)
$B_{iv(1)}$	=	dry soil to dry plant partitioning coefficient of ith contaminant in forage (C_{sgi}/C_{si})
CF_p	=	dry plant mass to wet plant mass ratio (unitless)
λ_{ri}	=	radioactive or chemical decay constant of ith contaminant (h^{-1})
t_h	=	duration of period between harvest and consumption (h)

The concentration of U-238 in plants grown in soil at 1 pCi/g of U-238 ($C_{s(p)\ U238}$) has been selected to illustrate how contaminant concentrations in feed and forage can be estimated from contaminant concentrations in soil. The dry soil to wet plant partitioning coefficient of U-238 in feed and forage ($B_{iv(1)}$) is 8.5 x 10^{-3} g_{soil}/g_{plant}. The periods between harvest and consumption (t_h) of forage and stored feed are 720 hours and 2,160 hours, respectively. The radiological decay constant of U-238 λ_{ri} is

1.77×10^{-14} h^{-1}. This value is so small that the $\exp(-\lambda_{ri}\ t_h)$ term approaches a value of 1 (i.e., no significant decay) for both feed and forage calculations. Substituting these parameter values into Equation C.3-65 yields:

$$C_{s(p)\ U238} = (1\ pCi/g_{soil})(8.5 \times 10^{-3}\ g_{soil}/g_{plant})(1)$$
$$C_{s(p)\ U238} = 8.5 \times 10^{-3}\ pCi/g_{plant} \qquad \text{(C.3-66)}$$

Once the concentration in vegetation has been estimated, concentrations in the animal product can be calculated using Equation C.3-65. Continuing the example begun in Equation C.3-64, the calculated concentration of U-238 in feed and forage attributable to soil uptake ($C_{s(p)\ U238}$ in Equation C.3-66) is about 8.5×10^{-3} pCi/g_{plant}. The dry plant mass to wet plant mass ratio is 1.0. In this study, cows consume 25,000 g/d of potentially contaminated forage (Q_g), 25,000 g/d of potentially contaminated feed (Q_f), and 500 g/d of potentially contaminated soil (Q_s). The plant to beef and plant to milk biotransfer factors for U-238 in cows are 2.0×10^{-7} d/g (F_{mi}) and 6.0×10^{-7} d/mL (F_{di}), respectively. The times between harvesting and consumption (t_h) of meat and milk are 24 hours and 480 hours, respectively. The radiological decay constant of U-238 λ_r is 1.77×10^{-14} h^{-1}. This value is so small that the $\exp(-\lambda_{ri}\ t_h)$ term approaches a value of 1 (i.e., no significant decay) for both meat and milk calculations.

Substituting the parameter values presented for the beef cattle scenario in Equation C.3-64 yields a meat concentration ($C_{sm\ U238}$) of:

$$C_{sm\ U238} = (2.0 \times 10^{-7}\ d/g_{meat})[(8.5 \times 10^{-3} pCi/g_{feed})(25000\ g_{feed}/d)$$
$$+ (8.5 \times 10^{-3}\ pCi/g_{forage})(25000\ g_{forage}/d) + (1\ pCi/g_{soil})(500\ g_{soil}/d)]$$
$$C_{sm\ U238} = 1.85 \times 10^{-4}\ pCi/g_{meat} \qquad \text{(C.3-67)}$$

Substituting the parameter values presented for the dairy scenario in Equation C.3-64 yields a milk concentration ($C_{sd\ U238}$) of:

$$C_{sd\ U238} = (6.0 \times 10^{-7}\ d/mL_{milk})[(8.5 \times 10^{-3}\ pCi/g_{feed})(25000\ g_{feed}/d)$$
$$+ (8.5 \times 10^{-3}\ pCi/g_{forage})(25000\ g_{forage}/d) + (1\ pCi/g_{soil})(500\ g_{soil}/d)]$$

$$C_{sd\ U238} = 5.55 \times 10^{-4}\ pCi/mL_{milk} \qquad \text{(C.3-68)}$$

Once the concentrations of U-238 in animal products are known, the magnitude of intake by the on-property resident can be estimated. The farmer ingests beef containing 0.000185 pCi/g_{meat} of U-238 ($C_{sm\ U238}$ in Equation C.3-66) and dairy products containing 0.000555 pCi/mL_{milk} of U-238 ($C_{sd\ U238}$ in Equation C.3-67) for each pCi/g of U-238 in soil over a 70-year lifetime. The exposure frequency is 350 days per year (EF = 350 d/y). The fraction ingested from the contaminated source (FI x IR) is 75 g/d for beef and 300 mL/d for dairy products. The exposure

duration (ED) is 25,550 days. The lifetime intake of U-238 from this meat supply is calculated using Equation C.3-23.

Substituting the appropriate parameter values for the beef ingestion scenario produces a lifetime intake via meat ($I_{sm\ U238}$) of:

$$I_{sm\ U238} = (1.85 \times 10^{-4}\ pCi/g_{meat})(75\ g_{meat}/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{sm\ U238} = 3.40 \times 10^{2}\ (pCi/lifetime) \qquad \text{(C.3-69)}$$

Substituting the appropriate parameter values for the dairy product ingestion scenario produces a lifetime intake via dairy products ($I_{sd\ U238}$) of:

$$I_{sd\ U238} = (5.55 \times 10^{-4}\ pCi/mL_{milk})(300\ mL_{milk}/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{sd\ U238} = 4.08 \times 10^{3}\ (pCi/lifetime) \qquad \text{(C.3-70)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/g of U-238 in soil will produce an incremental lifetime intake of 340 pCi of U-238 via the meat ingestion pathway and an intake of 4080 pCi of U-238 via the dairy ingestion pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{m\ U238} = SF_{ing\ i} \times I_{m\ U238}\ (meat)$$
$$or$$
$$ILCR_{d\ U238} = SF_{ing\ i} \times I_{d\ U238}\ (dairy) \qquad \text{(C.3-71)}$$

where

$ILCR_{d\ U238}$ = incremental lifetime cancer risk factor from ingestion of meat or dairy products
$SF_{ing\ i}$ = slope factor for ingestion of constituent "i" $(pCi)^{-1}$

The relationship between soil concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 from consuming meat and dairy products calculated by Equations C.3-69 and C.3-70 and the U-238 ingestion slope factor, $2.0 \times 10^{-11}\ (pCi)^{-1}$ for $SF_{ing\ i}$, into Equation C.3-71. This yields:

Meat:

$$ILCR_{m\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)(3.4 \times 10^{2}\ pCi/lifetime)$$
$$ILCR_{m\ U238} = 6.8 \times 10^{-9}\ risk/lifetime \qquad \text{(C.3-72)}$$

Dairy:

$$ILCR_{d\ U238} = (2.0 \times 10^{-11}\ (risk\backslash pCi)(4.08 \times 10^{3}\ pCi)$$
$$ILCR_{d\ U238} = 8.16 \times 10^{-8}\ risk/lifetime \qquad \text{(C.3-73)}$$

The exposure models used in this scenario respond linearly to changes in concentration. Therefore, each pCi/g of U-238 in soil will produce an UR of about 6.8 x 10^{-9} via the meat pathway and 8.16 x 10^{-8} via the milk pathway.

C.3.3.4 Direct Radiation Exposure

Since the publication of the FEMP Risk Assessment Work Plan Addendum (DOE 1992), EPA has published a new set of slope factors. Changes in these slope factors require the use of a different equation to calculate risks resulting from external radiation exposures from soil than the one originally presented in the FEMP Risk Assessment Work Plan Addendum. The new equation is:

$$ILCR_e = SF_{ext} \times C_s \times ED \times EF \times CF \times [ET_{in} \times (1-S_i) + ET_{out} \times (1-S_o)] \qquad \text{(C.3-74)}$$

where

$ILCR_e$	=	incremental lifetime cancer risk
C_s	=	concentration in surface soil (pCi/g)
SF_{ext}	=	HEAST slope factor (g/pCi - y)
ED	=	exposure duration (y/lifetime)
EF	=	exposure frequency (d/y)
ET_{in}	=	exposure time indoors on-site (h/d)
ET_{out}	=	exposure time outdoors on-site (h/d)
S_i	=	indoor shielding factor (0.5, from the Supplemental Guidance to the Risk Assessment Work Plan Addendum)
S_o	=	outdoor shielding factor outdoors (0, assumes no shielding)
CF	=	conversion factor (1/8760 y/h)

The risk to an on-property resident RME directly attributable to 1 pCi/g of U-238 in soil is the example calculation. In this calculation, exposure duration (ED) is 70 years, and the exposure frequency is 350 days per year (EF = 350 d/y). The exposure time for outdoor activities assumes the resident is outdoors 2000 hours out of a 350 day year (ET_{out} = 2000 h/350 d). The exposure time for indoor activities is the remainder of the time available (ET_{in} = 24 h/d - ET_{out}). The value for the indoor shielding factor (S_i) is 0.5, and the value for the outdoor shielding factor (S_o) is 0. The value for SF_{ext} is 5.1 x 10^{-8} (g/pCi - y). Substituting these parameters into Equation C.3-74 yields:

$$ILCR_e = (SF_e)(1\ pCi/g)(70y/lifetime)(350d/y)(y/8760\ h) \times [(18.3\ h/d)(1-0.5)+(5.7\ h/d)(1-0.0)]$$
$$ILCR_e = 2.12 \times 10^{-6}\ risk/lifetime \qquad \text{(C.3-75)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/g of U-238 in soil will increase the source strength by 41.5 pCi-y/g-life and the UR by 2.12 x 10^{-6} via the direct exposure pathway.

C.3.3.5 Calculation of Aggregate Risks For On-Property Resident from All Soil Pathways

In this scenario, a hypothetical resident ingests contaminated dirt and crops grown in or on contaminated soil and beef and milk from cows grazing on contaminated soil or vegetation. The receptor also receives exposures from direct dermal contact, in the case of chemicals, and direct irradiation, in the case of radionuclides. The total risks to the RME on-property resident exposed to soil from these pathways may be calculated as:

$$ILCR_{soil\ i} = (I_{s\ i} + I_{sv\ i} + I_{sm\ i} + I_{sd\ i}) \times SF_{ing\ i} + ILCR_{e\ i} \qquad \text{(C.3-76)}$$

where

$ILCR_{soil\ i}$	=	total unit ILCR from exposure to soil
$ILCR_{e\ i}$	=	unit ILCR from direct radiation
$I_{s\ i}$	=	unit intake from incidental soil ingestion (pCi)
$I_{sv\ i}$	=	unit intake from ingesting vegetables and fruit (pCi)
$I_{sm\ i}$	=	unit intake from ingesting meat (pCi)
$I_{sd\ i}$	=	unit intake from ingesting dairy products (pCi)
$SF_{ing\ i}$	=	HEAST slope factor for ingestion of constituent "i" (risk/pCi)

The intake by this hypothetical receptor for each pCi/L of U-238 in soil from each of these pathways has been calculated in Sections C.3.3.1 though C.3.3.3. The UR factor from external exposure to direct radiation is presented in Section C.3.3.4. Substituting these values into Equation C.3-76, along with the appropriate HEAST slope factors for ingestion of uranium, yields:

$$ILCR_{soil\ U238} = \{[(4.41 \times 10^3\ pCi/lifetime) + (2.56 \times 10^3\ pCi/lifetime) + (3.40 \times 10^2\ pCi/lifetime) + (4.08 \times 10^3\ g/lifetime)] \times (2.0 \times 10^{-11} (risk/pCi)\} + 2.12 \times 10^{-6}$$

$$ILCR_{soil\ U238} = 2.35 \times 10^{-6}\ risk/lifetime \qquad \text{(C.3-77)}$$

The exposure models used in this scenario respond linearly to changes in concentration. Therefore, each additional pCi/g of U-238 in soil will produce an UR factor of 2.35×10^{-6} to the RME on-property resident farmer from all direct exposure soil pathways investigated. This value, combined with the total UR factor from the air pathways times the soil-to-air transfer factor (as shown in Section C.2,equation, C.2-3) would be used to calculate soil PRGs.

C.3.4 SURFACE WATER EXPOSURES INCLUDING HOUSEHOLD USE

Applicable receptors for calculation of PRGs for surface water include the Great Miami River user (Great Miami River), a recreational youth, and off-property user of meat and milk products. In this example, the Great Miami River user was used to demonstrate calculation of unit risks associated with using surface water containing U-238. Unit risks for U-238 in surface water from Paddys Run would be calculated in a manner analogous to this example but would consider exposure pathways and parameters specific for the receptor.

C.3.4.1 Drinking Water Ingestion Pathway

Ingestion of contaminated drinking water can be a major contributor to environmental intakes of a receptor. An estimate of intake from drinking water is calculated from Equations C.3-32 and C.3-33, presented in Section C.3.2.1 for groundwater. The lifetime intake for drinking surface water containing 1 pCi/L of U-238 ($C_{sw\ U238}$) is similar to that for groundwater or:

$$I_{sw\ U238} = (C_{sw\ U238}\ pCi/L)(49{,}000\ L/lifetime)$$
$$I_{sw\ U238} = 49{,}000\ pCi/lifetime \qquad \text{(C3.78)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each pCi/L of U-238 in surface water will produce a lifetime intake of 49,000 pCi of U-238 via this one pathway. The UR to this receptor for this pathway from this radionuclide is calculated using Equation C.3-35.

The relationship between water concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the ingestion slope factor for U-238, 2.0 x 10^{-11} (risk\pCi), for $SF_{ing\ i}$ in Equation C.3-35 as follows:

$$ILCR_{sw\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)(49{,}000\ pCi/lifetime)$$

which yields:

$$ILCR_{sw\ U238} = 9.8 \times 10^{-7}\ risk/lifetime \qquad \text{(C.3-79)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in surface water will produce an UR factor of about 9.8 x 10^{-7} via drinking water pathway.

C.3.4.2 Incidental Ingestion of Surface Water While Swimming

People living near bodies of water receiving contaminated runoff may accidentally ingest contaminated water while swimming. Intake from incidental ingestion of surface water while swimming is the same as drinking water ingestion as quantified in Equations C.3-32 and C.3-33. The ingestion rate (IR), however, is 0.05 L/h. The exposure time (ET) is 2.6 h/d, the exposure frequency is 7 days per year (EF = 7 d/y), and the exposure duration (ED) is 70 years. The concentration of U-238 in surface water at 1 pCi/L ($C_{sw\ U238}$) has been chosen for this example. The lifetime intake for U-238 is estimated using Equation C.3-32. Using the presented parameter values, this becomes:

$$I_{sws\ U238} = (1\ pCi/L)(0.05\ L/h)(2.6\ h/d)(7\ d/y)(70\ y)$$
$$I_{sws\ U238} = 64\ pCi/lifetime \qquad \text{(C.3-80)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each pCi/L of U-238 in water will produce a lifetime intake of 64 pCi of U-238 via swimming pathway.

The ILCR to this receptor for this pathway from this radionuclide is based on Equation E.3-35 and substitution of the ingestion slope factor for U-238, 2.0×10^{-11} $(pCi)^{-1}$, for $SF_{ing\ i}$. This yields:

$$ILCR_{sws\ U238} = (2.0 \times 10^{-11}\ risk/pCi)(64\ pCi/lifetime)$$
$$ILCR_{sws\ U238} = 1.27 \times 10^{-9}\ risk/lifetime \qquad \text{(C.3-81)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an UR of about 1.3×10^{-9} via swimming pathway.

C.3.4.3 Ingestion of Beef and Dairy Products Produced with River Water

This scenario assumes that river water is used to water stock and irrigate feed. This pathway is identical to that described for groundwater in Section C.3.2.3. Animals drinking surface water ingest contaminants directly. Plants irrigated with water take up constituents via root uptake and direct deposition onto exposed surfaces by irrigation water. Ingestion of these plants by livestock also contributes to the body burden of these contaminants in the animals. Humans using products from these animals can ingest the contamination contained in them as well.

The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g., future exposures), this concentration can be calculated using the method set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992). The concentration of a contaminant in animal products such as beef or milk is estimated using Equation C.3-42. If measured values for the concentrations of constituents in stored feed are not available (e.g., future exposures), this concentration is estimated using Equation C.3-43. Application of default parameters to this equation yields a concentration of U-238 in stored feed attributable to irrigation of about 9.82×10^{-3} pCi/g. Considering the default values assumed for livestock consumption of feed (25,000 g/d), the plant to beef and plant to milk biotransfer factors for U-238 [2×10^{-7} d/g, ($F_{m\ U238}$) and 6×10^{-7} d/mL ($F_{d\ U238}$), respectively], and the ingestion of water by livestock (about 50 L/d and 60 L/d, for beef and milk cows, respectively), yields a concentration of U-238 in beef of:

$$C_{swm\ U238} = (2.0 \times 10^{-7}\ d/g)[(25{,}000\ g/d)(9.82 \times 10^{-3}\ pCi/g) + (50\ L/d)(1\ pCi/L)]$$
$$C_{swm\ U238} = 5.91 \times 10^{-5}\ pCi/g \qquad \text{(C.3-82)}$$

and in dairy products of:

$$C_{swd\ U238} = (6.0 \times 10^{-7}\ d/mL)[(25{,}000\ g/d)(9.82 \times 10^{-3}\ pCi/g) + (60\ L/d)(1\ pCi/L)]$$
$$C_{swd\ U238} = 1.83 \times 10^{-4}\ pCi/mL \qquad \text{(C.3-83)}$$

The resulting intake by humans is then estimated using Equations C.3-23 and C.3-24. Thus, the consumer of meat products containing 5.91 x 10^{-5} pCiL/g of U-238 and milk products containing 1.83 x 10^{-4} pCi/mL of U-238 for each pCi/L of U-238 in water yields a dose of:

$$I_{swm\ U238} = (5.91 \times 10^{-5}\ pCi/g)(75\ g/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{swm\ U238} = 109\ pCi/lifetime \qquad \text{(C.3-84)}$$

Substituting the selected parameter values for the dairy products ingestion scenario, this becomes:

$$I_{swd\ U238} = (1.83 \times 10^{-4}\ pCi/mL)(300\ mL/d)(350\ d/y)(70\ y/lifetime)$$
$$I_{swd\ U238} = 1345\ pCi/lifetime \qquad \text{(C.3-85)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each pCi/L of U-238 in water will produce an unit intake of 109 pCi U-238 via the beef ingestion pathway and 1345 pCi of U-238 via the dairy products ingestion pathway. The UR to this receptor for these pathways from this radionuclide is calculated using Equation C.3-49 which yields:

Beef:

$$ILCR_{swm\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)^{-1})(109\ pCi/lifetime)$$
$$ILCR_{swm\ U238} = 2.2 \times 10^{-9}\ risk/lifetime \qquad \text{(C.3.86)}$$

Dairy:

$$ILCR_{swd\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)^{-1})(1345\ pCi/lifetime)$$
$$ILCR_{swd\ U238} = 2.7 \times 10^{-8}\ risk/lifetime \qquad \text{(C.3-87)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an UR factor of 2.2 x 10^{-9} via the beef pathway and 2.7 x 10^{-8} via the milk pathway.

C.3.5 SEDIMENT EXPOSURES

A youth is the reference receptor used to calculate risk-based PRGs for U-238 in sediment based on recreational land use or trespassing. The pathways of concern for U-238 in sediment for the youth include incidental ingestion and external radiation exposure.

C.3.5.1 Incidental Ingestion of Sediment

Evaluation of the sediment incidental ingestion pathway is performed using Equations C.3-54 and C.3-55 presented in Section C.3.3.1 for soil. Parameters associated with the incidental ingestion of

sediment by the youth differ for this pathway and are described below. The ingestion rate assumed for ingestion of sediment is the same as soil (IR = 100 mg/day), with a fraction of the ingestion weighted according to the cumulative hours exposed of 1 hour out of 16 waking hours/day (1/16 = 0.0625). The exposure frequency is 52 days per year (EF = 52 d/y), and the exposure duration (ED) is 12 years. Substituting these parameter values into Equation C.3-53 yields:

$$I_{sed\ U238} = (1\ pCi/g)(0.1\ g/d)(0.0625)(52\ d/y)(12\ y/lifetime)$$
$$I_{sed\ U238} = 4\ pCi/lifetime \qquad \text{(C.3-88)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/g of U-238 in sediment will produce an ILCR of about 4 pCi of U-238 via this pathway.

The ILCR to this receptor for this pathway from this radionuclide is calculated using Equation C.3-57. The risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 calculated in Equation C.3-88 and the ingestion slope factor for U-238, 2.0×10^{-11} (risk\pCi)$^{-1}$, for $SF_{ing\ i}$ into Equation C.3-57 yields:

$$ILCR_{sed\ U238} = (2.0 \times 10^{-11}\ (risk/pCi)(4\ pCi/lifetime)$$
$$ILCR_{sed\ U238} = 8.0 \times 10^{-11}\ risk/lifetime \qquad \text{(C.3-89)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/g of U-238 in sediment will produce an UR factor of about 8×10^{-11} via this pathway.

C.3.5.2 Direct Radiation Exposure

Equation C.3-74 is used for calculation of external exposure to sediment, as described in Section C.3.3.4. The parameters for the youth exposed to sediment in Paddys Run via this exposure pathway are as follows. In this calculation, exposure duration (ED) is 12 years, and the exposure frequency is 52 days per year (EF = 52 d/y). The exposure time is 1 hour per day, which is all considered an outdoor activity (ET_{out} = 1 h/d). The exposure time for indoor activities does not apply to this example. The value for outdoor shielding factor (S_o) is 0. Substituting these parameters into Equation C.3-74 yields:

$$ILCR_{sed\ e} = (5.1 \times 10^{-8})\ (pCi/g)(12y/lifetime)(52d/y)(y/8760\ h) \times [(1\ h/d)(1-0.0)]$$
$$ILCR_{e} = 3.63 \times 10^{-9}\ risk/lifetime \qquad \text{(C.3-90)}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/g of U-238 in sediment will increase the source strength by 7.1×10^{-2} pCi-y/g-life and the UR by 3.63×10^{-9} via the direct exposure pathway.

C.3.5.3 Calculation of Aggregate Risks for Youth from All Sediment Pathways

In this scenario, a youth is assumed exposed to U-238 in Paddys Run sediments via incidental ingestion and external exposure while trespassing or recreating on property. The total risks to the youth exposed to sediment from these pathways may be calculated as:

$$ILCR_{sed\ i} = (I_{sedi} \times SF_{ing\ i}) + (ILCR_{sed\ ei}) \qquad \text{(C.3-91)}$$

where

$ILCR_{sed\ i}$	=	total ILCR for sediment
$ILCR_{sed\ ei}$	=	ILCR from direct radiation
$I_{sed\ i}$	=	unit intake from incidental sediment ingestion (pCi/lifetime)
$SF_{ing\ i}$	=	slope factor for ingestion of constituent "i" (risk/pCi)

The intake by this hypothetical receptor for each pCi/L of U-238 in sediment from incidental ingestion has been calculated in Sections C.3.5.1. The UR from external exposure to direct radiation is presented in Section C.3.5.2. Substituting these values into Equation C.3-91, along with the appropriate slope factors for ingestion and inhalation of uranium, yields:

$$ILCR_{sed\ U238} = (8.0 \times 10^{-11}) + ((3.63 \times 10^{-9})$$
$$ILCR_{sediment\ U238} = 3.7 \times 10^{-9} \qquad \text{(C.3-92)}$$

The exposure models used in this scenario respond linearly to changes in concentration. Therefore, each additional pCi/g of U-238 in sediment will produce an UR of about 3.7×10^{-9} to the expanded trespasser or any of the recreational receptors from sediment from all direct exposure pathways investigated.

C.3.6 MULTIPLE AGE GROUP RECEPTORS

Four of the receptors considered in this appendix consist of multiple age groups where the ILCRs or HIs are summed/weighted over the age groups. They are:

- Expanded Trespasser - ages 7-18 and 19-50
- Recreational User, Developed Park - ages 0-6, 7-18, 19-55, 56-70
- Recreational User, Undeveloped Park - ages 0-6, 7-18, 19-55, 56-70
- Recreational User, Wildlife Refuge - ages 0-6, 7-18, 19-55, 56-70

Since carcinogenic risk from both chemical and radiological exposures is considered to be a cumulative effect, the summing of risks over age groups does not represent a problem. That is, the expanded trespasser exposure from the 7 to 18 age group is carried over to the 19 to 50 age group, and the total carcinogenic risk is the sum of the exposure for both age groups.

The youth portion of the expanded trespasser scenario visits the site from ages 7 through 18 (ED = 12) for 2 hours over 110 days per year has an exposed skin surface area of 4200 cm^2 and is assumed to breathe 0.83 m^3/hr (BR) and ingest soil at a rate of 0.1 mg of per day. Because the youth is at the site for a portion of the day, the youth is assumed to ingest 0.125 of the usual 0.1 g per day of dirt.

The adult portion of the expanded trespasser scenario visits the site from ages 19 through 50 (ED = 32) for 1 hour over 40 days per year has an exposed skin surface area of 5750 cm^2 and is assumed to breathe 0.83 m^3/hr (BR) and ingest soil at a rate of 0.1 mg of per day. Because the adult is at the site for a portion of the day, the adult is assumed to ingest 0.125 of the usual 0.1 g per day of the dirt.

For example for a U-238 soil concentration of 1 pCi/g, the UR for soil ingestion exposure using Equation C.3-54 and C.3-57 for the expanded trespasser youth (ages 7 to 18) with the appropriate parameters is:

$$ILCR_{yo} = 2.0 \ x \ 10^{-11}(1.0)(0.10)(0.125)(110)(12) = 3.3 \ x \ 10^{-10} \qquad \text{(C.3-93)}$$

The ILCR for inhalation exposure by the youth using Equation C.3-1 and C.3-4 is:

$$ILCR_{yI} = 2.4x10^{-8}(2x10^{-5})(0.83)(2)(110)(12)(1.0) = 1.05x10^{-9} \qquad \text{(C.3-94)}$$

The ILCR for direct radiation exposure by the youth using Equation C.3-74 is:

$$ILCR_{yD}=5.1x10^{-8}\left(\frac{1.0(2)(110)(12)(1.0)}{8760}\right) = 1.53x10^{-8} \qquad \text{(C.3-95)}$$

The combined exposure for the youth is:

$$ILCR_{y}=(3.3 \ x \ 10^{-10})+(1.05 \ x \ 10^{-9})+(1.53 \ x \ 10^{-8})=1.67 \ x \ 10^{-8} \qquad \text{(C.3-96)}$$

Similarly, for a U-238 soil concentration of 1 pCi/g, the ILCR for soil ingestion exposure using Equation C.3-54 for the expanded trespasser adult (ages 19 to 50) with the appropriate parameters is:

$$ILCR_{aO}= 2.0 \ x \ 10^{-11}(1.0)(0.10)(0.125)(40)(32)(1.0) = 3.2x10^{-10} \qquad \text{(C.3-97)}$$

The ILCR for inhalation exposure by the adult using Equation C.3-4 is:

$$ILCR_{aI}=2.4 \times 10^{-8}(2 \times 10^{-5})(0.83)(1)(40)(32)(1.0) = 5.10x10^{-10} \qquad \text{(C.3-98)}$$

The ILCR for direct radiation exposure by the adult using Equation C.3-74 is:

$$ILCR_{aD}=5.1x10^{-8}\left(\frac{1.0(1)(40)(32)(1.0)}{8760}\right) = 7.45x10^{-9} \qquad \text{(C.3-99)}$$

The combined exposure for the adult is:

$$ILCR_{a}=(3.2 \times 10^{-10})+(5.1x10^{-10})+(7.45 \times 10^{-9})=8.28x10^{-9} \qquad \text{(C.3-100)}$$

The total UR for the expanded trespasser from exposure to 1 pCi/g of U-238 in the soil is then the sum of youth and adult age groups, which is $2.49x10^{-8}$. Since this is a unit risk value (exposure to 1 pCi/g in surface soil), the PRG for a target risk of $1x10^{-6}$ is:

$$PRG = 1x10^{-6} / 2.49x10^{-8} = 40\ pCi/g \qquad \text{(C.3-101)}$$

However, this approach of summing across age groups cannot be used for calculating noncarcinogenic unit toxicity factors. HIs can not be summed across age groups because the HIs are calculated as an annual average and the effects are not cumulative over years of exposure. This is in part because the noncarcinogenic effects are assumed to have a threshold. That is, if the absorbed dose is less than the toxic or threshold dose, then no harmful effect is assumed to occur. In addition, it is assumed no bioaccumulation occurs or if it does, it is at such a slow rate that the accumulated body burden is still less than the threshold dose. In a practical sense, this means that exposure to noncarcinogens as a child, which are quite different from carcinogenic exposures, does not carry forward to adult life.

Therefore, a different method of calculation has to be performed to weight noncarcinogenic exposure for multiple age group receptors. In essence, a weighted average by age is performed.

Total uranium will be used to present these calculations. The oral RfD for total uranium noncarcinogenic exposure is 0.003 mg/(kg*day) and the dermal RfD is 0.00015 mg/(kg*day). The body weight (BW) of the youth is averaged to be 43 kg with an exposed skin surface area of 4380 cm^2. The body weight of the adult is 70 kg with an exposed skin surface area of 5750 cm^2. The

dermal adherence of the dirt on the skin is 1 mg/cm^2 and 1 percent of the uranium is absorbed through the skin. Inhalation exposure is not considered because there is not an inhalation RfD or RfC.

With these parameters, the youth HQ from ingestion is:

$$HQ_{yO} = \frac{1.0(0.10)(0.125)(110)(1.0)}{0.003(43)(1000)(365)} = 2.92 \times 10^{-5} \qquad \text{(C.3-102)}$$

The youth dermal HQ is:

$$HQ_{yD} = \frac{1.0(4380)(1.0)(0.01)(110)(1.0)}{(0.00015)(43)(1000000)(365)} = 2.05 \times 10^{-3} \qquad \text{(C.3-103)}$$

The youth HI from oral and dermal exposure to 1 mg/kg of uranium in the soil is:

$$HI = (2.92 \times 10^{-5}) + (2.05 \times 10^{-3}) = 2.08 \times 10^{-3} \qquad \text{(C.3-104)}$$

Since the soil concentration is 1.0 mg/kg, this is a unit toxicity value and the total uranium PRG for a HI of 1.0 is :

$$U\ PRG_y = 1 / 2.08 \times 10^{-3} = 481\ mg/kg \qquad \text{(C.3-105)}$$

The adult ingestion HQ is:

$$HQ_{aO} = \frac{1.0(0.10)(0.125)(40)(1.0)}{(0.003)(70)(1000)(365)} = 6.52 \times 10^{-6} \qquad \text{(C.3-106)}$$

The adult dermal HQ is:

$$HQ_{aD} = \frac{1.0(5750)(1.0)(0.01)(40)1.0}{0.00015(70)(1000000)(365)} = 6.00 \times 10^{-4} \qquad \text{(C.3-107)}$$

The adult HI from oral and dermal exposure to 1 mg/kg of uranium in the soil is:

$$HI = 6.52 \times 10^{-6} + 6.00 \times 10^{-4} = 6.07 \times 10^{-4} \qquad \text{(C.3-108)}$$

The adult PRG for total uranium is:

$$PRG = 1 / 6.07 \times 10^{-4} = 1649\ mg/kg \qquad \text{(C.3-109)}$$

The weighted PRG for the multiple user receptor is:

$$PRG = \frac{1.0}{\left(\frac{(2.08 \times 10^{-3} \times (12)) + (6.07 \times 10^{-4}(32))}{12+32}\right)} = 991\ mg/kg \qquad \text{(C.3-110)}$$

This PRG represents a soil uranium concentration which is not likely to cause a noncarcinogenic effect when the expanded trespasser is exposed to surface soils over the combined period of exposure.

C.4.0 TOXICOLOGICAL INFORMATION

C.4.1 INTRODUCTION

The objective of this section is to provide information on the toxic effects of exposure to the FEMP site COCs. This section qualitatively discusses the adverse human biological effects associated with exposure to these COCs. Toxicity profiles for each of the Operable Unit 5 COCs were presented in the Operable Unit 5 RI Report (DOE 1994) and they will not be duplicated here. The toxicological information explained here and presented in summary fashion in Tables C.4-1 and C.4-2 was used in Appendix H.7.0 and H.8.0 of this FS report to quantify receptor risk.

The following section presents a brief explanation of the methods and assumptions used by the U.S. EPA to set toxicity criteria. Section C.4.2.1 explains how RfDs and reference concentrations (RfCs) are established to assess noncarcinogenic risk. Section C.4.2.2 explains how slope factors are identified which allow for calculation of the ILCR due to exposure to chemical carcinogens found at the site. Section C.4.2.3 explains how radiocarcinogenicity slope factors are used to calculate the "maximum likelihood estimate of the age-averaged lifetime total cancer risk per unit intake or exposure" for radioactive contaminants (EPA 1993). Section C.4.3 explains how the toxicity criteria were adjusted for dermal exposure assessments and Section C.4.4 explains the toxicity equivalence factors method used to assess the cancer risk from mixtures of structurally related compounds such as polychlorinated biphenyls (PCBs), chlorinated dibenzodioxins, and polycyclic aromatic hydrocarbons (PAHs). Finally, Section C.4.6 explains how background concentrations of contaminants were addressed when establishing proposed remediation levels.

C.4.2. TOXICITY CRITERIA

C.4.2.1 Noncarcinogenic Toxic Effects

It is assumed for the noncarcinogenic effects of chemicals that a dose exists below which no adverse health effects will be seen (EPA 1989b). Below this "threshold" dose, it is believed that exposure to a constituent can be tolerated without adverse effects and the body burden is not increased. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposure doses above a threshold level. Maternal and developmental endpoints are also considered to have a threshold dose.

The potential for noncarcinogenic health effects resulting from exposure to chemical contaminants is assessed by comparing an exposure estimate (intake) to a RfD. RfDs are expressed in units of mg/kg/day and represent the daily intake (averaged over a year) of contaminant per kilogram of body weight, which is below the effect threshold for that contaminant. In essence, the RfD represents the threshold dose. In addition, the noncarcinogenic exposure doses are assumed not to be cumulative

from age group to age group over a lifetime exposure. A RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs.

The EPA reviews all relevant human and animal studies for each compound and selects the studies pertinent to the derivation of specific RfDs. Each study is evaluated to determine the "no observable adverse effect level" (NOAEL), if data are inadequate for such a determination, or the "lowest observable adverse effect level" (LOAEL). The NOAEL corresponds to the dose, in mg/kg/day, that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose, in mg/kg/day, that can be administered over a lifetime that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect." To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for: (1) extrapolation of data from laboratory animals to humans (interspecies extrapolation); (2) variation in human sensitivity to the toxic effects of a compound (intraspecies differences); (3) derivation of a chronic RfD based on a subchronic rather than a chronic study; and/or (4) derivation of an RfD from the LOAEL rather than the NOAEL. Each of these uncertainties is usually a factor of ten. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data (EPA 1989b).

EPA (1994a, 1994b) has also derived reference concentrations (RfCs) for the inhalation route. These inhalation noncancer toxicity values are usually expressed as in units of mg/m^3. Because noncancer risk characterization requires an estimate of dose in units of mg/kg/day, the inhalation RfC must be converted to an inhalation RfD. This conversion is done by assuming that adult human receptors weigh 70 kg and inhale 20 m^3 of air per day. This conversion does not account for factors such as the dynamics of the respiratory system, diversity among human receptors, diversity across species, and differences in the physicochemical properties of contaminants.

RfDs and RfCs for noncarcinogenic COCs are presented in Table C.4-1. The primary source for toxicological reference values is IRIS, an on-line database that contains current health risk and regulatory information (EPA 1994b). Provisional RfDs and RfCs are tabulated in HEAST (EPA 1994a) and EPA's Environmental Criteria and Assessment Office was also used as a source for provisional RfD/RfC values. Surrogate chemicals were not used for derivation of an RfD unless the chemical similarity was very close and the derivation was highly defensible. Several of the COCs identified for Operable Unit 5 including magnesium, manganese, and zinc are also micronutrient or essential elements which are needed in low levels for normal human growth and maintenance.

The noncarcinogenic risk associated with a chemical exposure is expressed as a HQ. The HQ is a ratio of the estimated chemical intake based on the measured exposure concentration at the site (dose)

for a COC, divided by the appropriate oral or inhalation. If the HQ exceeds one, there is potential for some harmful effect occurring or the threshold may be exceeded. If the HQ is equal to or less than one, the exposure level is not likely to cause adverse effects. If exposure to multiple chemicals occurs, the potential for harmful effects is assessed by summing the HQs and is designated the HI. In keeping with EPA guidance (1989b), all noncarcinogenic risk was considered additive for a given receptor. Since the noncarcinogenic COCs found at Operable Unit 5 are associated with various adverse effects which are manifested by distinct target organs and systems, the assumption of additivity of effects may overstate the potential for harmful effects. It must be recognized that there is also the potential for the effects of two or more chemicals to be synergistic. That is, the combined effects of exposure to two chemicals may be worse than exposure to either chemical alone because of interactions. The HIs for the Operable Unit 5 COCs for the various receptors can be found in Sections H.7.0 and H.8.0 of this FS report.

C.4.2.2 Chemical Carcinogen Risk

The ILCR from a nonradiological chemical carcinogen is calculated as a product of the reasonable maximum daily intake, in mg/kg/day, and the cancer slope factor (CSF). EPA's model of chemical carcinogenesis assumes that the relationship between an exposure to a carcinogen and the cancer risk is linear over the entire dose range; however, this may not be true at very low doses (EPA 1986). This assumes that there is no threshold of exposure dose below which no harmful effects will occur. Because of this, carcinogenic effects are considered to be cumulative across age groups when considering lifetime exposures.

CSFs are upper-bound [95 percent upper confidence limit (UCL)] estimates of the increased cancer risk per unit dose, where risk is expressed as the probability that an individual will develop cancer within his or her lifetime as the result of exposure to a given level of a carcinogen. All cancers or tumors are considered whether or not death occurred as a result. This approach is inherently conservative because of the no-threshold assumption and the use of the 95 percent UCL of the estimated slope of dose versus cancer risk.

The toxicity information considered in the assessment of potential carcinogenic risks includes a weight-of-evidence classification and a slope factor. A constituent may be placed in one of three groups in EPA's classification system to indicate its potential for carcinogenic effects: Group A, a human carcinogen; Group B1 or B2, a probable human carcinogen; and Group C, a possible human carcinogen. Constituents that cannot be classified as human carcinogens because of a lack of data are placed in Group D, and those for which there is evidence that the chemicals are not carcinogens in humans are placed in Group E (EPA 1989b).

C.4.2.3 Radiocarcinogens

Some elements have isotopes consisting of unstable atoms (i.e., they undergo spontaneous transformation into more stable atoms). These isotopes are said to be radioactive and the transformation process is known as radioactive decay. Radioactive decay is usually accompanied by the emission of charged particles and gamma rays. These emissions are called radiation.

There are three types of radiation which are potentially of concern at the FEMP: alpha, beta, and gamma. Alpha and beta radiation consist of charged particles capable of ionizing nearby matter. These radiations generally have little ability to penetrate deeply into adjacent matter and can be interdicted by skin, air, and clothing. In most cases, the emission of alpha or beta particles from an atom is followed by a release of x-rays or gamma radiation. Depending on their energies, these radiations may have considerably more penetration power than either alpha or beta radiation and are thus more difficult to shield.

Radiation exposures are commonly separated into external and internal exposures. For external exposures, gamma radiation is the primary concern at environmental levels because alpha and beta radiation generally have a low penetrating power, and skin and air become effective radiation shields in most cases.

Inhalation and ingestion are the primary routes for internal exposure to radionuclides. For internal exposures, alpha and beta particles become more important because their energy is directly absorbed by living cells. Once in the body, the degree of exposure depends on the absorption and retention characteristics of the radionuclide. These absorption and retention characteristics are based on the chemical form of the radionuclide in a compound and not on the isotopic form of the radionuclide.

Radioactive contamination within Operable Unit 5 is characterized as low-level ionizing radiation. The principal adverse biological effects associated with ionizing radiation from radioactive substances in the environment are mutagenicity, teratogenicity, and carcinogenicity. Mutagenicity is the ability to induce genetic mutations in the nuclei of either body cells or reproductive cells. Teratogenicity is the ability to induce or increase the incidence of congenital malformations, which are permanent structural or functional deviations produced during embryonic growth and development.

Carcinogenicity is the ability to produce cancer. The carcinogenicity of a radioactive isotope of an element depends on several factors including:

- The type of radiation emitted by the radioisotope
- The energy of the radiation emitted
- The radiological half-life of the isotope
- The retention and concentration characteristics of the radioisotope in the human body

Carcinogenicity is believed to be the limiting deleterious effect at the levels of radiation dose encountered within Operable Unit 5 and has been used as the sole basis for assessing the radiation-related human health risks of a site contaminated with radionuclides (EPA 1989a)

The relationship between radiation dose and health effects is relatively well characterized for high doses (i.e., greater than 10 rad) (UNSCEAR 1982). Therefore, risk estimates are strictly applicable only to large populations exposed to high levels of radiation. Lower levels of exposure may constitute a health risk, but a direct cause and effect relationship is difficult to establish because a particular effect in an individual receptor can be produced by many different processes. For low-dose exposures, health effects, including carcinogenesis, are presumed to occur but their incidence can only be estimated by using extrapolation from data obtained at higher doses (UNSCEAR 1982).

CERCLA Radiological Risk Characterization Methods

In this assessment, the risk of developing a radiologically or chemically induced carcinogenic response from exposure is calculated as the ILCR. If a receptor is directly exposed to the ionizing radiation of a radionuclide or either ingests, inhales, or is dermally exposed to a carcinogenic chemical or radionuclide, the risk of initiating a cancer from that exposure is calculated and expressed as a probability. For example, an ILCR of one in a million is expressed as 1×10^{-6}. The carcinogenic risk due to exposure to a radionuclide is calculated as the product of the radionuclide's activity, expressed in pCi, and the CSF for that radionuclide, expressed in exponential form.

In accordance with CERCLA guidance, the EPA assumes unit intakes of and external exposure to a radionuclide over a 70-year lifetime (EPA 1989b). The annual radiation dose equivalent from the radionuclide to each organ in each year of life is calculated and this information was used in Sections H.7.0 and H.8.0 of this FS report to characterize receptor risk. The average excess number of all types of radiation-induced fatal cancers that occur in a year was estimated for the corresponding dose equivalents received during that year and relevant preceding years. The excess number of radiation-induced fatal cancers is derived from epidemiological data, extrapolated from high radiation doses to low doses, and by use of hypothetical models that project risk through a lifetime (Sections H.7.0 and H.8.0 of this FS report). The relationship between cancer incidence and exposure to radioactive materials is quantified by using mathematical extrapolation models. These models estimate the largest possible linear slope (within the 95 percent confidence limit) at low extrapolated doses consistent with the data. Because EPA is concerned with assessing cancer incidence, each radionuclide slope factor has been calculated by dividing the excess fatal cancer risk for that radionuclide by the mortality-to-incidence risk ratio (EPA 1989a) for the types of cancer induced by that radionuclide. This "radiocarcinogenicity slope factor" is characterized as the "maximum likelihood estimate of the age-averaged lifetime total excess cancer risk per unit intake or exposure"

(EPA 1994a). The true risk to humans, as estimated by the slope factors, is not likely to exceed this upper bound estimate and may actually be lower.

The EPA Office of Radiation Programs (ORP) has CSFs for radionuclides of potential concern at Superfund sites. These values are listed in HEAST (EPA 1994a) and presented as the risk of cancer incidence per unit intake of a radionuclide contaminant. The radionuclide slope factors used in this assessment are expressed in units of pCi^{-1} or g/yr-pCi and are presented in Table C.4-2.

It should be noted that the chemical ILCR and the radiological ILCR are not truly additive. This is because the chemical ILCR is based on all cancers, fatal or not. The radiological ILCR is based on fatal cancers, so adding these two risk values together is not a true sum of risk.

Non-CERCLA Radiological Risk Characterization Method

An alternative method must be used to quantify the risk to a receptor from direct exposure to penetrating radiation from buried radiological sources or radiological sources of irregular geometry (e.g., sources other than contaminated surface soil). The method involves two steps: 1) radiation dose equivalent (mrem) to the receptor from the source is estimated and 2) risk is characterized as the product of estimated dose equivalent (mrem) and a risk factor expressed per unit of dose equivalent ($mrem^{-1}$). A risk factor of 6.2×10^{-7} $mrem^{-1}$ is used (EPA 1989a).

C.4.3 QUANTIFYING DERMAL EXPOSURE RISKS

Dermal RfD values and CSFs are derived from the corresponding oral values. In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal (GI) absorption factor. The resulting dermal RfD is based on the absorbed dose, which is the appropriate value with which to compare a dermal dose which is absorbed through the skin. In a similar manner, a dermal CSF is derived by dividing the oral CSF by the GI absorption efficiency. The oral slope factor is divided, rather than multiplied, by the GI absorption efficiency because CSFs are expressed as reciprocal dose (EPA 1989b).

The most important consideration regarding the uncertainty associated with a dermal RfD or CSF is the accuracy of the GI absorption efficiency factor. For this reason, the toxicity profiles presented in the Operable Unit 5 RI Report (DOE 1994) contain pharmacokinetic information in which the oral absorption data are evaluated. Where appropriate, the low (most conservative) end of the range of available GI absorption data for humans is used in the derivation of the dermal RfD or CSF. When the human data are insufficient, animal data are used. Data from high-dose experiments are not used if more suitable data are available and it appears that saturation of the GI absorption process could have occurred. When sufficient quantitative data are not available, a default GI absorption factor is used. As noted by EPA (1989a), the absorption of many metals from the GI tract is limited, and a GI

absorption fraction of 0.05 is provided as a reasonable default for metals and inorganic substances when an appropriate value is not available in the literature.

C.4.4 TOXICITY EQUIVALENCE FACTORS

One approach used to assess the cancer risk of mixtures of structurally related compounds such as PCBs, dioxins/furans, and PAHs is to characterize the toxicities of these compounds relative to the toxicity of a compound representative of the group. This is known as the toxicity equivalence factors (TEFs) approach and it takes into account the differing potencies of carcinogenic compounds from structurally related mixtures. This approach was used in the following instances:

- The carcinogenicity of all PCB isomers is assumed to be equal to the carcinogenicity of Aroclor-1260. Dose-response data for other isomers are not as well established (ATSDR 1991a).
- The carcinogenicity of dioxins and furans are determined using EPA's revised TEF (EPA 1990b). These TEFs were determined with the basic assumption that all dioxins and furans are carcinogenic.
- The carcinogenicity of PAHs is initially determined using the benzo(a)pyrene CSFs and refined using a relative potency approach (EPA 1993b).

Polychlorinated Biphenyls

PCBs are mixtures of up to 209 structurally related congeners. They consist of two benzene rings with up to five chlorines attached to each ring. PCBs are relatively nonflammable and have useful heat exchange and dielectric properties. They were used primarily in the electric industry in capacitors and transformers and were also used in the formulation of lubricating and cutting oils, pesticides, adhesives, plastics, inks, paints, and sealants. Monsanto, the sole producer of PCBs in the United States, marketed them under the generic trade name Aroclor followed by four digits. The first two digits were 12, indicating the number of carbons in the benzene rings. The last two digits indicated the percent, by weight, of chlorine. For example, Aroclor-1254 denotes a mixture of PCBs containing 54 percent chlorine by weight. As the percent chlorination goes up, so too does environmental persistence. The environmental persistence, toxicities, and bioaccumulation potential of PCBs lead to the cessation of their commercial production within the United States in 1984. Three PCBs, Aroclor-1260, -1254, and -1248, were identified as COCs for Operable Unit 5. Existing toxicological information on PCBs suggests that PCB mixtures containing more highly chlorinated biphenyls are more potent inducers of hepatocellular carcinoma in rats (ATSDR 1991a). For the Operable Unit 5 risk assessment, the toxicity of PCBs was assumed to be equal to the toxicity of Aroclor-1260, which has the highest percent by weight of chlorine for the COCs found at Operable Unit 5 (DOE 1994b). This is a conservative approach to assessing the risk due to PCB exposures.

Chlorinated Dibenzodioxins and Chlorinated Dibenzofurans

Chlorinated dibenzo-p-dioxin and dibenzofurans (CDDs/CDFs) consist of a family of 210 structurally related compounds typically associated with combustion sources. 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) is one compound in this group which has been shown to elicit a wide range of toxic responses in animals at exceptionally low doses. Toxic effects associated with 2,3,7,8-TCDD exposure include cancer, adverse reproductive effects, thymic atrophy, chloracne, and a "wasting syndrome" leading to death. For risk assessment purposes, EPA classifies 2,3,7,8-TCDD as a B2 potential human carcinogen with a potency factor that exceeds all other carcinogens evaluated by EPA to date. The chemical is also the most potent reproductive toxin yet evaluated by EPA.

While the toxicity of 2,3,7,8-TCDD is exceptional, this compound rarely occurs alone. In most of the cases analyzed, the concentrations of some of the other 209 CDDs/CDFs greatly exceed those of 2,3,7,8-TCDD. Long-term in vivo toxicity data for many of the CDD/CDF congeners is limited or nonexistent. However, a much larger body of information is available from short-term tests. These experiments cover a wide variety of endpoints, but the relative potency of the different compounds compared to 2,3,7,8-TCDD is generally consistent from one assay to another. While long-term toxicity results that directly measure the biological response for a site-specific mixture of CDDs/CDFs would be preferred over a relative toxicity approach (such as the TEF method), EPA approved long-term toxicity values are not available at this point.

To assess the risks associated with exposure to complex mixtures of CDDs/CDFs, a TEF approach was developed (EPA 1990). This method uses available toxicological data and reasoning on the basis of structure/activity relations to assign TEFs which allow the relative toxicity of specific CDD and CDF congeners to be expressed in terms of 2,3,7,8-TCDD equivalents. This is done by multiplying the concentration of each CDD/CDF congener by its TEF to yield its concentration in 2,3,7,8-TCDD equivalents. The sum of all congener-specific 2,3,7,8-TCDD equivalents can then be used in pathway-specific intake equations to estimate exposure. These exposures can then be combined with the CSF of 2,3,7,8-TCDD to generate the upper limit of the excess risk of developing cancer as a result of exposures to CDDs and CDFs. The TEFs used for this risk assessment were updated in 1989 and are supported by an international consensus reached by a working group of the North Atlantic Treaty Organization's Committee on Challenges of Modern Society (EPA 1990).

Polycyclic Aromatic Hydrocarbons

PAHs are a group of structurally related compounds which are formed during the incomplete combustion of coal, oil, wood, and other organic substances. While PAHs are formed during a variety of human activities such as cooking operations, steel manufacturing, and the combustion of fossil fuels, these compounds are also found to be naturally occurring. PAHs are widely distributed

throughout all environmental media; however, ambient levels of PAHs are generally much higher in urban areas (EPA 1993b).

The relative potency factor (RPF) approach was used to assess the cancer risk of PAHs found in Operable Unit 5. Use of RPFs takes into account the differing potencies of carcinogenic PAHs and yields a more realistic estimate of risk that is founded on existing biological information. The concentration of each carcinogenic PAH found in Operable Unit 5 was multiplied by its RPF to adjust for their relative potencies as compared to benzo(a)pyrene. The sum of these values was then used as the carcinogenic PAH source term value to estimate intake and dose. RPF intake values were then assessed using the slope factor assigned for benzo(a)pyrene.

C.4.5 Toxicological Profiles

Three of the metals which are COCs require further examination as to their toxicological properties and include: arsenic, manganese, and zinc. Because arsenic is a known human carcinogen and the residual risk and toxic effects have been estimated to be above guidelines, its toxicological properties will be discussed in more detail. Manganese, and zinc are essential elements required by all mammals including humans. The absorption, excretion and body burdens are under homeostatic control by the receptor. The assumptions and equations used in the exposure models do not consider these homeostatic controls and the toxic effects may be overestimated. The following profiles present these controls.

C.4.5.1 Arsenic

Background Information

Arsenic is a heavy metal that is ubiquitous in the environment and is found in most soils. A nationwide survey of surface soil metal concentrations was performed by the USGS (Shacklette and Boorhgen 1984). It found that 48 percent of the surface soil samples had between 6.5 and 16.0 mg/kg arsenic. The geometric mean of these samples was 5.2 mg/kg with a modal value of 6.5 mg/kg. One of the samples in this survey was taken off Interstate 74 near the Indiana border. This sample contained 10 mg/kg of arsenic. The FEMP site background was found to be 9 mg/kg. This value fits in the range established by the survey.

Arsenic is a normal component of most foods and is found in the tissues of all life which includes mammals, aquatic, marine life, and plants. It has been shown that shellfish from the ocean contain the highest concentrations of arsenic. It is not thought to be an essential element. A typical dietary intake for humans was estimated to be 0.19 mg/day or 0.003 mg/kg/day. If the diet excludes seafoods, the average intake is 0.04 mg/day or 0.0006 mg/kg/day for a 70 kg man (Friberg et al. 1986). The upper range for arsenic concentrations in foods are 0.065 mg/kg for beef, 0.05 mg/kg for corn, 0.03 mg/kg for potatoes, and 0.025 mg/kg for milk (Seiler et al. 1988).

Both arsenate and arsenite are well absorbed by both the inhalation and oral routes (ATSDR 1993). Absorption via the dermal route is not well studied, but arsenic is absorbed through the skin (Friberg et al. 1986). The metabolism of arsenic includes reversible oxidation-reduction so that both arsenite (+3 state) and arsenate (+5 state) are present in the urine of animals treated with either state. Arsenite is oxidized and methylated to form dimethylarsenate, which is the predominate arsenic compound in urine of animals and humans. The organic arsenic compounds are not readily metabolized to the inorganic compounds (Friberg et al. 1986). Elimination through the urine is the excretion pathway and 60 to 70 percent of the daily intake is excreted each day. Since the body has a mechanism for detoxifying and eliminating inorganic arsenic, normal daily intake does not usually cause a toxic or carcinogenic effect. However, there are epidemiological reports where arsenic in the potable water source has been associated with skin cancer (Tseng 1977).

Noncarcinogenic Effects

Arsenic trioxide is one of the oldest poisons used by man. In pre-Christian time, its effect and dosage was described in detail. Arsenic trioxide has also been used over the years for treatment of parasitic diseases such as syphilis. Even though its use as a treatment for parasites has been abandoned for most diseases, it is still used for some tropical parasites. The principal noncarcinogenic effect of arsenic chronic overdoses are weakness, languor, anorexia, and nausea (Seiler et al. 1988). Chronic exposures also produce melanosis and hyperkeratosis of the skin. Occupational inhalation exposures also produce skin lesions, although in very high exposures, respiratory dysfunctions are also found (Friberg et al. 1986). EPA (1994b) derived a oral RfD of 3.0×10^{-4} mg/kg/day. This value is based on a NOAEL of 8.0×10^{-4} mg/kg/day for skin lesions from Tseng (1977). An inhalation RfD has not been derived.

Carcinogenic Effects

Inorganic arsenic is clearly a carcinogen in humans. Occupational inhalation exposure is associated with lung cancer in persons employed as smelter workers and in pesticide application workers. Oral exposure to high levels of arsenic in drinking water has been associated with increased risk of skin cancer (Tseng 1977; ATSDR 1993). However, the same cancers have not been induced in animals by many routes of exposure to many species of animals (ATSDR 1993). EPA has derived an oral risk value for drinking water of 5.0×10^{-5} μg/L (EPA 1994b). An inhalation risk value of 4.3×10^{-3} per $\mu g/m^3$ was derived from the incidence of lung cancer in occupationally exposed men (EPA 1994a).

C.4.5.2 Manganese

Background

Manganese is widely distributed in the earth's crust, but it does not occur naturally in its native state. Oxides, carbonates and silicates are the most important among manganese containing minerals. Manganese is an essential element for mammals including humans. The recommended daily intake is

4 mg/day or 0.057 mg/kg/day for a 70 kg man (Sieler et al. 1988). Estimates of normal daily intake from food consumption range from 2.1 to 9 mg/day or 0.30 to 0.13 mg/kg/day for a 70 kg man (Friberg et al. 1986; ATSDR 1991b).

The total manganese body burden of a standard man of 70 kg has been estimated to be about 10 to 20 mg. Whole blood manganese, most of which is bound to hemoglobin in erythrocytes, averages 9 μg/L (range 3.9 to 15) in normal adults when measured by atomic absorption spectrometry. Serum manganese in normal adults averages 1.8 μg/L, ranging from 0.9 to 2.9 μg/L.

The predicted residual FEMP site soil concentration of 850 parts per million is greater than the range of 300 to 700 ppm reported for 50 percent of surface soil samples collected in a national soil survey (Shacklette and Boerngen 1984). The 95th percentile background soil manganese concentration at the FEMP was found to 1300 mg/kg. Therefore, the 850 ppm residual manganese is at the high end of background manganese soil levels reported for the continental United States. The predicted residual Great Miami Aquifer manganese concentration is 1.60 mg/L, which can be compared to the background Great Miami Aquifer manganese concentration of 0.90 mg/L.

Noncarcinogenic Toxicity

The EPA RfD for manganese of 0.14 mg/kg/day for chronic human consumption of manganese in the diet is based on a composite of three human studies. The principal toxic effect is central nervous system disturbances. The World Health Organization (WHO) in 1973 reported no adverse effects in humans consuming supplements of 8 to 9 mg minutes/day or 0.11-0.13 mg/kg/day. A study by Schroeder et al. (1966) reported a chronic human NOAEL of 11.5 mg/day or 0.18 mg/kg/day. The National Research Council in 1989 determined an "adequate and safe" intake of manganese to be 2 to 5 mg/day or 0.029-0.070 mg/kg/day for adults, which included an "extra margin" of safety from the level of 10 mg/day or 0.14 mg/kg/day, which the National Research Council considered safe for an occasional intake. EPA has established a separate RfD for manganese for drinking water (EPA 1994b). This value is 0.005 mg/kg/day and is based on a study in Greece where an epidemiological study was done on three separate populations, each consuming natural source water with three different levels of manganese. The endpoint of this study was a neurological exam which was nonspecific for manganese toxic effects. The IRIS report emphasized that this RfD was to be used for drinking water only (EPA 1994b).

Various dietary factors as well as the form of manganese can have a significant bearing on the dose absorbed from the gastrointestinal tract. Many constituents of a vegetarian diet (e.g., tannins, oxalates, phytates, fiber, calcium, and phosphorus) have been found to inhibit manganese absorption presumably by forming insoluble complexes in the gut. Individuals who are deficient in iron demonstrate an increase in manganese absorption. Manganese uptake and elimination are under

homeostatic control, generally allowing for a wide range of dietary intakes considered to be safe. Because of the homeostatic control humans maintain over manganese, it is generally not considered to be toxic when ingested with the diet. While the RfD process involves the determination of a point estimate of an oral intake, it is also stated that this estimate is associated "with uncertainty spanning perhaps an order of magnitude" (EPA 1994b).

Absorption of ingested manganese is regulated by homeostatic mechanisms; generally manganese absorption constitutes only a few percent of the amount ingested in man but may be increased by iron deficiency. The absorption rate will depend on the amount ingested and on tissue levels of manganese. A human study performed by Thompson et al. (1971) indicates that manganese absorption takes place by diffusion in iron overload states and by active transportation in the duodenum and jejunum in iron-deficiency states. Manganese homeostasis is primarily achieved by excretion. Absorbed manganese is almost totally excreted via the intestinal wall by several routes (Saric 1986). Manganese is absorbed from the small intestine and is then transported via blood in trivalent form bound to beta 1-globulin, transmanganin. Manganese is excreted in bile and through the intestinal wall. Excretion through the intestinal wall constitutes the principal mechanism for regulating the amount in tissues. With high manganese intake, it is also excreted in pancreatic juice. The amount excreted in urine is small. The uniform manganese concentration in mammals and the lack of accumulation with age is due to an efficient homeostasis which regulates manganese excretion more than its absorption. Manganese toxicity in man arising from excessive intakes in foods and beverages has never been reported and is difficult to conceive of this occurring, except where industrial contamination occurs (EPA 1994b).

The importance of this homeostatic control is that the meat and dairy food uptake models do not assume any homeostatic control but rather a simple partitioning from plant to animal. Since the intermediary (cow) in this pathway has a similar manganese metabolism as man, manganese levels in milk and meat would be at normal tissue levels regardless of intake for a healthy animal. This means the food pathways may be overly conservative. This issue is discussed further in Appendix H of this FS report.

Manganese is a natural component of most foods. A summary of mean manganese concentration in 234 foods analyzed by the U.S. Food and Drug Administration is presented in the table below. The highest manganese concentrations (up to 40 ppm) are found in nuts and grains, with lower levels (up to 4 ppm) found in milk products, meats, fish, and eggs.

As mentioned above, the average residual on-site soil concentration of manganese is at the high end of the background manganese concentrations found in the United States. It is reasonable to assume that these background manganese concentrations are also representative of farm soil concentrations in the

United States. The results of the market basket survey of food manganese concentrations would also be expected to reflect the analyses of fruits and vegetables, meat, and dairy products produced on farm land containing soil with up to 900 ppm manganese. Variability in soil manganese concentrations could be one factor to explain the wide range of manganese levels reported in the market basket survey.

C.4.6 ASSESSING BACKGROUND IN THE DERIVATION OF PRELIMINARY REMEDIATION GOALS/PRELIMINARY REMEDIATION LEVELS

In the Operable Unit 5 baseline risk assessment, PRGs were calculated for those receptors which demonstrated the highest risk under each of the land use objectives. The PRGs were compound-specific and receptor-specific. For example, the soil PRG for uranium reflects the risk due to dermal exposure, direct radiation, inhalation, and ingestion exposures to this contaminant for given receptors. For compounds which have both carcinogenic and noncarcinogenic effects, PRGs were determined for both endpoints. The PRG for a given risk level was determined by comparing the PRG that yielded an ILCR at a particular level with the PRG that yielded a HQ of 0.2. The lower of the two PRG values was selected to ensure that neither the ILCR nor the HQ would be exceeded. PRGs were also calculated assuming cross media transport from soil to groundwater and to ensure compliance with maximum concentration levels.

Preliminary remediation levels (PRLs) represent the remediation goal for a particular block of soil considering all potential pathways to the ultimate receptors. The PRL for a unit of soil is the lowest value among the various PRGs calculated. For radioactive contaminants, background concentrations were added to the PRGs to arrive at PRLs. EPA guidance does not permit the addition of background values for nonradioactive contaminants. Therefore, PRGs are the PRLs for these contaminants with no consideration for background.

TABLE C.4-1
MANGANESE CONCENTRATIONS IN SELECTED FOODS[a]

Type of food	Range of mean concentrations (ppm)
Nuts and nut products	18.21-46.83
Grains and grain products	0.42-40.70
Legumes	2.24-6.73
Fruits	0.20-10.38
Fruit juices and drinks	0.05-11.47
Vegetables and vegetable products	0.42-6.64
Infant foods	0.17-4.83
Meat, poultry, fish, and eggs	0.10-3.99
Milk and milk products	0.02-0.49

[a]ATSDR 1991b

TABLE C.4-2
TOXICITY CRITERIA FOR OPERABLE UNIT 5 CONTAMINANTS OF CONCERN

Chemical	Reference Dose: Oral Route of Exposure (mg/kg/day) [UF][a]	Reference Dose: Inhalation Route of Exposure (mg/kg/day) [UF][a]	Target Organ for Noncarcinogenic Effects (Oral / Inhalation)	Cancer Slope Factor: Oral Route of Exposure $(mg/kg/day)^{-1}$	Cancer Slope Factor: Inhalation Route of Exposure $(mg/kg/day)^{-1}$	U.S. EPA Weight of Evidence[b]
Volatile Organic Compounds						
1,1-Dichloroethane	$1.0x10^{-1}$[f]	$1.43x10^{-1}$[f] [1000]	NA / no effects observed	NA	NA	C (mammary gland tumors and liver tumors)
1,1-Dichloroethene	$9.0x10^{-3}$[o] [1000]	NA	Liver lesions / NA	$6.1x10^{-1}$[o]	$1.8x10^{-1}$[o,d]	C (glandular tumors in mice)
1,2-Dichloroethane	NA	$2.86x10^{-3}$[p]	NA	$9.1x10^{-2}$[o]	$9.1x10^{-2}$[o,d]	B2 (lung tumors in mice)
Acetone	$1.0x10^{-1}$[o]	NA		NA	NA	
Benzene	NA	$1.71x10^{-3}$	NA / effects on the blood	$2.9x10^{-2}$[o]	$2.9x10^{-2}$[o,d]	A (nonlymphocytic leukemia; neoplasia in rats, mice)
Boron	$9.0x10^{-2}$	$5.7x10^{-3}$	Testicular atrophy / NA	NA	NA	NA
Bromoform	$2.0x10^{-2}$	NA	Liver lesions / NA	$7.9x10^{-3}$[f]	$3.9x10^{-3}$	B2
Bromomethane	$1.4x10^{-3}$[f]	$1.43x10^{-3}$[f]	NA	NA	NA	NA
Bromodichloromethane	$2.0x10^{-2}$	NA	Renal cytomegaly	$6.2x10^{-2}$[F]	$6.88x10^{-2}$	B2
Carbazole	NA	NA	NA	$2.0x10^{-2}$[o]	NA	B2 (liver tumors)
Carbon tetrachloride	$7.0x10^{-4}$[o] [1000]	$5.7x10^{-4}$[F]	Liver lesions / NA	$1.3x10^{-1}$[o]	$5.3x10^{-2}$[o,d]	B2 (liver tumors)
Carbon disulfide	$1.0x10^{-1}$[o]	$2.86x10^{-3}$[f,g] [1000]	Fetal toxicity, malformations / fetal toxicity	NA	NA	NA
Chlorobenzene	$2.0x10^{-2}$[o] [1000]	$5.7x10^{-3}$[f,g] [10000]	Changes in liver tissue / liver effects	NA	NA	D
Chloroform	$1.0x10^{-2}$[o] [1000]	NA	Fatty cyst formation in liver / NA	$6.1x10^{-3}$[o]	$8.1x10^{-2}$[o,d]	B2 (liver tumors in mice)
Ethylbenzene	$1.03x10^{-1}$[f]	$2.86x10^{-1}$	Liver toxicity / liver toxicity	NA	NA	NA
Methylene chloride	$6.0x10^{-2}$[o] [100]	$8.57x10^{-1}$[f,g] [100]	Liver toxicity / liver toxicity	$7.5x10^{-3}$[o]	$1.6x10^{-3}$[o,d]	B2 (liver neoplasms, alveolar/ bronchiolar neoplasms in mice; salivary gland tumors)
4-Methyl-2-pentanone	$5.0x10^{-2}$	$8.0x10^{-2}$[f]	NA	NA	NA	NA
2-Butanone	$6.0x10^{-1}$[o]	$2.86x10^{-1}$	NA	NA	NA	NA
Toluene	$2.0x10^{-1}$	$1.14x10^{-1}$	Liver, kidney, fetal malformations / neurological toxicity	NA	NA	NA

000926

TABLE C.4-2
(Continued)

Chemical	Reference Dose: Oral Route of Exposure (mg/kg/day) [UF][a]	Reference Dose: Inhalation Route of Exposure (mg/kg/day) [UF][a]	Target Organ for Noncarcinogenic Effects (Oral / Inhalation)	Cancer Slope Factor: Oral Route of Exposure $(mg/kg/day)^{-1}$	Cancer Slope Factor: Inhalation Route of Exposure $(mg/kg/day)^{-1}$	U.S. EPA Weight of Evidence[b]
Volatile Organic Compounds (Continued)						
Tetrachloroethene	$1.0x10^{-2o}$ [1000]	NA	Liver toxicity in mice / NA	5.2×10^{-2}	NA	C-B2
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	$4.0x10^{-3}$	NA	Depressed humoral immune status / NA	$5.6x10^{-2}$	$5.7x10^{-2}$	C
Trichloroethene	$6.0x10^{-3h}$	NA	NA	$1.1x10^{-2h}$	$6.0x10^{-3h}$	C
Vinyl chloride	NA	NA	NA	$1.9x10^{0f}$	$3.0x10^{-1f}$	A
Xylenes	$2.0x10^{0}$	NA	Weight loss / NA	NA	NA	D
Semivolatile Organic Compounds						
bis-(2-Chloroiospropyl) ether	$4.0x10^{-2}$	NA	NA	$7.02x10^{-2}$	$3.5x10^{-2}$	C
3,3'-Dichlorobenzidene	NA	NA	NA	$4.5x10^{-1}$	NA	B2
4-Methylphenol	$5.0x10^{-3}$	NA	NA	NA	NA	NA
N-Nitroso-di-n-propylamine	NA	NA	NA	$7.0x10^{0o}$	NA	B2
N-Nitroso-di-phenylamine	NA	NA	NA	$4.9x10^{-3}$	NA	B2
Pentachlorophenol	$3.0x10^{-2o}$ [100]	NA	Liver and kidney disease / NA	$1.2x10^{-1o}$	NA	B2 (multiple tumor types)
bis(2-ethylhexyl)phthalate	$2.0x10^{-2o}$ [1000]	NA	Increased liver weight / NA	$1.4x10^{-2o}$	NA	B2 (liver tumor responses in rats and mice)
di-n-Octylphthalate	$2.0x10^{-2}$	NA	NA	NA	NA	NA
4-Nitroaniline	$3.0x10^{-3}$	NA	NA	NA	NA	NA
Tributylphosphate	$5.0x10^{-3Q}$	NA	NA	NA	NA	NA
Polycyclic Aromatic Hydrocarbons						
Benzo(a)anthracene	NA	NA	NA	$7.3x10^{-1i}$	$6.1x10^{-1i}$	B2 (mice tumors)
Benzo(a)pyrene	NA	NA	NA	$7.3x10^{0i}$	$6.1x10^{0i}$	B2 (forestomach tumors in rats, mice; respiratory tract tumors in hamsters)
Benzo(b)fluoranthene	NA	NA	NA	$7.3x10^{-1i}$	$6.1x10^{-1i}$	B2 (lung tumors in mice)

TABLE C.4-2
(Continued)

Chemical	Reference Dose: Oral Route of Exposure (mg/kg/day) [UF][a]	Reference Dose: Inhalation Route of Exposure (mg/kg/day) [UF][a]	Target Organ for Noncarcinogenic Effects (Oral / Inhalation)	Cancer Slope Factor: Oral Route of Exposure $(mg/kg/day)^{-1}$	Cancer Slope Factor: Inhalation Route of Exposure $(mg/kg/day)^{-1}$	U.S. EPA Weight of Evidence[b]
Polycyclic Aromatic Hydrocarbons continued						
Benzo(k)fluoranthene	NA	NA	NA	$7.3x10^{-2}$[i]	$6.1x10^{-2}$[i]	B2 (lung tumors in mice)
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	$7.3x10^{-3}$[i]	$6.1x10^{-3}$[i]	B2 (tumors and malignant lymphoma in mice; chromosomal abnormalities in hamsters)
Dibenzo(a,h)anthracene	NA	NA	NA	$7.3x10^{0}$[i]	$6.1x10^{0}$[i]	B2 (tumors in mice; DNA damage, gene mutations in bacteria)
Indeno(1,2,3-cd)pyrene	NA	NA	NA	$7.3x10^{-1}$[i]	$6.1x10^{-1}$[i]	B2 (tumors in mice following lung implants)
Phenanthrene	NA	NA	NA	NA	NA	D
Pesticides / PCBs						
Aroclor-1254	NA	NA	NA	$7.7x10^{0}$[k]	NA	B2[k] (liver tumors in rats; suggestive evidence of liver cancer in humans)
Aroclor-1260	NA	NA	NA	$7.7x10^{0}$[k]	NA	B2[k] (liver tumors in rats; suggestive evidence of liver cancer in humans)
Chlordane*	$6.0x10^{-5}$[o] [1000]	NA	Increase in liver size in females / NA	$1.3x10^{0}$[o]	$1.4x10^{0}$[o,d]	B2 (benign and malignant liver tumors in mice)
Dieldrin	$5.0x10^{-5}$[o] [100]	NA	Liver lesions / NA	$1.6x10^{+1}$[o]	$1.6x10^{+1}$[o]	B2 (liver tumors in mice)
Dioxins / Furans						
Heptachlorodibenzo-p-dioxin	NA	NA	NA	$1.5x10^{+5}$[r]	$1.5x10^{+5}$[r]	
Heptachlorobenzofuran	NA	NA	NA	$1.5x10^{+5}$[r]	$1.5x10^{+5}$[r]	
Octachlorodibenzo-p-dioxin	NA	NA	NA	$1.5x10^{+5}$[r]	$1.5x10^{+5}$[r]	
Octachlorodibenzofuran	NA	NA	NA	$1.5x10^{+5}$[r]	$1.5x10^{+5}$[r]	B2 (liver tumors in mice)

TABLE C.4-2
(Continued)

Chemical	Reference Dose: Oral Route of Exposure (mg/kg/day) [UF][a]	Reference Dose: Inhalation Route of Exposure (mg/kg/day) [UF][a]	Target Organ for Noncarcinogenic Effects (Oral / Inhalation)	Cancer Slope Factor: Oral Route of Exposure $(mg/kg/day)^{-1}$	Cancer Slope Factor: Inhalation Route of Exposure $(mg/kg/day)^{-1}$	U.S. EPA Weight of Evidence[b]
Inorganics						
Antimony	$4.0x10^{-4}$[o] [1000]	NA	Longevity, blood glucose, cholesterol / NA	NA	NA	D
Arsenic	$3.0x10^{-4}$[o] [3]	NA	Changes in the skin / NA	$1.75x10^{0}$	$1.5x10^{+1}$[o,d]	A (lung cancer, skin cancer)
Barium	$7.0x10^{-2}$[o] [3]	$1.4x10^{-4}$[f,g] [1000]	Increased blood pressure / fetotoxicity	NA	NA	D
Beryllium	$5.0x10^{-3}$[o] [100]	NA	No adverse effects observed / NA	$4.3x10^{0}$[o]	$8.4x10^{0}$[o,d]	B2 (lung cancer in rats, monkeys; tumors of the bone in rabbits)
Cadmium	$5.0x10^{-4}$(water)[o] [10] $1.0x10^{-3}$(food)[o] [10]	NA	Significant increase of protein in the urine / NA	NA	$6.3x10^{0}$[o,d]	B1 (respiratory system tumors in humans; inhalation/occupational)
Chromium, hexavalent	$5.0x10^{-3}$[o] [500]	NA	No adverse effects observed / NA	NA	$4.2x10^{+1}$[o,d]	A (lung tumors)
Chromium, trivalent	$1.0x10^{0}$[o] [100]	NA	No effects observed / NA	NA	NA	NA
Cobalt	$6.0x10^{-2}$[l]	$3.0x10^{-7}$[l]	NA	NA	NA	NA
Copper	$3.71x10^{-2}$[l]	NA	NA	NA	NA	D
Cyanide	$2.0x10^{-2}$[o] [100]	NA	Weight loss, thyroid effects / NA	NA	NA	D
Fluoride	$6.0x10^{-2}$[o] [10]	NA	Dental fluorosis	NA	NA	NA
Lead	NA	NA	NA	NA	NA	B2 (kidney tumors in mice, rats)
Manganese	$5.0x10^{-3}$(water)[o] [1] $1.4x10^{-1}$(food)[o] [1]	$1.4x10^{-5}$[o] [1000]	Central nervous system effects / Central nervous system effects	NA	NA	D
Mercury (inorganic)	$3.0x10^{-4}$[f] [1000]	$8.6x10^{-5}$[f,g] [30]	Kidney effects / neurotoxicity	NA	NA	D
Molybdenum	$5.0x10^{-3}$[o] [30]	NA	Increased uric acid levels / NA	NA	NA	D
Nickel	$2.0x10^{-2}$[o,m] [300]	NA	Decreased organ and body weights / NA	NA	$8.4x10^{-1}$[f]	A

TABLE C.4-2
(Continued)

Chemical	Reference Dose: Oral Route of Exposure (mg/kg/day) [UF][a]	Reference Dose: Inhalation Route of Exposure (mg/kg/day) [UF][a]	Target Organ for Noncarcinogenic Effects (Oral / Inhalation)	Cancer Slope Factor: Oral Route of Exposure $(mg/kg/day)^{-1}$	Cancer Slope Factor: Inhalation Route of Exposure $(mg/kg/day)^{-1}$	U.S. EPA Weight of Evidence[b]
Inorganics (Continued)						
Selenium	5.0×10^{-3}[o] [3]	NA	Clinical selenosis / NA	NA	NA	D
Silver	5.0×10^{-3}[o] [3]	NA	Benign permanent bluish discoloration of the skin / NA	NA	NA	D
Thallium	7.0×10^{-5}[o] [3000]	NA	Liver, blood, hair effects / NA	NA	NA	NA
Uranium	3.0×10^{-3}[o] [1000]	NA	Nephrotoxicity	NA	NA	NA
Vanadium	7.0×10^{-3}[f] [100]	NA	NA	NA	NA	D
Zinc	3.0×10^{-1}[o] [3]	NA	Decrease in erythrocyte superoxide dismutase / NA	NA	NA	D

[a][UF] Uncertainty Factor
[b]U.S. EPA Carcinogen Classification:
Group A: Human Carcinogen (sufficient evidence of carcinogenicity in humans).
Group B: Probable Human Carcinogen (B1-limited evidence of carcinogenicity in humans; B2-sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans).
Group C: Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data).
Group D: Not Classifiable as to Human Carcinogenicity (inadequate or no evidence).
Group E: Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies).
[c]Dose-response parameter obtained from the U.S. EPA Integrated Risk Information System (IRIS). March 1994.
[d]Dose-response parameter calculated from a unit risk value.
[e]U.S. EPA Environmental Criteria Assessment Office, Cincinnati, September 1993.
[f]Dose-response parameter obtained from the U.S. EPA Health Effects Assessment Summary Tables (HEAST), Annual FY 1994 NTIS No. PB92-921199. March 1994, Updated September, 1994. Other CDDs/CDFs evaluated using the Toxicity Equivalence Factor method.
[g]Dose-response parameter calculated from a reference concentration.
[h]U.S. EPA, Region III, Risk-Based Concentration Table, Fourth Quarter 1993.
[i]Cancer slope factor (CSF) derived by application of EPA's relative potency factor (RPF) to benzo(a)pyrene CSF(7.3/mg/kg-day). See Table A.4-5 for EPA's RPFs.
[j]U.S. EPA Environmental Criteria Assessment Office, Risk Assessment Issue Paper for: "Provisional RfD for Cobalt (7440-48-4)," dated December 1992.
[k]Cancer slope factor for PCBs in general based on slope factor for Arochlor 1260.
[l]Reference dose derived from action level of 1.3 mg/L, which represents the Maximum Contaminant Level Goal (MCLG).
[m]Oral reference dose is for nickel as soluble salts.
[n]Oral reference dose is for thallic oxide.
RBC Red blood cells
CNS Central nervous system
ChE Cholinesterase
NA Information not available.
[o]U.S. EPA Environmental Criteria Assessment Office, Cincinnati, Memorandum 10/5/92.
[p]U.S. EPA Environmental Criteria Assessment Office, Cincinnati, Momorandum 9/94
[q]OU4 RI/FS Report Department of Energy February 1994

TABLE C.4-3

SUMMARY OF CANCER SLOPE FACTORS AVAILABLE FOR FEMP RADIONUCLIDE CONTAMINANTS

Radionuclide[e,f]	SF_o[a] (Risk/pCi)	SF_i[a] (Risk/pCi)	SF_e[a,b] (Risk/yr per pCi/g Soil)	ICRP Lung Class[c]	GI Absorption Factor[d]
Cesium-137 + 1D	2.8E-11	1.9E-11	2.0E-06	D	1.0E+00
Neptunium-237 + 1D	2.2E-10	2.9E-08	4.3E-07	W	1.0E-03
Lead-210 + 2D	6.6E-10	4.0×10^{-9}	1.6×10^{-10}	D	2.0×10^{-1}
Plutonium-238	2.2E-10	3.9E-08	2.8E-11	Y	1.0E-03
Plutonium-239/240	2.3E-10	3.8E-08	2.7E-11	Y	1.0E-03
Radium-226 + 8D	7.8E-10	2.0E-09	6.0E-6	W	2.0E-01
Radium-228 + 1D	1.0E-10	6.9E-10	2.9E-06	W	2.0E-01
Radon-222 + 4D	1.7E-12	7.7E-12	5.9E-06	*	1.0E+00
Strontium-90 + 1D	3.6E-11	6.2E-11	0.0E+00	D	3.0E-01
Technetium-99	1.3E-12	8.3E-12	6.0E-13	W	8.0E-01
Thorium-228 + 7D	5.5E-11	7.8E-08	5.6E-06	Y	2.0E-04
Thorium-230	1.3E-11	2.9E-08	5.4E-11	Y	2.0E-04
Thorium-232 + 10D	1.2E-11	2.8E-08	2.6E-11	Y	2.0E-04
Uranium-234	1.6E-11	2.6E-08	3.0E-11	Y	5.0E-02
Uranium-235 + 1D [g]	1.6E-11	2.5E-08	2.4E-07	Y	5.0E-02
Uranium-238 + 2D	2.0E-11	2.4E-08	5.1E-08	Y	5.0E-02

[a]SF_o = Oral cancer slope factor; SF_i = Inhalation cancer slope factor; SF_e = External radiation cancer slope factor. SF_o, SF_i and SF_e acquired from U.S. EPA, Health Effects Assessment Summary Tables, March 1994, Updated September 1994 (FY 1993).
[b]SF_e incorporates a soil depth and density of 0.1 m and 1430 kg/m^3, respectively.
[c]Lung clearance classification recommended by the International Commission on Radiological Protection (ICRP): Y=Year, W=Week, D=Day, *=Gas.
[d]Gastrointestinal (GI) absorption factors are the fractional amounts of each radionuclide absorbed across the GI tract into the bloodstream. Lung clearance classifications and GI absorption factors are provided for reference only. DO NOT use these factors to adjust (i.e., multiply or divide) inhalation or ingestion slope factors.
[e]"+D" Indicates that the slope factors (SFs) presented incorporate SFs that are available for the individual primary decay chain products. U.S. EPA, Health Effects Assessment Summary Tables, March 1994
[f]Slope factors to be used to evaluate future exposure scenarios involving parent radionuclide in equilibrium with progeny products.
[g]Slope factors for U-235+1D will be used to evaluate exposures to U-235/236.

LIST OF REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR), 1990, Toxicological Profile for Manganese and Compounds, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1993, Toxicological Profile for Arsenic, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1991a, Toxicological Profile for Selected PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016), U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1991b, Toxicological Profile for Manganese, U.S. Public Health Service, Atlanta, GA.

Baes, C. F., III, R. D. Sharp, A. L. Sjoreen, and R. W. Shor, 1984, "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture,: ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, TN.

Browning, E., 1969, Toxicity of Industrial Metals, 2nd Edition, Butterworths, London.

Casarett, L.J., and J. Doull, 1991, Caserett and Doull's Toxicology: The Basic science of Poisons, M.O. Amblur, J. Doull, and C.D. Klassen eds., 4th Edition, Pergamon Press, New York, NY.

Friberg, L., G.F. Nordberg, and V.B. Vouk, 1986, Handbook on the Toxicity of Metals, 2nd Edition, Elsener, New York, NY.

National Research Council (NRC), Food and Nutrition Board, 1989, Recommended Dietary Allowances, 10th Ed. National Academy Press, Washington, D.C., pp. 230-235.

Saric, M., 1986, Manganese, Handbook on the Toxicology of Metals, L. Friberg, G.F. Nordberg, V.B. Vouk, eds. 2nd ed., Vol.2: Specific Metals, Elsevier Science Publishers B.V., New York, NY.

Schroeder, H.A., Balassa, J.J.and Tipton, I.H., 1966, Essential Trace Metals in Man: Manganese, a Study in Homeostatis, J. Chron. Dis. 19: 545-571.

Seiler, H.G., A. Sigel, and H. Sigel, 1988, Handbook on Toxicity of Inorganic Compounds, Marcel Dekker, Inc., New York, NY.

Shacklette, H. T. and J. G. Boerngen, 1984, Elemental Concentrations in Soils and other Surficial Materials of the Conterminous United States, U.S. Geological Survey Professional Paper 1270, U.S. Dept. of the Interior, Washington, DC.

Thomson, A.B.R., Olatunbasun, D., Valberg, S.L. and Lugwig, J., 1971, Interrelation of Intestinal Transport System for Manganese and Iron, Journal of Laboratory Clinical Medicine, 78: 642-655.

Tseng, W. P., 1977, "Effects and Dose-response Relationships of Skin Cancer and Blackfoot Disease with Arsenic," Environmental Health Perspectives, Vol. 19, pp. 109-119, (Cited in EPA 1992).

LIST OF REFERENCES
(Continued)

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1982, "Ionizing Radiation: Sources and Biological Effects," Report to the General Assembly, with Annexes, United Nations Scientific Committee on the Effects of Atomic Radiation, New York, NY.

U.S. Dept. of Agriculture, 1982, "Soil Survey of Hamilton County, Ohio," USDA, SCS, Washington, D.C.

U.S. Dept. of Energy, 1992, Risk Assessment Work Plan Addendum, prepared for Remedial Investigation and Feasibility Study, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Field Office, Cincinnati, OH.

U.S. Dept. of Energy, 1994a, Supplemental Guidance to the Risk Assessment Work Plan Addendum, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Field Office, Fernald, OH.

U.S. Dept. of Energy, 1994b, "Remedial Investigation Report for Operable Unit 5," Fernald Environmental Management Project, DOE, Fernald Area Office, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA), 1986, "Guidelines for Carcinogen Risk Assessment," Federal Register 51 (185), pp. 33992-34003.

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

U.S. Environmental Protection Agency (EPA), 1989b, "General Quantitative Risk Assessment Guidelines for Noncancer Health Effects," prepared by the Office of Health and Environmental Assessment for the Risk Assessment Forum, ECAO-CIN-538, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA), 1990, Exposure Factor Handbook, EPA/600/8-89/043.

U.S. Environmental Protection Agency (EPA), 1991a, "User's Guide for Lead: A PC Software Application for the Uptake/Biokinetic Model Version 0.50," prepared by Syracuse Research Corporation Under Contract No. 68-CO-0043 for the Environmental Criteria and Assessment Office, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA), 1991b, "Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals," Publication 9285.7-01B, EPA, Office of Emergency and Remedial Response.

U.S. Environmental Protection Agency (EPA), 1992, "Supplemental Guidance to RAGS: Calculating the Concentration Term," prepared by the Office of Solid Waste and Emergency Response, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1993a, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," Region III Technical Guidance Manual.

LIST OF REFERENCES
(Continued)

U.S. Environmental Protection Agency (EPA), 1993b, "Provisional Guidance for Qualitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," March 1993, ECAO-CIN-842.

U.S. Environmental Protection Agency (EPA), 1994a, Health Effects Assessment Summary Tables, Annual Update FY 1993," including Suppl. A, March 1993, prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1994b, "Integrated Risk Information System (IRIS)" computer database, EPA, Washington, DC.

U.S. Evironmental Protection Agency (EPA), Environmental Criteria and Assessment Office (ECAO), 1994c, Memorandum from Joan Dollaride to Pat Van Leeuwen, September 21, 1994, "Systemic and Carcinogenic Toxicity Information for Benzene, Carbon Tetrachloride, Chloroethane, 1,2-Dichloroethane, Kepone, perchloroethylene, and styrene," Cincinnati, OH.

World Health Organization (WHO), 1973, "Trace Elements in Human Nutrition: Manganese, Report of a WHO Expert Committee," Technical Report Service, 532, WHO, Geneva, Switzerland, pp. 34-36