5857 U-004-404.9

FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 2, DRAFT AUGUST 1994 - VOLUME 1 OF 6

08/23/1994

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ASIBILITY STUDY REPORT FOR OPERABLE UNIT 2

NALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

EDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 1 OF 6
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SECTIONS 1-3

AUGUST 1994

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

FEASIBILITY STUDY REPORT OPERABLE UNIT 2

Volume 1 of 6
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August 1994

DRAFT

U.S. DEPARTMENT OF ENERGY
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LIST OF ACRONYMS AND ABBREVIATIONS

ac	acre
ACA	Amended Consent Agreement
ADM	Action Description Memorandum
AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AIRFA	American Indian Religious Freedom Act
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ASL	Analytical Support Level
ASTM	American Society for Testing and Materials
AWWT	Advanced Wastewater Treatment
BDN	bio-denitrification
BOB	bottom of boring
CAA	Clean Air Act
CAMU	corrective action management unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
CIS	Characterization Investigation Study
CLP	Contract Laboratory Program (EPA)
cm/sec	centimeters per second
cu ft/sec	cubic feet per second
cu m	cubic meter
cu m/sec	cubic meter per second
cu yd	cubic yard
CMSA	consolidated metropolitan statistical area
COA	certificate of analysis
COE	U.S. Army Corps of Engineers
COC	contaminant of concern
CPC	constituent of potential concern

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

CRARE	Comprehensive Remedial Action Response Evaluation
CSM	conceptual site model
CT	central tendency
CWA	Clean Water Act
DCG	Derived Concentration Guide (DOE)
DCR	Document Change Request
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DQO	data quality objective
EA	environmental assessment
E&S	erosion and sedimentation
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDA	U.S. Energy Research and Development Administration
ERMC	environmental restoration management contractor
EWDF	exempted waste disposal facility
FEMA	Federal Emergency Management Agency
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Company
FFCA	Federal Facility Compliance Agreement
FID	flame ionization detector
FIDLER	Field Instrumentation for Detecting Low-Energy Radiation
FMPC	Feed Materials Production Center
FONSI	Finding of No Significant Impacts
FR	Federal Register
FS	feasibility study
ft	feet
ft/yr	feet per year
GC/MS	gas chromatograph/mass spectrometry
GIS	Geographic Information System
GMA	Great Miami Aquifer
GMR	Great Miami River

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

GRA	general response action
GPR	ground penetrating radar
ha	hectare
HASP	Health and Safety Plan
HELP	Hydrologic Evaluation of Landfill Performance
HI	hazard index
HQ	hazard quotient
HSL	Hazardous Substance List
HWMU	hazardous waste management unit (RCRA)
IBC	intermediate bulk container
ILCR	incremental lifetime cancer risk
IP	Implementation Plan
ISA	Initial Screening of Alternatives
ISC	Industrial Source Complex
ISCLT	Industrial Source Complex Long Term
ISO	International Shipping Organization
IT	IT Corporation
K_d	distribution coefficient
km	kilometer
lbs/hr	pounds per hour
LCDS	leachate collection/disposal system
LD/LC	leak detection/leachate collection
LLW	low-level radioactive waste
LLWDF	low-level radioactive waste disposal facility
m	meter
μg/g	micrograms per gram
μg/L	micrograms per liter
μg/kg	micrograms per kilogram
μm	micrometer
MAGLC	maximum acceptable ground-level concentrations
MCL	maximum contaminant level
MCLG	maximum contaminant level goal

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mi	mile
MIR	maximum individual risk
MSL	mean sea level
MUSLE	Modified Universal Soil Loss Equation
NAAQS	National Ambient Air Quality Standards
NAD	North American Datum
NAGPRA	Native American Graves Protection and Repatriation Act
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NLO	National Lead Company of Ohio
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
O&M	operations and maintenance
OAC	Ohio Administrative Code
ODAST	one-dimensional analytical salute transport
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
OHPO	Ohio Historic Preservation Office
OPRAH	Ohio Possible Range Animal Habitat
ORAU	Oak Ridge Associated Universities
ORC	Ohio Revised Code
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PEIS	programmatic environmental impact statement

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LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

PCB	polychlorinated biphenyls
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
pH	negative log of the hydrogen ion concentration
PIC	products of incomplete combustion
PID	photoionization detector
PM_{10}	particulate matter
PP	proposed plan
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PRG	preliminary remediation goal
PRL	preliminary remediation level
PRP	potentially responsible party
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RA	risk assessment
RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RfD	reference dose
RFI	RCRA Facility Investigation
RI	remedial investigation
RI/FS	Remedial Investigation/Feasibility Study
RM	river mile
RME	reasonable maximum exposure
RMI	Reactive Metals, Incorrporated
ROD	record of decision
RSE	Removal Site Evaluation
SAP	Sampling and Analysis Plan

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

SARA	Superfund Amendment and Reauthorization Act of 1986
SAR/CR	site-wide analysis request/custody record
SC/DM	Site Characterization/Data Management
SCQ	Site-Wide CERCLA Quality Assurance Project Plan
SDWA	Safe Drinking Water Act
SED	Site-wide Environmental Database
SHPO	State Historic Preservation Officer
SOWC	Southwest Ohio Water Company
SR	State Route
SVOC	semivolatile organic compound
SWCR	Site-Wide Characterization Report
SWDA	Solid Waste Disposal Act (State of Ohio)
SWDF	solid waste disposal facility
SWIFT III	Sandia Waste Isolation Flow and Transport (computer model)
SWMU	solid waste management unit (RCRA)
TAL	target analyte list
TBC	to be considered
TCA	trichloroethane
TCLP	toxicity characteristic leaching procedure
TLD	thermoluminescence dosimeter
TOC	total organic carbon
TSCA	Toxic Substances Control Act
TU	temporary unit
UCL	upper confidence limit
UMTRA	uranium mill tailings remedial action
USCS	Unified Soils Classification System
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VOA	volatile organic analysis
VOC	volatile organic compound
WEMCO	Westinghouse Environmental Management Company of Ohio
WMCO	Westinghouse Materials Company of Ohio

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Executive Summary

EXECUTIVE SUMMARY

This report documents the feasibility study (FS) phase of the Remedial Investigation/Feasibility Study (RI/FS) for Operable Unit 2 at the Fernald Environmental Management Project (FEMP). The FEMP, formerly known as the Feed Materials Production Center, is a 425-hectare (1,050-acre), U.S. Department of Energy (DOE) facility located approximately 29 kilometers (18 miles) northwest of Cincinnati, Ohio, near the small rural community of Fernald. The primary mission of the facility, which operated from 1952 to 1989, was to provide high-purity uranium metal products to support U.S. defense programs.

In 1986, the U.S. Environmental Protection Agency (EPA) and DOE entered into a Federal Facility Compliance Agreement (FFCA) covering environmental impacts associated with site activities. In response to the FFCA, a site-wide RI/FS program was initiated pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 1989, the facility was placed on the National Priorities List, known as the "Superfund List," by EPA. A Consent Agreement was signed by DOE and EPA in 1990 and was amended in 1991.

The Ohio Environmental Protection Agency is participating in the FEMP RI/FS process through direct involvement in review meetings, public meetings, and technical review of project documentation.

The RI/FS is part of the CERCLA process by which the nature and extent of contamination at a site is documented and appropriate remedial alternatives to protect human health and the environment are evaluated. The Operable Unit 2 Remedial Investigation Report provides a detailed understanding of the nature and extent of waste materials, the present and potential future impacts of these materials on the surrounding environment, and the present and future risks to human health if these wastes are not remediated. The Operable Unit 2 FS develops and compares a range of possible remedial alternatives to identify the most effective approach for meeting specific cleanup goals. A Proposed Plan is submitted in conjunction with the FS and identifies the preferred comprehensive alternative for remediation of Operable Unit 2. The Proposed Plan summarizes the alternatives considered, identifies the preferred alternative, and summarizes the information relied upon in the selection of the preferred alternative.

Public participation in the RI/FS process is encouraged. A summary of the Proposed Plan is prepared to facilitate public review. A public comment meeting will be held to obtain public comments, and a responsiveness summary of public comments will be prepared. Selection of the preferred remedial alternative will be documented in a Record of Decision. The Record of Decision will be issued by the EPA after consideration of comments received from the public and other interested parties.

NEPA Integration

Consistent with DOE policy, the FEMP is integrating the requirements of the National Environmental Policy Act (NEPA) into the RI/FS process whenever practicable. However, DOE's CERCLA/NEPA integration policy is not intended to represent a statement on the legal applicability of NEPA to remedial actions under CERCLA.

On May 15, 1990, a Notice of Intent was published in the Federal Register. The Notice of Intent outlined the NEPA/CERCLA integration approach to evaluate the environmental impacts associated with planned cleanup activities at the site. As identified in the Notice of Intent, the FS for the lead FEMP operable unit, Operable Unit 4, was issued as a Feasibility Study/Proposed Plan - Draft Environmental Impact Statement and was written to incorporate NEPA values at the level of an environmental impact statement. Furthermore, the RI/FS documents for the remaining operable units will be written to include NEPA values. An Action Description Memorandum documenting the decision to prepare environmental assessments for Operable Units 1, 2, and 5 was prepared (Hamrick 1994).

In addition, the Operable Unit 2 Feasibility Study/Proposed Plan - Environmental Assessment has been written to include a cumulative impact analysis to evaluate the environmental consequences of implementing the Operable Unit 2 representative alternative with the leading remedial alternatives for Operable Units 3 and 5 and the preferred alternatives for Operable Units 1 and 4 (Appendix G of the FS). The term "representative alternative" is employed in the NEPA discussions to indicate an alternative that is acceptable for evaluation with regard to NEPA but was not designated as the preferred alternative at the time Appendices G and H were developed. The preferred alternative is first identifed in the Proposed Plan, based on the FS. Leading remedial alternatives (a term from the Site-Wide Characterization Report (DOE 1993c) are utilized for analysis of those Operable Units for which an FS has not yet been developed. This discussion of the NEPA cumulative impacts will be

updated, as appropriate, for each of the remaining operable units, as the FEMP progresses through the RI/FS process.

Comprehensive Response Action Risk Evaluation

The Comprehensive Response Action Risk Evaluation (CRARE) provides an analysis of total cumulative residual human health risk projected to remain after the proposed remediation of the FEMP is complete. A CRARE was submitted in conjunction with the Operable Unit 4 FS and addressed the preferred alternative for remediation of Operable Unit 4 in conjunction with the leading remedial alternatives identified in the Site-Wide Characterization Report (DOE 1993c) for Operable Units 1, 2, 3, and 5. An updated CRARE is provided in Appendix I of the Operable Unit 2 FS and evaluates the preferred alternatives for Operable Units 1, 2, and 4, together with the leading remedial alternatives for Operable Units 3 and 5.

DESCRIPTION OF OPERABLE UNIT 2

The work plan for the site-wide RI/FS (DOE 1992b) identified 27 specific areas, or units, within the FEMP for investigation. Subsequent evaluations increased the number of units to 39. It soon became apparent that, for purposes of effective management, the 39 units should be categorized and grouped. The resultant grouping formed the five operable units of the FEMP:

- Operable Unit 1 - Waste Pit Area
- Operable Unit 2 - Other Waste Areas
- Operable Unit 3 - Former Production Area
- Operable Unit 4 - Silos 1 through 4
- Operable Unit 5 - Environmental Media

Operable Unit 2 consists of the subunits described below and comprises the wastes, berms, liners, and soil within their boundaries:

- The Solid Waste Landfill was reportedly used for the disposal of cafeteria waste, rubbish, and other types of waste from the nonprocess areas and from on-site construction/demolition activities.

- The North and South Lime Sludge Ponds contain waste from the FEMP water treatment plant operations, coal pile storm water runoff, and boiler plant blowdown. The South Lime Sludge Pond is inactive and overgrown with grasses and shrubs, while the North Lime Sludge Pond is currently in use.

- The Inactive Flyash Pile was used for the disposal of ash from the boiler plant, other nonprocess wastes, and construction rubble such as concrete, gravel, asphalt, masonry, and steel rebar.

- The South Field was reportedly used as a burial site for FEMP nonprocess wastes such as flyash, on-site construction/demolition rubble, and soils that may have contained low levels of radioactivity. A slope at the southwest border of the South Field was used as the backstop for the FEMP security firing range for 35 years. Lead bullets used during target practice were embedded in this slope.

- The Active Flyash Pile was the disposal area for flyash and bottom ash from the FEMP boiler plant.

These five subunits cover a total of approximately 8.6 hectares (21.5 acres) and contain an estimated 83,000 cubic meters (109,000 cubic yards) of ash, 12,000 cubic meters (16,000 cubic yards) of sludge, and 147,000 cubic meters (193,000 cubic yards) of soil and debris in the form of berms, cover, and fill material.

BASELINE RISK ASSESSMENT

A baseline risk assessment was conducted as part of the Operable Unit 2 RI. Risk was evaluated in the context of four land-use scenarios:

- Current land use with DOE ownership and control of public access
- Current land use without DOE access control
- Future land use assuming federal ownership
- Future land use assuming private ownership

For all scenarios, it was assumed that no additional cleanup of Operable Unit 2 would occur beyond that which has already taken place.

For the private ownership land-use scenario, the incremental lifetime cancer risk (ILCR) for the on-property resident farmer (adult and child) due to exposure to all media and all pathways ranges from 10^{-2} (1 in 100) for the South Field to 10^{-5} (1 in 100,000) at the Lime Sludge Ponds. This is higher than the target range of 10^{-4} (1 in 10,000) to 10^{-6} (1 in 1,000,000) considered acceptable by EPA. In addition, at the South Field and the flyash piles, the hazard index (HI) for exposure to noncarcinogenic materials is higher than both the 0.2 target value and the 1.0 level considered to provide adequate protection.

The exposure pathways which pose the most significant risk are external radiation from radionuclides in surface soils and ingestion and use of uranium contaminated groundwater. Consumption of produce and livestock products contaminated directly or indirectly by exposure to groundwater or soil contaminated with radionuclides and benzo-a-pyrene is also a significant pathway.

ILCRs to expanded trespasser and off-property farmer receptors under the federal ownership land-use scenario are one to two orders of magnitude above the target risk of 10^{-6}. The off-site farmer and child receptors have HIs above the target hazard level of 0.2 for consumption of groundwater and produce irrigated by groundwater contaminated by uranium. The HIs for the expanded trespasser were all below the target hazard levels.

FEASIBILITY PROCESS AND CONCLUSIONS

The alternatives for remediation in this FS were developed in accordance with EPA guidance by following a series of logical steps that involved developing, in succession, more specific definitions of potential remedial alternatives. The steps include the following:

- Development of contaminant- and media-specific remedial action objectives, preliminary remediation goals (PRGs), and preliminary remediation levels (PRLs)
- Identification of volumes and/or areas of waste media to be addressed
- Identification of general response actions
- Identification and screening of remedial technologies and process options
- Evaluation and screening of process options within each technology
- Assembly of a wide range of remedial alternatives using the selected process options within each remedial technology

Preliminary Remediation Levels (PRLs)

The cleanup levels, called PRLs, for contaminated media/soil are established in Section 2.0 of the FS using the following process:

- Risk-based soil and groundwater preliminary remediation goals (PRGs) were established for each COC. Risk-based PRGs are chemical-specific, medium specific concentration levels necessary to address the contaminants and all direct pathways found to be of concern during the baseline risk assessment for the on-property farmer. While groundwater is outside of the scope of remedial actions considered under this FS, the groundwater risk-based PRGs were determined because groundwater serves as a cross-media pathway for the uptake of COCs from contaminated material located in Operable Unit 2.

- Modified soil PRGs were developed from risk-based PRGs based on various combinations of institutional controls, cross-media impacts, and source controls. Source controls consist of barriers to potential horizontal flow of perched groundwater and infiltration controls.

- Soil PRLs for Operable Unit 2 subunit areas were determined for four scenarios: (1) private ownership, (2) federal ownership, (3) federal ownership with lateral perched water control at the South Field and Inactive Flyash Pile, and (4) federal ownership with vertical infiltration control at all subunits and lateral perched water control at the South Field and Inactive Flyash Pile. The PRLs are the lowest value from any of the pertinent risk-based and cross-media PRGs, with the exception of the radionuclide COCs for which the PRLs are the PRGs plus background.

Source controls increased the allowable PRLs and, thereby, increased the number of remedial alternatives that could be considered.

Remedial Action Objectives

Remedial action objectives (RAOs) for Operable Unit 2 were based on site-specific COCs and exposure pathways. The goals for protecting human health and the environment depend on the contaminated media and the exposure pathways. The exposure pathways are dependent on the future land use designated for the FEMP site. The two land-use scenarios considered for the Operable Unit 2 subunits are federal ownership with restricted access and the private ownership with no use limitations. The RAOs for Operable Unit 2 actions are presented in Table ES-1.

Development of Remedial Alternatives

A wide range of potential remedial technologies and process options have been identified for Operable Unit 2. These technologies and process options have been screened for effectiveness, implementability and cost. Those which passed this screening process include mechanical excavation, subsurface drains to control potential horizontal flow in the perched groundwater zone, stabilization/solidification, drying, vitrification, soil washing, capping, and on- and off-site disposal. Ancillary technologies/processes include institutional actions, such as physical barriers, security guards, and deed restrictions; sorting/separation; crushing/shredding; and truck/rail transportation.

These technologies/process options were then combined to form preliminary remedial alternatives which are representative of potential combinations. The following eight remedial alternatives were initially developed:

TABLE ES-1

OPERABLE UNIT 2
SPECIFIC REMEDIAL ACTION OBJECTIVES

Land Use	Reduction of Contaminant Source	Access Restrictions to Contaminant Source or Impacted Media	Reduce or Eliminate Transport of Contaminants	Elimination of Receptors Exposure to Contaminant Source
Private Ownership	To meet PRLs for Private Ownership (Table 2-22)	None	None	None
Continued Federal Ownership (No Source Controls)	To meet PRLs for Federal Ownership (Table 2-23)	Restrict use and access of Operable Unit 2 Subunits	None	None
Continued Federal Ownership Lateral Perched Water Control	To meet PRLs for Federal Ownership with Lateral Perched Water Control in South Field area (Table 2-24)	Restrict use and access of Operable Unit 2 Subunits	Eliminate lateral movement of perched water at the Inactive Flyash Pile and South Field	None
Continued Federal Ownership Lateral Perched Water Control and Vertical Infiltration Control (Capping System)	To meet PRLs for Federal Ownership with Infiltration Control at all subunits and Perched Water Control in the South Field area (Table 2-25)	Restrict use and access of Operable Unit 2 Subunits	(1) Eliminate lateral movement of perched water at Inactive Flyash Pile and South Field (2) Reduce infiltration of water through the contaminant source (3) Eliminate surface water and air transport of contaminants.	Eliminate receptors' direct contact with the waste

- Alternative 1 -- No Action

  Under this alternative, no further action would be taken. The no action Alternative provides a baseline for comparison in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

- Alternative 2 -- Consolidation and Capping

  Under this alternative, waste and contaminated soil would be consolidated and capped.

- Alternative 3 -- Excavation and Off-Site Disposal

  Under this alternative, all contaminated material with COC concentrations exceeding PRLs would be removed and disposed off site. For purposes of cost evluation, Envirocare was selected as the representative, off-site disposal facility.

- Alternative 4 -- Excavation and Off-Site Disposal with Treatment of Fraction Exceeding Waste Acceptance Criteria

  This alternative is essentially the same as Alternative 3, except that any material exceeding waste acceptance criteria at the off-site disposal facility would be treated to achieve those criteria prior to shipment.

- Alternative 5 -- Excavation and On-Site Disposal

  Under this alternative, all contaminated material with COC concentrations exceeding PRLs would be removed and disposed in an on-site engineered disposal cell.

- Alternative 6 -- Excavation and On-Site Disposal with Off-Site Disposal of Fraction Exceeding Waste Acceptance Criteria

  This alternative is essentially the same as Alternative 5, except that material exceeding the waste acceptance criteria for on-site disposal would be disposed off site.

- Alternative 7 -- Excavation and On-Site Disposal with Off-Site Disposal of Fraction Exceeding Waste Acceptance Criteria

  This alternative is essentially the same as Alternative 5, except that material exceeding the waste acceptance criteria for on-site disposal would be treated to achieve these criteria prior to disposal.

- Alternative 8 -- Excavation and Treatment with On-site Disposal

  Under this alternative, all contaminated material with COC concentrations exceeding PRLs would be removed, treated, and placed in an on-site engineered disposal cell.

These preliminary remedial alternatives were then screened for effectiveness, implementability and cost. On the basis of this screening process, Alternatives 1, 2, 3, and 6 were selected as the most appropriate for detailed analysis. Alternative 4 was screened out in favor of Alternative 3 because Operable Unit 2 contaminated material is not expected to exceed the waste acceptance criteria for the off-site disposal facility. Alternative 5 was screened out in favor of Alternative 6 because it is anticipated that some contaminated material will exceed the waste acceptance criteria for on-site disposal. Alternative 7 was screened out in favor of Alternative 6 because it offers no significant advantage because of the small amount of material expected to exceed the waste acceptance criteria for on-site disposal. Alternative 8 was screened out in favor of Alternative 6 because the additional cost is not justified.

Detailed and Comparative Analysis

The objectives of the detailed/comparative analysis are to:

- Further define the reasonable alternatives that have been carried forward from the alterative screening phase of the CERCLA process

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- Individually assess each alternative against the evaluation criteria specified in the NCP and EPA guidance (EPA 1988a)
- Compare alternatives with each other to assess the relative performance of each alternative with respect to each evaluation criterion

Nine evaluation criteria have been developed to address the CERCLA requirements as stated in the NCP (40 CFR 300.430). They are:

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with ARARs

An alternative must satisfy the threshold criteria to be selected as a remedial action.

Balancing Criteria

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

Modifying Criteria

- State acceptance
- Community acceptance

The final two modifying criteria will be evaluated following public and agency comments on the Proposed Plan and will be addressed in the Record of Decision once a final remedial action decision is made.

Results of Detailed and Comparative Analysis

Alternative 1, No Action, was carried forward into the detailed analysis as a baseline for comparison as required by the NCP. Except for Alternative 1, all other remedial alternatives (referred to as the "action" alternatives) would satisfy the threshold criteria.

Each action alternative would reduce exposures and risks to humans and the environment by either containing the contaminated material at/near the subunit, or by removing contaminated material/soil above the pertinent PRLs and placing that material in an on-site disposal or off-site disposal facility. Federal ownership with access controls would be required of any area that contains wastes and/or

does not meet PRLs for the private ownership scenario. Therefore, each of the alternatives would provide protectiveness of human health and the environment under the Federal ownership land-use scenario.

Alternative 2 would provide protectiveness by capping the contaminated material in three consolidation areas and installing a subsurface drainage system in the South Field area to eliminate a potential lateral pathway in the glacial till. The capping system would be designed to isolate the contaminated material, preclude human and ecological intrusion, and limit potential impacts to the groundwater to an acceptable level. However, there would be no liner nor a leak-detection system to monitor performance.

Alternative 3 would provide protectiveness by disposing of the contaminated material in engineered facilities in the arid west where, due to harsh climatic conditions, there is little resident population or usable groundwater/surface water resources in the immediate vicinity.

Alternative 6 would provide protectiveness by disposing of the contaminated material in an on-site facility designed to isolate the contaminated material, preclude human and ecological intrusion, and limit potential impact to the groundwater to an acceptable level. The FS proposes a feasible location, design, and waste acceptance criteria for an on-site disposal facility. The geology of the on-site disposal facility location, based on a series of soil borings in the area, would be protective of human health and the environment. However, the location, design, and waste acceptance criteria for the disposal facility would be subject to review during the Remedial Design phase. DOE would construct only one disposal facility at the FEMP. Therefore, should on-site disposal be selected for other FEMP operable units, the disposal facility capacity and footprint would be adjusted accordingly during remedial design.

With the exception of Alternative 6, all of the action alternatives would meet identified ARARs and non-ARAR requirements. For protection of human health and the environment, OEPA regulations prohibit the construction of solid waste landfills over sole-source aquifers, such as the Great Miami Aquifer. Therefore, a waiver from this regulation, based on the equivalent standard of performance, would be required to implement Alternative 6. The equivalent standard of performance, protection of human health and the environment, would be achieved by the design of the on-site disposal facility as demonstrated by the risk assessment contained in this FS Report.

The comparison of the balancing criteria shows that the action alternatives have differences, but not major differences:

- All of the action alternatives would provide an effective long-term solution to the current or potential risk from Operable Unit 2 subunits.

- All of the action alternatives would include treatment of construction water at the on-site advanced wastewater treatment facility. These alternatives would also include treatment of a small volume of lead-contaminated mixed waste from the firing range portion of the South Field and disposal at the designated off-site facility. In addition, crushing/shredding, dewatering/drying, and in situ stabilization/solidification of contaminated material would be included in each alternative, as required. However, these treatments would affect only a very small volume of and would not result in significant reductions of toxicity, mobility, or volume.

- Short-term risks to remediation workers and off-site receptors would differ slightly among the action alternatives, primarily because of the amount of material excavated and transported off site.

- All of the action alternatives would employ proven technology and conventional equipment and therefore would be equal on a technical feasibility basis. There are no administrative feasibility issues associated with Alternative 2. Alternative 3 would require public acceptance of the transport of contaminated material across several states to the off-site facility; this process is expected to be very difficult. Alternative 6 would require an EPA waiver from the Ohio Environmental Protection Agency disposal-facility siting requirements, which is expected to be moderately difficult to obtain.

- The cost estimates developed in the feasibility study process are order-of-magnitude estimates with an intended accuracy range of -30 to +50 percent. For the action alternatives, Alternative 2 would be the least costly ($69.5 million) on a present worth basis, followed by Alternative 6 ($110.3 million) and Alternative 3 ($212.8 million).

In terms of the trheshold and balancing criteria, the alternatives can be summarized as follows:

- Consolidation and capping is the lowest-cost alternative, but does not offer an engineered liner with leachate collection and leak detection to ensure cap integrity. However, monitoring of the groundwater wells at the edge of the subunit would ensure the protection of the groundwater for off-property users.

- Excavation and disposal at an off-site facility would remove the source of contamination from the site. Thus, this alternative is considered to be the most protective. However, this alternative would cost almost twice as much as the next lowest cost alternative. Additionally, the public would be concerned about off-site transportation and disposal of wastes.

- Excavation and on-site disposal with off-site disposal of the fraction exceeding the WAC offers an increase in effectiveness from the other on-site option, consolidation and capping. This is based on an engineered liner that provides leachate collection and leak detection. By combining all the waste into one disposal location, this alternative also allows increased

flexibility in land use options, a reduced buffer area, and centralized operation and maintenance.

The screening of alternatives in Section 4.0, detailed analysis of alternatives in Section 5.0, and the comparative analysis in Section 6.0 are based on the future land-use scenario assuming continued federal ownership and access controls with a PRL risk level of 1×10^{-6}. However, differences that would result from a private ownership land-use scenario should be of interest to stakeholders and have been noted throughout Sections 4.0, 5.0, and 6.0. All of these differences are primarily associated with two factors: level of protectiveness and volume of material with COC concentrations above the PRLs. This latter factor, which is due to risk-based cleanup criteria associated with the land-use scenarios, primarily impacts cost.

Alternative 2, Consolidation and Capping, would not be protective of the on-property resident farmer under the private ownership land-use scenario. Alternatives 3 and 6 would be protective if contaminated material with COC concentrations above the PRLs for the on-property resident farmer is removed from the subunits.

Table ES-2 summarizes the present-worth cost of the various alternatives for the federal and private ownership land-use scenarios and varying PRL risk levels. As indicated, the cost differences between alternatives do not vary significantly when the risk level changes. However, the cost difference between Alternatives 3 and 6 widens when private ownership is considered.

The factors associated with varying land-use scenarios and PRL risk levels do not significantly alter the comparative analysis of alternatives. This comparative analysis indicates that all "action" alternatives are relatively indifferent to target risk, and that Alternative 6 is relatively indifferent to land use. These factors demonstrate the flexibility of the Operable Unit 2 alternatives; however, the cost of remediation of the FEMP site as a whole may be very sensitive to land use and target risks.

TABLE ES-2

COMPARISON OF NET PRESENT WORTH COSTS ALTERNATIVE LAND-USE SCENARIOS AND PRL RISK VALUES

Operable Unit 2 Alternative	Net Present Worth Cost ($millions)			
	Federal Ownership		Private Ownership	
	Target ILCR = 10^{-5}	Target ILCR = 10^{-6}	Target ILCR = 10^{-5}	Target ILCR = 10^{-6}
1 - No Action	0	0	0	0
2 - Consolidation and Capping	61.2	69.6	NA	NA
3 - Excavation and Off-Site Disposal	175.6	212.8	321.8	464.9
6 - Excavation and On-Site Disposal with Off-Site Disposal of Fraction Exceeding Waste Acceptance Criteria	92.9	110.3	105.5	148.3

Indicates land-use scenario and PRL risk value used for comparative analysis.

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1.0

1.0 INTRODUCTION

This report has been prepared to present the findings of the Feasibility Study (FS) for Operable Unit 2 at the Fernald Environmental Management Project (FEMP). The FEMP is a 425 hectare (ha) [1,050 acre (ac)], U.S. Department of Energy (DOE)-owned, contractor-operated facility located in southwestern Ohio, about 27 kilometers (km) [17 miles (mi)] northwest of downtown Cincinnati, Ohio. The facility is located north of Fernald, Ohio, a small farming community, and lies on the boundary between Hamilton and Butler counties (Figure 1-1). Of the total site area, 344 ha (850 ac) are in Crosby Township of Hamilton County, and 81 ha (200 ac) are in Ross and Morgan townships of Butler County. Formerly known as the Feed Materials Production Center (FMPC), the facility functioned primarily for the production of metallic uranium fuel elements, target cores, and other uranium products for use in weapons, production reactors, and other programs operated by the DOE. At times, thorium was processed and stored at the facility. As a result of these processes, the facility generated radioactive and non-radioactive wastes.

Production operations were halted in 1989 to focus available resources on environmental restoration initiatives at the facility. One of these initiatives, the Remedial Investigation/Feasibility Study (RI/FS), is being conducted pursuant to the terms of the 1991 Amended Consent Agreement with the U.S. Environmental Protection Agency (EPA) to identify the cleanup actions to be undertaken at the FEMP to address human health and environmental concerns. These concerns include the potential impacts on human health and the environment from past releases of hazardous materials from the FEMP to air, water, and surrounding soils; continuing releases of hazardous materials from the facility; and the on-site accumulation of a large inventory of uranium process materials and low-level radioactive and hazardous wastes at the site.

Based on these concerns and on an evaluation of existing environmental sampling data, the FEMP was placed on the National Priorities List (NPL), in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) in November 1989. Inclusion on the NPL reflects the relative importance that the federal government places on ensuring expeditious completion of cleanup actions at the FEMP site.

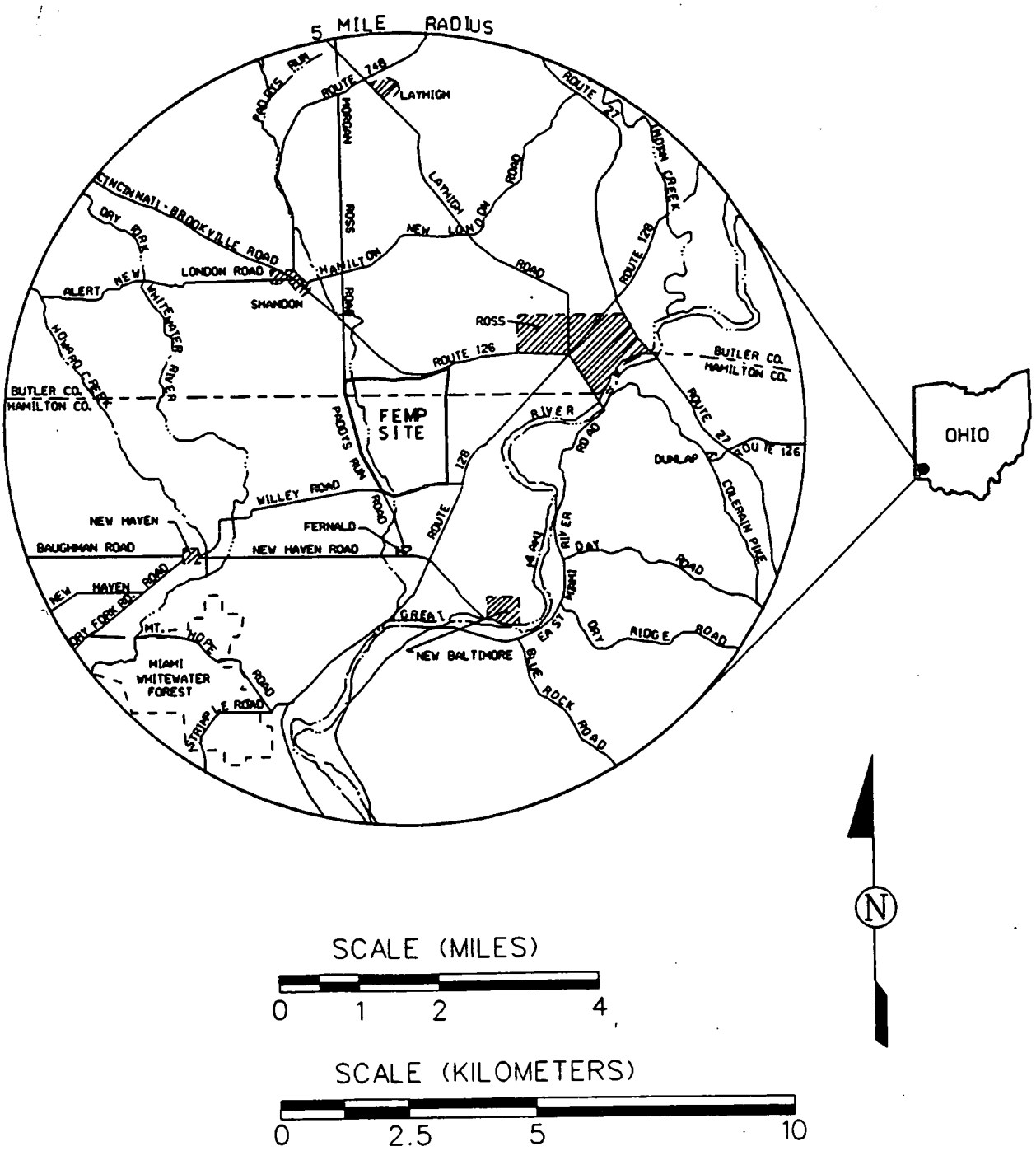

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FIGURE 1-1
FEMP FACILITY LOCATION MAP

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The Fernald site is defined as all areas within the property boundary of the FEMP and any other areas that received released hazardous substances, pollutants, contaminants, or hazardous constituents from the FMPC or are within the scope of FEMP projects.

To promote a more structured and expeditious cleanup of the FEMP site, the facility and environmental issues associated with the site are being managed as five operable units (Figure 1-2). Operable units are used to divide the cleanup of the site and may be geographical-specific site programs, initial phases of an action, or concurrent actions at different locations on the site. Separate RI/FS documentation is being issued for the operable units at the FEMP, which are defined as:

- Operable Unit 1: Waste Pit Area. Waste Pits 1 through 6, Clearwell, Burn Pit, berms, liners, and soil within the operable unit boundary, as approved in the RI/FS Work Plan Addendum.

- Operable Unit 2: Other Waste Units. Flyash Piles, other South Field disposal areas, Lime Sludge Ponds, Solid Waste Landfill, berms, liners, and soil within the operable unit boundary, as approved in the RI/FS Work Plan Addendum.

- Operable Unit 3: Former Production Area. 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 coal pile.

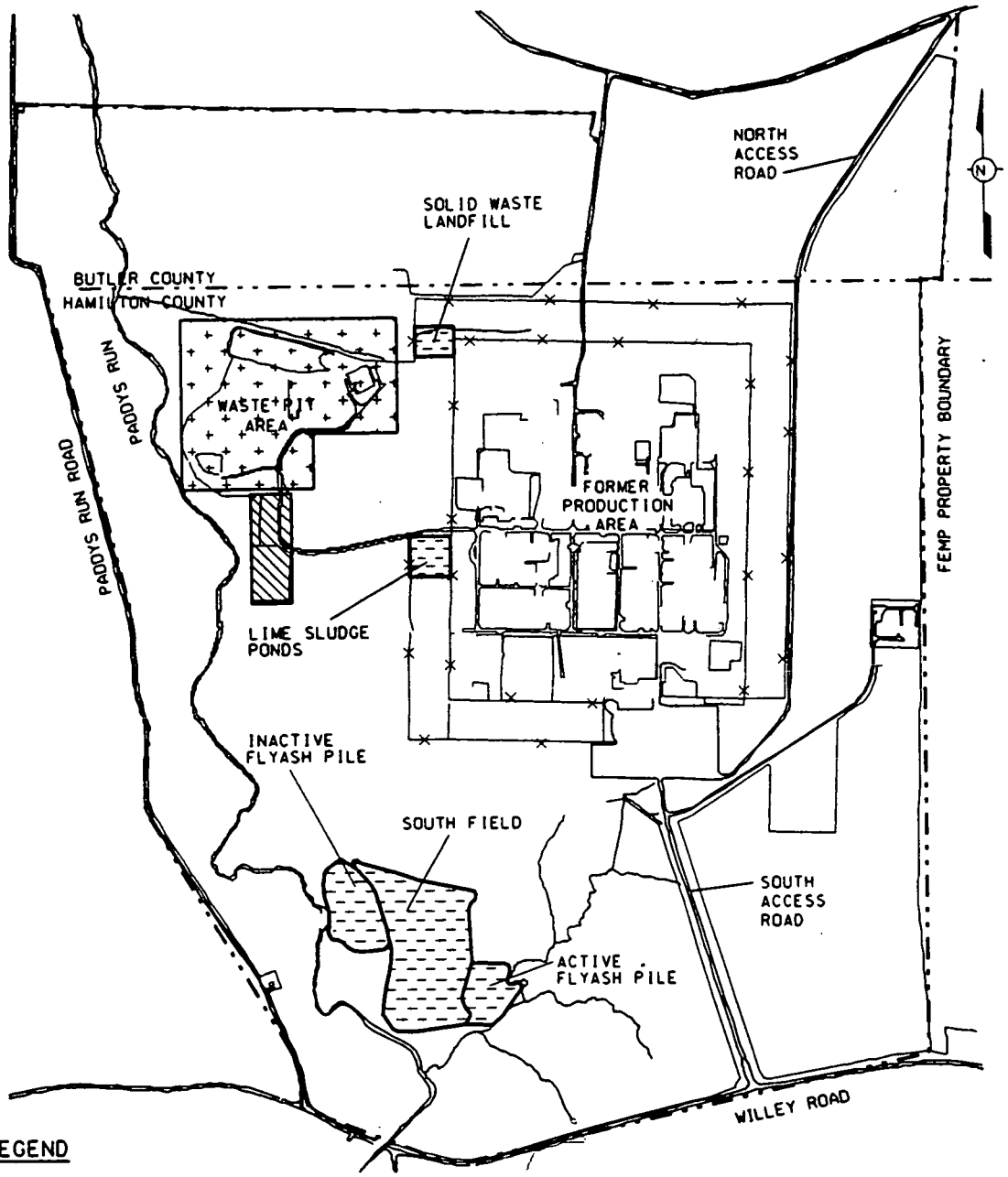
- Operable Unit 4: Silos 1 through 4. Silos 1, 2, 3, and 4, berms, decant sump tank system, and soil within the operable unit boundary, as approved in the RI/FS Work Plan Addendum.

- Operable Unit 5: Environmental Media. Groundwater, surface water, soil not included in the definitions of Operable Units 1 through 4, sediment, flora, and fauna.

- Operable Unit 6: Comprehensive Site-Wide Operable Unit. The Comprehensive Site-Wide Operable Unit was added as a provision of the 1991 Amended Consent Agreement. This is not a specific site area; rather, the purpose is to evaluate the remedies selected for Operable Units 1 through 5 to ensure that they protect of human health and the environment.

Operable Unit 2 consists of five waste subunits with relatively large volumes of conventional industrial wastes that were assumed to have small amounts of radionuclides. These subunits, listed below, are in different locations on the site, as shown on Figure 1-2.

- Solid Waste Landfill
- Lime Sludge Ponds
- Inactive Flyash Pile



LEGEND

- OPERABLE UNIT 1
- OPERABLE UNIT 2
- OPERABLE UNIT 4

SCALE

0 1200 2400 FEET

0 288 576 METER

NOTE

OPERABLE UNIT 3 INCLUDES ALL BUILDINGS, PIPELINES, AND ABOVEGROUND STRUCTURES IN THE FORMER PRODUCTION AREA. OPERABLE UNIT 5 INCLUDES GROUNDWATER, SURFACE WATER, SOILS, SEDIMENTS, FLORA AND FAUNA IN THE REGIONAL AREA AS WELL AS THE FORMER PRODUCTION AREA.

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FIGURE 1-2
RI/FS OPERABLE UNITS

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- South Field
- Active Flyash Pile

1.1 PURPOSE AND OBJECTIVES OF FEASIBILITY STUDY

1.1.1 Purpose of Feasibility Study

This FS has been prepared following the basic methodology outlined in CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA) (hereinafter jointly referred to as CERCLA), in particular Section 121, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 Code of Federal Regulations (CFR) Part 300], and the requirements outlined in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a). The NCP states in part that:

- The primary objective of the FS is to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the remedial action options can be presented to a decision-maker and an appropriate remedy selected [40 CFR §300.430(e)(1)].

- Alternatives shall be developed that protect human health and the environment by recycling waste or by eliminating, reducing, and/or controlling risks posed through each pathway by a site [40 CFR §300.430(e)(2)].

This FS develops and evaluates a range of remedial alternatives that will protect human health and the environment from risks associated with Operable Unit 2 subunits. Additionally, the FS provides sufficient information on the alternatives developed to allow evaluation of residual risks for the entire site.

The Comprehensive Response Action Risk Evaluation (CRARE) provides an analysis of total cumulative residual human health risk projected to remain after the proposed remediation of the FEMP site is complete. A CRARE was submitted in conjunction with the Operable Unit 4 FS and addressed the preferred comprehensive alternative for remediation of Operable Unit 4. The leading remedial alternatives identified in the Site-Wide Characterization Report (SWCR) (DOE 1993c) were used as a basis for analysis for Operable Units 1, 2, 3, and 5. An updated CRARE is provided in Appendix I of the Operable Unit 2 FS and evaluates the preferred comprehensive alternatives for Operable Units 1, 2, and 4. The leading remedial alternatives for Operable Units 3 and 5 continue to be used.

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An additional purpose of the FS is to provide National Environmental Policy Act (NEPA) analyses of environmental impacts of the remedial alternatives. This approach is in accordance with DOE's intent to integrate the requirements of NEPA into the CERCLA process in accordance with DOE Order 5400.4. It is not the intent of the DOE to make a statement of the legal applicability of NEPA to CERCLA actions. The specific NEPA/CERCLA integration approach for the FEMP was published in the Notice of Intent [55 Federal Register (FR) 20183, May 15, 1990], which concluded that:

- An Environmental Impact Statement (EIS) is the appropriate level of NEPA documentation for the lead operable unit (Operable Unit 4).
- NEPA/CERCLA integration will also be provided in the remaining operable unit NEPA/CERCLA documents. These documents will be "tiered to" (or reference) the lead RI/FS-EIS and will present impacts specific to the operable units. In addition, each RI/FS-NEPA evaluation will provide an appendix with updated cumulative impacts, as necessary.

The NEPA/CERCLA integration strategy, as outlined in the Implementation Plan (IP) for the NEPA/CERCLA integration activities at the FEMP site, was conditionally approved by the Office of the Assistant Secretary for Environment and Health, DOE (EH-1), on January 19, 1993. The purpose of the IP is to record the results of the scoping process and to provide guidance for the preparation of the lead FS/Proposed Plan (PP)-EIS for Operable Unit 4 and NEPA/CERCLA documents for the remaining operable units. An Action Description Memorandum (ADM) documenting the decision to prepare environmental assessments (EAs) for Operable Units 1, 2, and 5 was issued (Hamric 1994).

Section 1.5 of this FS summarizes information on the affected environment at Operable Unit 2.

1.1.2 Objectives of Feasibility Study

The FS/PP-EA for Operable Unit 2 contains characterization data for each subunit and nearby environmental media, and describes the affected environment for NEPA purposes. The NEPA evaluation will be contained within the detailed analysis of remedial alternatives for each subunit. The evaluation of environmental impacts in this report includes a discussion of the impacts to soil, air, water, biotic resources, wetlands, floodplains, cultural resources, socioeconomics, and land use; and a qualitative evaluation of ecological risks associated with Operable Unit 2 residual contaminants. The NEPA impact analysis of each alternative is integrated into Section 5.0 (Detailed Analysis of Alternatives) of this report and will likewise occur in the FS documents for the remaining operable units.

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Consistent with NEPA guidelines, the Operable Unit 2 FS includes evaluation of the cumulative environmental impacts of implementing the Operable Unit 2 representative alternative with the preferred alternatives for each of the other FEMP operable units (see Appendix G). To show progression from the term utilized in the SWCR, the term "representative alternative" is employed in the FS.

The discussion of the NEPA impact analysis related to potential remedial actions for the five operable units was presented in the Operable Unit 4 FS/PP-Draft EIS and will be updated in each operable unit-specific FS/PP-NEPA evaluation document, as appropriate, in sequence as each operable unit progresses through the RI/FS process.

In accordance with both CERCLA and NEPA processes, these documents will be made available to the public for comment. Public involvement is an important factor in the decision-making process for site remediation and public comments will be considered in remedy selection for each operable unit. Applying the integrated approach for CERCLA and NEPA, DOE plans to prepare and issue a draft Record of Decision (ROD) to be approved by the EPA for the Operable Unit 2 FS/PP-EA. At the completion of the EA process for Operable Unit 2, a determination will be made as to whether an EIS is necessary or whether the proposed action would have no significant impacts. The latter would result in the issuance of a Finding of No Significant Impacts (FONSI). The remaining operable units will also undergo NEPA evaluations. Application of an integrated CERCLA/NEPA process avoids the preparation of duplicate decision-making documents for the same activity.

In addition, the DOE is currently preparing a programmatic EIS (PEIS) for environmental restoration and waste management activities occurring nation wide. The PEIS will be issued as a draft document for public comment. All proposed remedial actions at the FEMP site, including those for Operable Unit 2, are considered to qualify as interim actions for the PEIS under the conditions established in 40 CFR 1506.1(c). Presently, the Operable Unit 2 proposed actions are considered interim actions because they are: (1) justified independently of the nation-wide program, (2) accompanied by an adequate EA, and (3) not prejudice to the ultimate decision on the program by determining subsequent development or limiting alternatives. However, before the ROD for Operable Unit 2 is approved by EPA, the DOE will further review these conditions to ensure that they are met at that time.

1.1.3 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 protection of human health and the environment. DOE maintains custody of the site 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. To support the decision as to whether a given waste site warrants the implementation of cleanup actions, EPA established a formalized risk assessment process. Under this process, several hypothetical scenarios, in which members of the public could be exposed to site contamination, are examined.

The ongoing RI/FS site characterization and routine environmental monitoring programs at the FEMP site 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 routine environmental monitoring program provides environmental 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 site environmental conditions.

Although human populations are not presently adversely impacted by Operable Unit 2 contaminants due to access and administrative controls (DOE 1993c), the purpose of DOE's environmental restoration program is to preclude the potential for such impacts 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.

1.2 PURPOSE AND ORGANIZATION OF REPORT

The purpose of this report is to evaluate the range of available remedial action alternatives for addressing the permanent disposition of the stored residues, their associated storage structures and facilities, if present, and existing contaminated environmental media within Operable Unit 2 at the FEMP site. This report has been prepared consistent with the requirements of CERCLA, the Amended Consent Agreement, applicable project documentation, and available EPA guidance. It has been prepared to provide the necessary information, when coupled with regulatory agency and community input, to support an informed decision regarding the appropriate remedy for Operable Unit 2. The report is organized as follows:

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- The remainder of Section 1.0 presents the FEMP site history and description, a discussion of the approach and objectives of the FS, summaries of previous investigations for Operable Unit 2, and summaries of the various facets of the Operable Unit 2 RI, including fate and transport modeling and baseline risk assessment.

- Section 2.0 develops the remedial action objectives for the Operable Unit 2 FS. Section 2.0 also identifies applicable or relevant and appropriate requirements (ARARs) and develops preliminary remediation goals for contaminated media within Operable Unit 2.

- Section 3.0 identifies the remediation volumes, the general response actions (GRAs), screening technologies and process options for Operable Unit 2, and identifies potential technologies and available process options for managing the residues and contaminated media.

- Section 4.0 develops preliminary remedial action alternatives for addressing each waste type and media associated with Operable Unit 2.

- Section 5.0 provides a more detailed description of the remedial action alternatives being considered and performs a detailed analysis of the alternatives employing criteria established by federal regulation. Each detailed analysis has been written to include an impact analysis of the affected environment pursuant to the requirements of NEPA.

- Section 6.0 presents a comparative analysis of the remedial alternatives for Operable Unit 2.

Supporting information is contained in Appendices A through I, which include more detailed discussions of available cost information, regulatory requirements, and the CRARE. The appendices are as follows:

- Appendix A - Sampling Results for Selected Contaminants
- Appendix B - Summary of Applicable, Relevant, and Appropriate Requirements
- Appendix C - Risk Evaluation for Remedial Alternatives Under Consideration for Operable Unit 2
- Appendix D - Groundwater Fate and Transport Modeling
- Appendix E - Engineering Calculations and Typical Details
- Appendix F - Detailed Cost Estimates
- Appendix G - Cumulative Impacts Analysis
- Appendix H - Floodplain and Wetlands Assessment
- Appendix I - Comprehensive Response Action Risk Evaluation

1.3 OVERVIEW OF FEMP ENVIRONMENTAL RESTORATION PROCESS

This section summarizes the major elements of the FEMP environmental restoration process, including the CERCLA process and a chronological history of regulatory events at the FEMP site.

1.3.1 CERCLA Process

The RI/FS is being conducted in accordance with the requirements of the Amended Consent Agreement between DOE and EPA. The Amended Consent Agreement provides that the RI/FS be performed consistent with CERCLA and other applicable EPA regulations and guidance. The RI/FS process is comprised of the following primary components:

- RI - presents information on the existing conditions at the site, defines the nature and extent of contamination, and presents an assessment of the risks to human health and the environment due to existing environmental conditions.
- FS - develops, screens, and evaluates technologies and alternatives for potential implementation to address identified human health and environmental concerns.
- PP - summarizes the proposed remedial alternative for implementation at a specific operable unit based on information collected and assessed in the RI/FS reports to facilitate input from the public and other interested parties in the decision-making process.
- ROD - responds to public comments on the PP, documents the selected alternative, and defines final cleanup goals and long-term monitoring requirements.

1.3.2 Regulatory History

Current environmental investigations and cleanup activities are being directed through the CERCLA process; however, many other environmental regulations [e.g., NEPA, Resource Conservation and Recovery Act (RCRA), Clean Water Act (CWA), and Clean Air Act (CAA)] impact site activities. Remedial activities through the CERCLA process will meet ARARs. The following paragraphs provide a chronological history of regulatory events at the FEMP.

On October 13, 1978, President Carter signed Executive Order 12088 (Federal Compliance with Pollution Control Standards) mandating all federal facilities, including DOE facilities, to comply with existing environmental statutes and regulations, including the CAA, CWA, and RCRA. On March 9, 1985, EPA issued a Notice of Noncompliance to the DOE identifying potential environmental impacts associated with the FEMP's past and ongoing operations. Between April 1985 and July 1986, conferences were held between DOE and EPA representatives to discuss the issues and to identify steps to achieve and maintain environmental compliance.

A groundwater monitoring program for Waste Pit 4 (Operable Unit 1) was initiated in August 1985 pursuant to the substantive and administrative requirements of RCRA, Subtitle C groundwater monitoring requirements. The monitoring program was required because of the FEMP's potential

disposal of hazardous waste (i.e., barium salts) in Waste Pit 4 after November 19, 1980, the effective date of RCRA.

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) was signed by the DOE and EPA to address environmental impacts associated with the FEMP site. In particular, the FFCA required the DOE to thoroughly and adequately investigate past and continuing activities at the FEMP site in order to formulate, assess, and implement appropriate remedial response actions. In response to the FFCA, the RI/FS process was initiated pursuant to CERCLA. The FMPC developed a CERCLA RI/FS Work Plan, Quality Assurance Project Plan, Health and Safety Plan, a RCRA Assessment Monitoring Plan for groundwater, and RCRA Part A and B permits.

The FMPC was added to the NPL on November 21, 1989 (54 FR 48184). On June 29, 1990, a Consent Agreement (the 1990 Consent Agreement), superseding the 1986 FFCA terms, was signed by the DOE and EPA. The agreement included continued compliance with the FFCA, the division of the site into five operable units, and an outline of activities and schedules for the RI/FS and ROD for each operable unit in accordance with the requirements of Sections 106(a) and 120 of CERCLA. The 1990 Consent Agreement was revised in September 1991 ("Amended Consent Agreement") to address additional environmental issues, revise the CERCLA schedules, and create a sixth operable unit.

The 1991 Amended Consent Agreement was modified on April 9, 1993, by an agreement between the DOE and the EPA resolving a dispute concerning the EPA's denial of the DOE's request for an extension of time to submit Operable Unit 2 documents. This agreement established new schedules extending the submittal dates of the Operable Unit 2 RI/FS/PP and draft ROD; it also accelerated Operable Unit 1, Operable Unit 3, and Operable Unit 5 draft ROD submission dates by 30 days each.

In parallel with the actions of EPA and DOE, the Ohio Environmental Protection Agency (OEPA) brought suit against the DOE on March 11, 1986, for alleged violations of State of Ohio RCRA and CWA regulations. The suit was settled when the DOE entered into a Consent Decree with the State of Ohio on December 2, 1988. The Consent Decree outlined specific actions necessary to attain compliance with RCRA and CWA regulations, including characterization and proper management of hazardous waste, groundwater monitoring of RCRA regulated units, and control of wastewater discharges and storm water runoff.

In December 1990, amendments were proposed to update the Consent Decree with regard to new agreements between the EPA and the DOE and to resolve compliance issues raised by the OEPA. The Stipulated Amended Consent Decree was signed on January 22, 1993.

1.4 DESCRIPTION AND HISTORY OF THE FEMP

The Atomic Energy Commission (AEC), predecessor to the U.S. Energy Research and Development Administration (ERDA), now the DOE, established the FMPC in conformance with AEC orders in the early 1950s. In 1951, National Lead Company of Ohio, Inc. (now NLO), entered into a contract with the AEC to be the operations and maintenance (O&M) contractor for the facility.

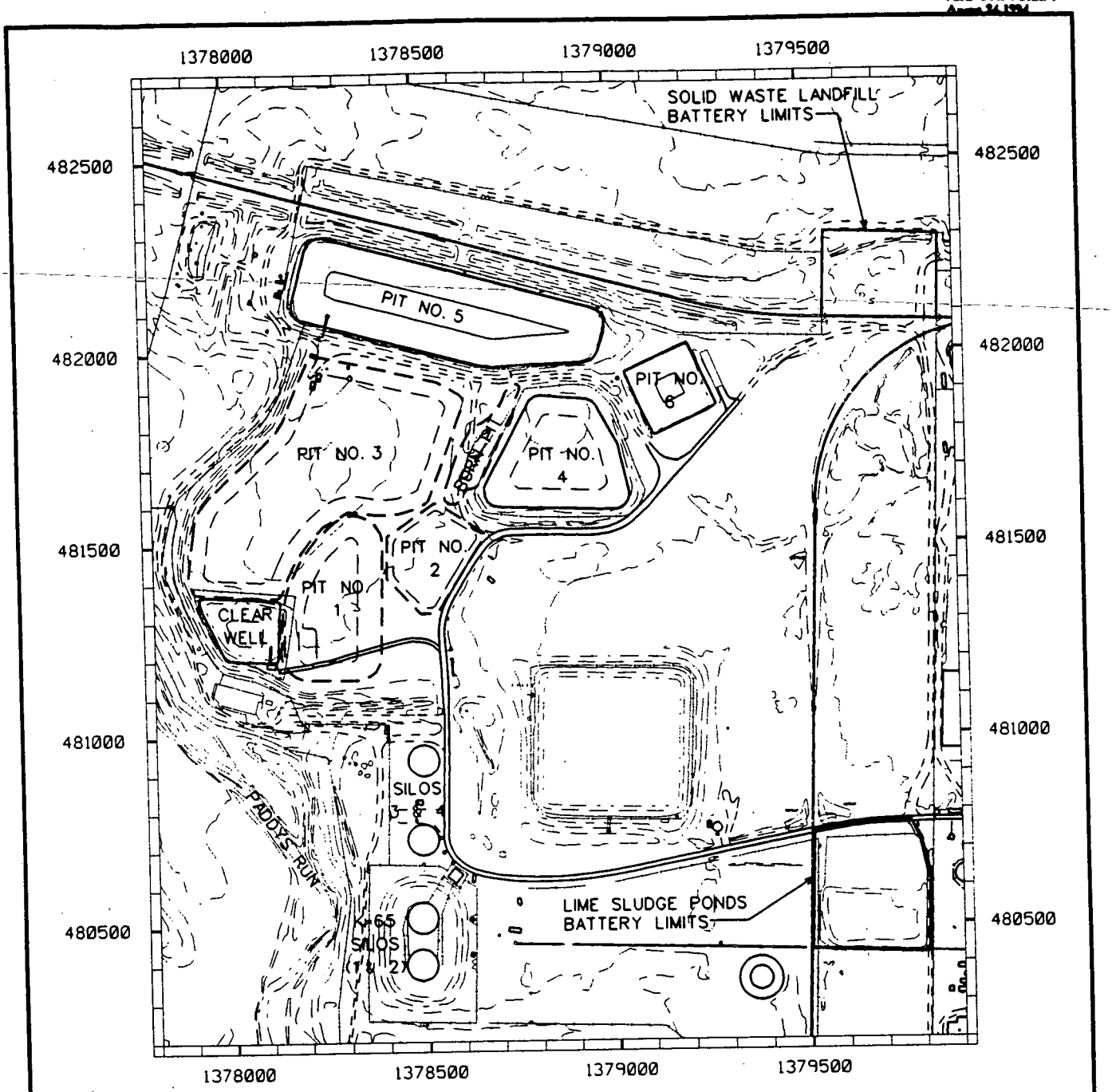
Production operations at the FMPC began in 1951 and were limited to a fenced 55 ha (136 ac) tract of land known as the Production Area, located near the center of the site. The Waste Storage Area (Figure 1-3) was constructed west of the Production Area to dispose of large quantities of liquid and solid wastes and includes two of the Operable Unit 2 subunits, the Solid Waste Landfill and the Lime Sludge Ponds. Prior to 1984, solid and slurried wastes from the FMPC processes were stored or disposed of in the on-site Waste Storage Area.

The remaining subunits in Operable Unit 2 are located in an area to the southwest of the former Production Area, as previously shown in Figure 1-2. This area was used to dispose of construction debris, boiler plant flyash and bottom ash, and other waste. Most of the wastes stored within Operable Unit 2 were not generated directly by uranium production, but through the support of plant operations.

1.4.1 FEMP Production Process

The primary mission of the FMPC during its 37 years of operation was the processing of "feed" materials to produce high purity uranium metal. These high purity uranium metals were then shipped to other DOE facilities for use in the nation's defense program (Figure 1-4). The following discussion is an overview of the production activities and materials handled at the FMPC.

Raw materials at the FEMP consisted of pitchblende ores obtained from mines in the former Belgian Congo (an area now known as Zaire) and Australia; uranium concentrates (yellowcake) obtained from uranium mills in Canada and the United States; uranium tetrafluoride (green salt or UF_4) and uranium hexafluoride (UF_6) obtained from the gaseous diffusion plants; uranium trioxide (UO_3) as a slightly



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- BATTERY LIMITS
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 200 400 800

SCALE (METER)
0 48 96 192

FIGURE 1-3
WASTE STORAGE AREA

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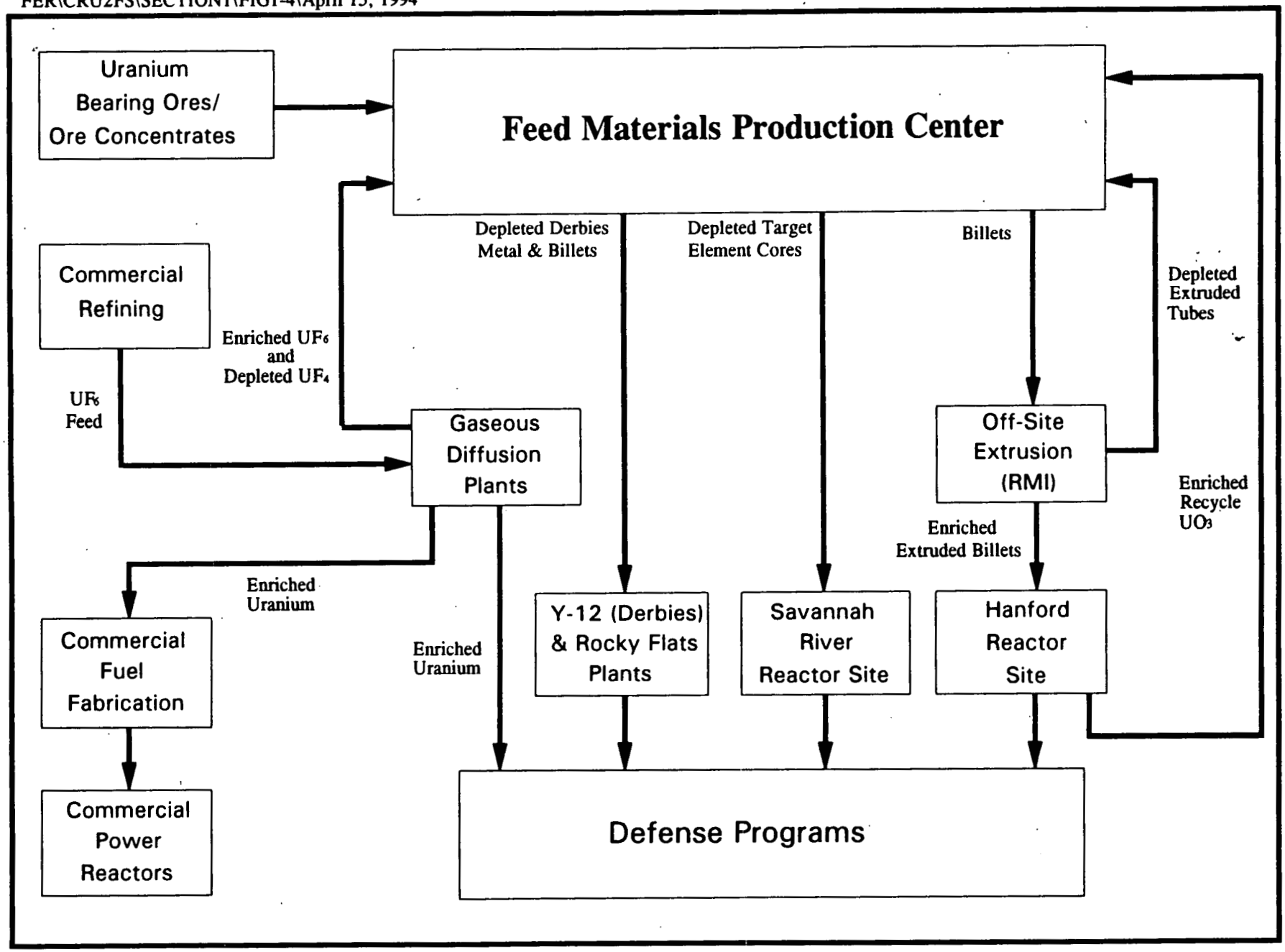


FIGURE 1-4. FMPC RELATIONSHIP TO DEFENSE PROGRAMS

enriched recycled material from the Hanford Purex Plant; and recovered uranium-bearing residues from processing operations at the FEMP site and elsewhere. Enriched uranium is uranium that contains a higher percentage of uranium-233 or -235 isotopes than that which occurs in natural uranium.

The chemical and metallurgical processes for the manufacture of uranium metal products occurred in seven of the FMPC's more than 50 production, storage, and support buildings. The physical layout of those buildings in the former Production Area is shown in Figure 1-5, and a flowchart of the uranium refinement production process is presented in Figure 1-6. Much of the discussion of the refining process and handling of wastes is taken from the following documents and will not be specifically referenced in the text:

- "Uranium Production Technology" (Harrington and Ruehle 1959)
- "A Closer Look at Uranium Metal Production, A Technical Overview" (FMPC 1988)

Impure raw materials were first introduced into the process through the sampling plant (Plant 1), where they were sampled to determine the uranium concentration and the uranium enrichment status. Impure raw materials were transferred to the refinery (Plant 2/3), where they were dissolved in nitric acid; the uranium was purified through solvent extraction to yield a solution of uranyl nitrate. Evaporation and denitrification processed the uranyl nitrate solution to UO_3 powder.

Uranium trioxide from Plant 2/3 was transported to the green salt plant (Plant 4), where it was converted to UF_4 by reaction with anhydrous hydrogen fluoride. The UF_4 was then transported to a metals production plant (Plant 5), where it was blended with magnesium metal granules and placed in a closed refractory-lined steel pot. The resulting product was a 300- to 375-pound piece of pure uranium metal and a by-product, magnesium fluoride slag. The uranium metal had the shape of a gentleman's top hat, or derby.

Some of the derbies were shipped directly to the Y-12 and Rocky Flats Plants. However, most remained in Plant 5, where they were remelted along with uranium scrap-metal from earlier machining operations and poured into graphite molds to form flat or cylindrical ingots. Flat ingots consisted of depleted uranium and were top-cropped, machined into billets, and then shipped to Rocky Flats Plant.

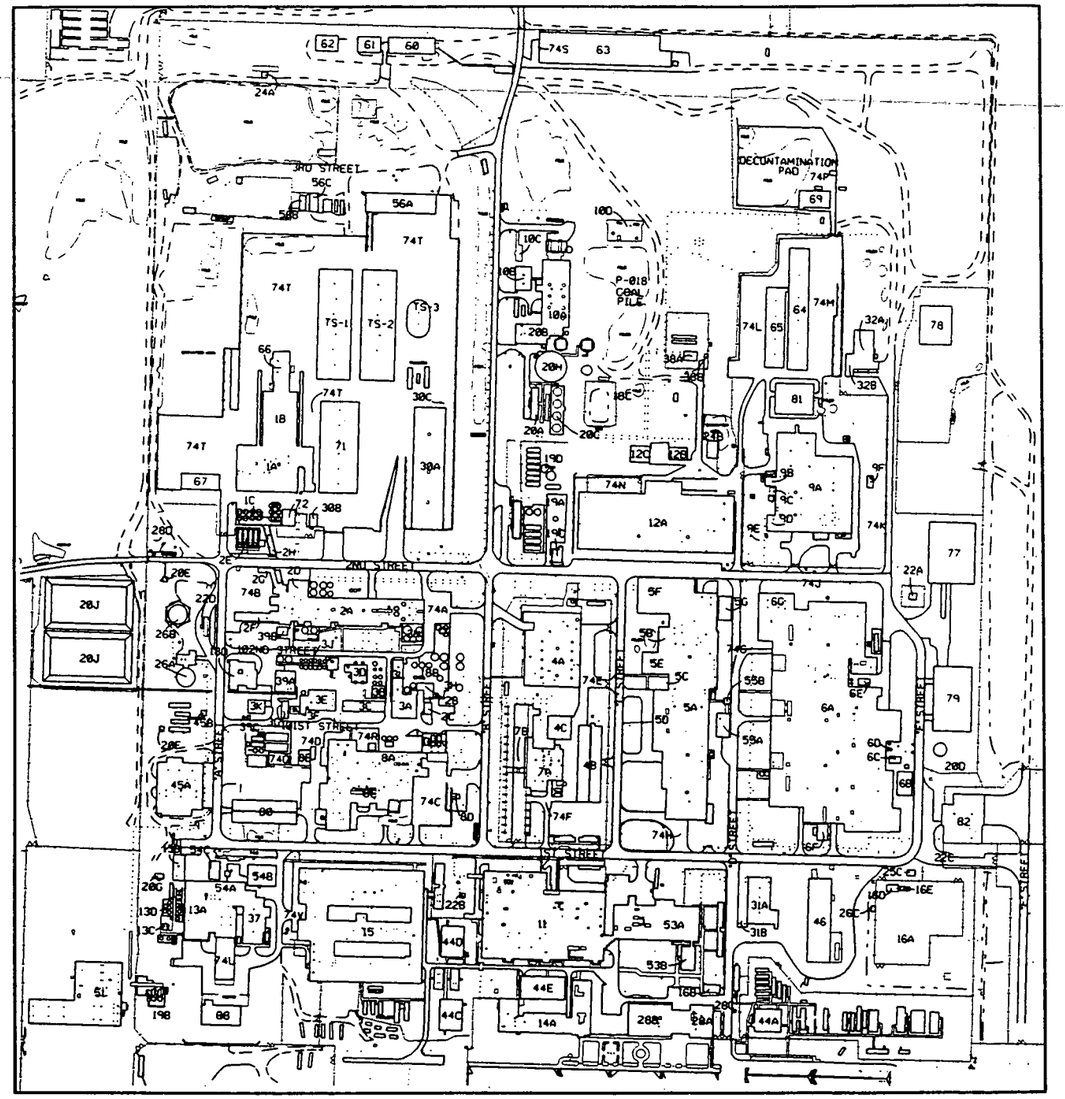
The cylindrical ingots consisted of either slightly enriched or depleted uranium. The ingots were center drilled into billets and then sent to Reactive Metals, Incorporated (RMI), in Ashtabula, Ohio. The enriched uranium billets were upset forged, machined, and then shipped to the DOE Hanford Site. The depleted uranium billets were extruded into tubes and returned to the FMPC, where they were cut into sections, heat treated, and machined to final dimensions. The completed tubes were finally shipped to the DOE Savannah River Site to be used as target element cores.

Small amounts of thorium were processed at the FMPC on several occasions from 1954 through 1975. Thorium operations were conducted in Plants 1, 4, 6, 8, and 9, and the Pilot Plant. Although thorium materials are no longer being received for storage, the FEMP serves as the thorium repository for DOE and maintains storage facilities for a variety of thorium materials. Existing thorium inventories have now been declared as waste and are being shipped to DOE's Nevada Test Site (NTS) for disposal.

Production at the FMPC peaked in 1960 at approximately 12,000 metric tons of uranium per year. A product decline began in 1964 and reached a low in 1975 of about 1,230 metric tons. During the 1970s, consideration was given to closing the FMPC. Thus, capital improvements and staffing were reduced. The staffing level, which peaked at 2,891 personnel in 1956, slowly declined to 662 personnel in 1972 and then to 538 personnel in 1979. In 1981, the FMPC once again began planning to accommodate increased production requirements. Production levels significantly increased, and there was a rapid staff buildup for several years. The renewed need for uranium metal resulted in the implementation of a major facilities restoration program.

1.4.2 Site Management

The contractual relationship between NLO and DOE continued until January 1, 1986. Westinghouse Materials Company of Ohio (WMCO), a wholly owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities for the site operations and facilities. Production ceased in the summer of 1989 due to a decline in uranium metal demand, and plant resources were focused on environmental cleanup activities. In June 1991, the site was officially closed as a federal production facility. Also in 1991, WMCO was renamed the Westinghouse Environmental Management Company of Ohio (WEMCO), and DOE renamed the site Fernald Environmental Management Project to reflect the change in mission. On December 1, 1992, Fernald Environmental Restoration Management Company (FERMCO) assumed responsibility for the site as



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 & 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
16A BDN SURGE LAGOON
16B GENERAL SUMP
16C COAL PILE RUNOFF BASIN
16D BIODENITRIFICATION TOWERS
16E STORM WATER RETENTION BASINS
16F PIT #5 SLUICE GATE
16G CLEARWELL PUMP HOUSE
16H BDN EFFLUENT TREATMENT FACILITY
16J METHANOL TANK
16K LOW NITRATE TANK
16L HIGH NITRATE TANK
16M HIGH NITRATE STORAGE TANK
16N WASTE PIT AREA STORM WATER RUNOFF CONTROL
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16Q WWTT VALVE HOUSE
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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. #173/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.
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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
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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)
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61 QUONSET HUT #2
62 QUONSET HUT #3
63 RC-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 3 EAST PAD
74H PLANT 3 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

LEGEND

==== ROADS

N

SCALE (FEET)

0 200 400 800

SCALE (METER)

0 48 96 192

FIGURE 1-5
FORMER PRODUCTION AREA LAYOUT

000062

fs005.dgn

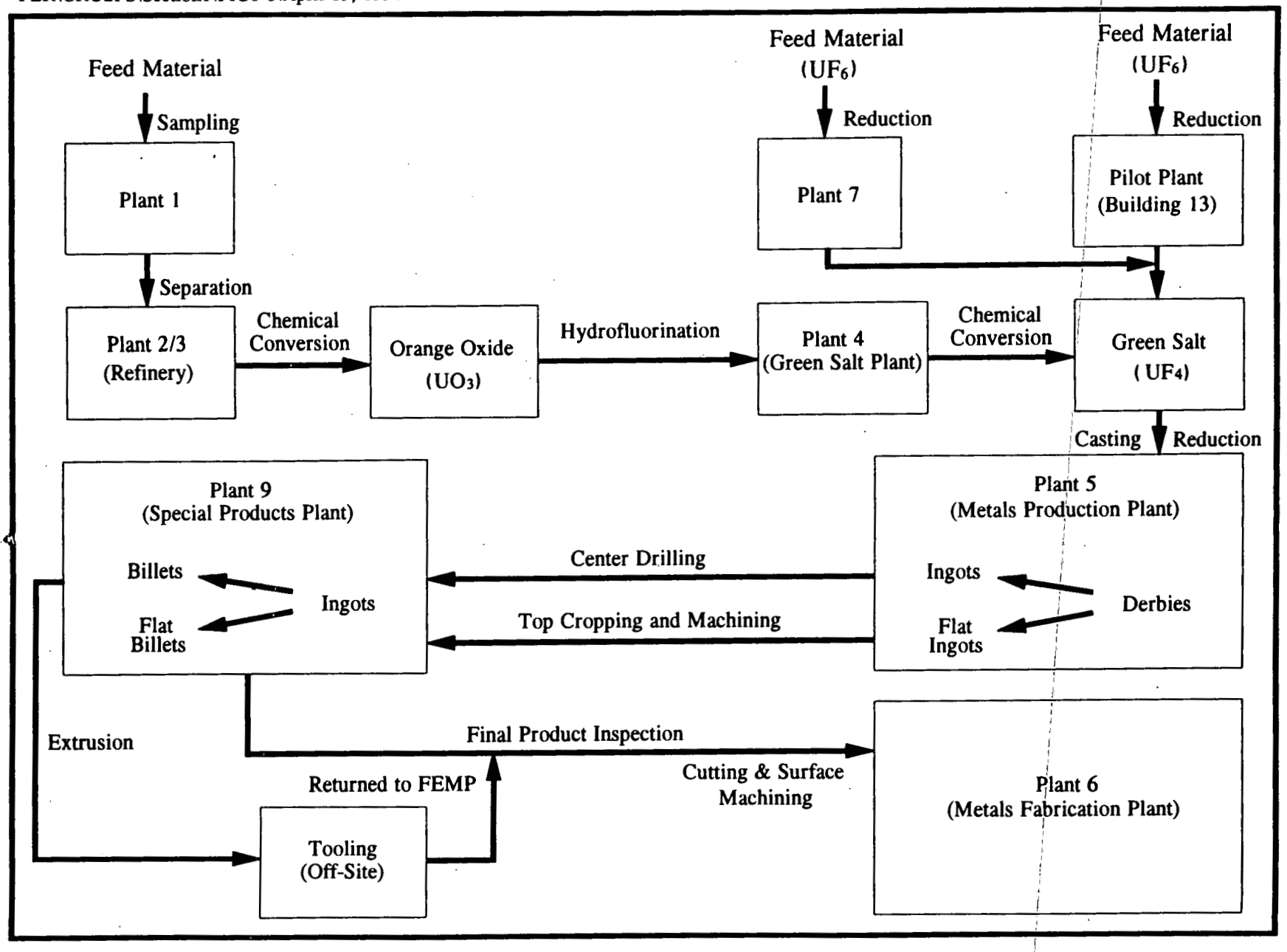

FIGURE 1-6 FEMP URANIUM METAL PRODUCTION PROCESS FLOW DIAGRAM

the first environmental restoration management contractor (ERMC) for DOE. FERMCO is a wholly owned subsidiary of Fluor Daniel, Inc.

1.5 SITE CHARACTERISTICS

This section describes the environment of the FEMP site. A brief description of the soil, air, water, biotic resources, floodplains, wetlands, and cultural resources is provided. More detailed information on these subjects is available in the Site-Wide Characterization Report (DOE 1993c).

1.5.1 General Description of FEMP Site

The southwestern Ohio area in which the FEMP site is located lies within the Till Plains region of the Central Lowland Physiographic Province. This area is characterized by gently to steeply rolling hills, which were formed as a result of several periods of glaciation. The topography of the area ranges from approximately 150 meters (m) [500 feet (ft)] mean sea level (MSL) along the Ohio River to almost 275 m (900 ft) MSL on the hilltops (DOE 1993c).

In the vicinity of the FEMP site, the hilly topography is separated by broad, flat areas that compose the floodplains of the larger surface water features. Some of the prominent flat areas in the vicinity of the FEMP site include the floodplains of the Great Miami River and the floodplains of the Whitewater River and Dry Fork Creek southwest of the FEMP (DOE 1993c).

The principal water resource within the region of the FEMP site is the Great Miami Aquifer, which has been designated as a sole-source aquifer under the provisions of the Safe Drinking Water Act. Principal sources of recharge for the Great Miami Aquifer include direct precipitation and natural and induced stream infiltration. Bedrock serves as a limited source of recharge in the area of the FEMP with water movement restricted through fractures and along bedding planes due to the impermeable nature of the shale units (DOE 1993c).

In the vicinity of the FEMP site, three surface water features predominate. These include the Great Miami River, Paddys Run, and a tributary to Paddys Run referred to as the Storm Sewer Outfall Ditch. Paddys Run parallels the western property boundary of the site and flows south into the Great Miami River. The Storm Sewer Outfall Ditch and headwater of the tributary are located at the southern boundary of the FEMP site and feed into Paddys Run. The Great Miami River flows just east of the FEMP site and exhibits meandering patterns that result in sharp directional changes.

The FEMP site and surrounding areas lie in a transition zone between two distinct sections of the Eastern Deciduous Forest Province as described by Bailey (1978): the Oak-Hickory and the Beech-Maple forests. 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 (e.g., white oak) as a common species.

Terrestrial ecological communities on the FEMP site consist of grazed and ungrazed pastures, two pine plantations, deciduous woodlands, riparian woodland, and the "reclaimed flyash pile area." The reclaimed flyash pile area coincides with the South Field and the Inactive Flyash Pile and was considered a distinct habitat by Facemire et al. (1990) because of its status as a mid-successional old field. 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 were catalogued at the FEMP site by Facemire et al. (1990).

Several threatened or endangered species (state and/or federally listed) have the potential to occur on the FEMP site. The Indiana bat, running buffalo clover, cave salamander, and spring coral-root are threatened and endangered species that have the potential to occur on the FEMP site due to favorable habitat; however, these have not actually been found residing on the site. Slender fingergrass and mountain bindweed are both state endangered species that have been reported on site by Facemire et al. (1990). Several threatened or endangered migratory birds have been sited on the FEMP but are not actually residing on the site. These include the northern harrier, northern waterthrush, dark-eyed junco, and bald eagle. A recent survey for the Sloan's crayfish has located individuals of this state-threatened species residing in Paddys Run. Additional detail on the Sloan's crayfish and other threatened and endangered species can be found in Section 1.5.3.3.

Floodplains within the FEMP property are confined to the north-south corridor containing Paddys Run. Outside the boundaries of the FEMP, the 100- and 500-year floodplains of the Great Miami River extend west of the Big Bend (a portion of the river which passes through a 180-degree curve) to an elevation near the eastern boundary of the facility. The 100- and 500-year floodplains of the river also extend northward along Paddys Run from the confluence of the two streams to a point north of the northern boundary of the FEMP.

A site-wide wetlands delineation was conducted in January 1993 in accordance with the 1987 Army Corps of Engineers (COE) Wetlands Delineation Manual. The purpose of the delineation was to determine the extent of Jurisdictional Wetlands and Waters of the United States at the FEMP site and to avoid or minimize impacts to these resources during future activities. The jurisdictional determination was approved by the COE on August 12, 1993. Results from the site-wide delineation indicate a total of 14.5 ha (35.9 ac) of jurisdictional wetlands on the FEMP site. Section 1.5.4 provides further details on wetlands.

1.5.2 Soil, Air, and Water

1.5.2.1 Soil

The Butler County and Hamilton County Soil Surveys [U.S. Department of Agriculture (USDA) 1980 and 1982, respectively] have 15 specific soil series or types mapped within the FEMP site boundaries (Figure 1-7). The major soils identified by the USDA as occurring in the vicinity of the FEMP include the Russell-Xenia-Wynn, Fincastle-Xenia-Wynn, and Fox-Genesee associations. 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 in the FEMP and to the west of the FEMP. These soils are light colored, medium acidic, and moderate in fertility and organic content (Table 1-1).

Soils exist within the FEMP site boundaries that are classified as prime agricultural soils; however, there are no areas within the boundaries considered to be prime farmland (Figure 1-7). Prime farmland, as defined by the USDA, 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 16.2 ha (40 ac) 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.

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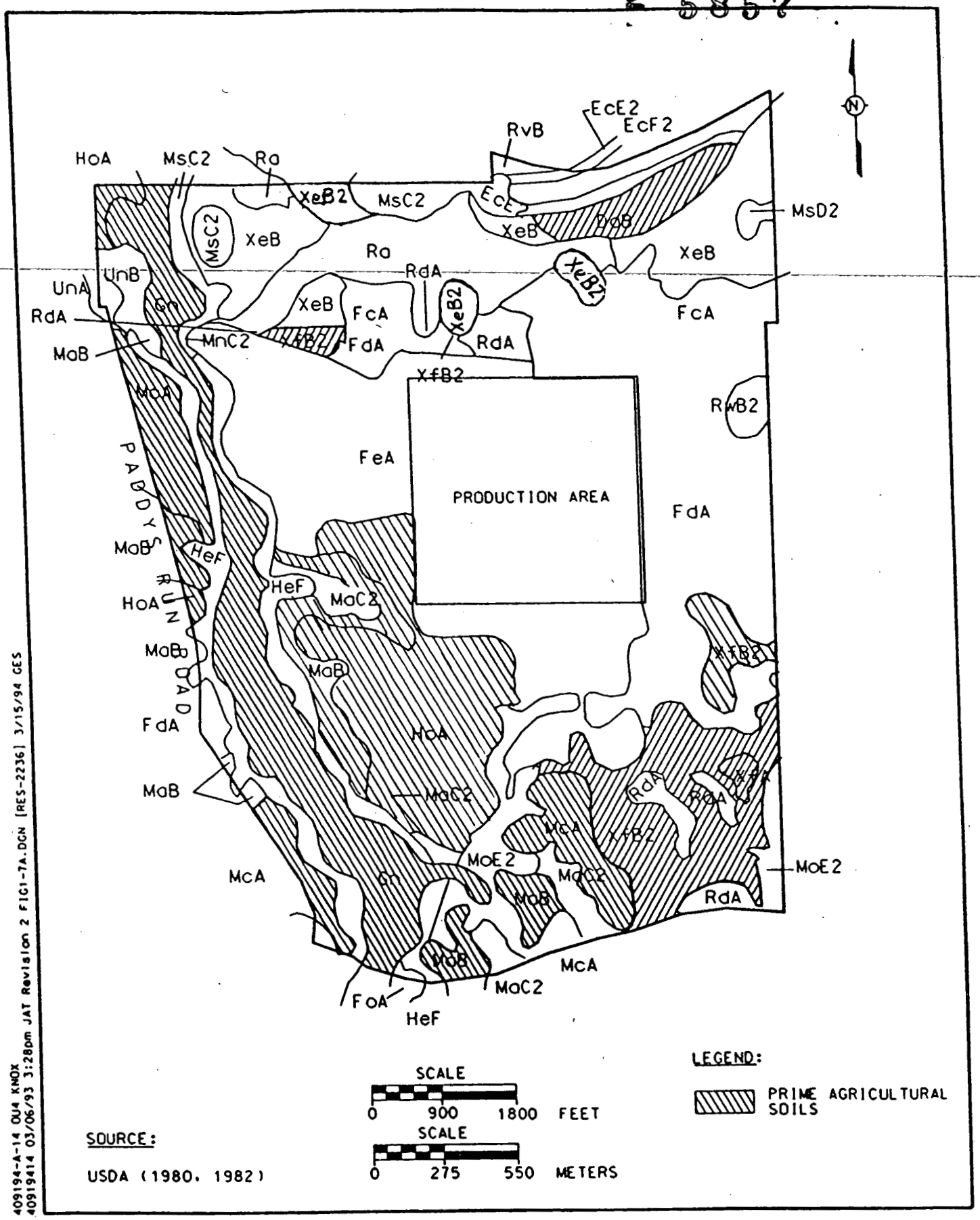

FIGURE 1-7 PRIME AGRICULTURAL SOILS WITHIN THE FEMP

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TABLE 1-1

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-Russell silt loams	2-6	Non-Prime
MsD2	Miamian-Russell 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: SWCR (1993c)

000067

1.5.2.2 Air

The meteorology of the FEMP site is typical of conditions throughout southwestern Ohio, but surface winds are often affected by the local terrain. The Great Miami River Valley's ridges near the FEMP site are the predominant features that influence wind patterns at the site.

The climate of southwestern Ohio is characterized as continental, and temperature varies widely throughout the year. Climatological data recorded at the Greater Cincinnati/Northern Kentucky Airport indicate that average monthly temperatures for the area range from -1.6°C (29°F) in January to 24.4°C (76°F) in July. The average annual precipitation, including melted snow, is 104.1 centimeters (cm) [41 inches (in.)].

1.5.2.3 Groundwater

The Great Miami Aquifer is the principal aquifer within the FEMP site boundary. The underground valley in which it occurs varies in width from about one-half mile to over two miles. The valley is filled with extensive deposits of sand and gravel ranging in thickness from 39.6 to 61 m (120 to 200 ft) in the valley to only several feet along the valley walls, and has a U-shaped cross section with a broad relatively flat bottom and steep valley walls. Beneath much of the FEMP site is a relatively continuous low permeable clay interbed ranging from about 1.5 to 6.1 m (5 to 20 ft) thick. The clay interbed occurs approximately 39.6 m (130 ft) below the land surface and, where present, divides the aquifer into upper and lower sand and gravel units (DOE 1993c).

The principal sources of groundwater recharge on the FEMP site are through direct precipitation, stream infiltration, leaky storm sewers, and bedrock. Infiltration of rainfall and snowmelt is the dominant regional source of groundwater recharge, providing approximately 2,157,450 liters (570,000 gallons) per day per square mile, or roughly 30.4 cm (12 in.) per year to the water table of the aquifer (DOE 1993c). Once the water reaches the aquifer, the groundwater underlying the northern portion of the site flows east toward the Great Miami River. Groundwater from the southern and southwestern portions of the site flows southeast through the buried valley. Near the southwest corner of the site, a groundwater flow component from the west is also present. This causes the recharge from certain reaches of Paddys Run to flow east-southeast until the regional southern component of flow is encountered (Figure 1-8).

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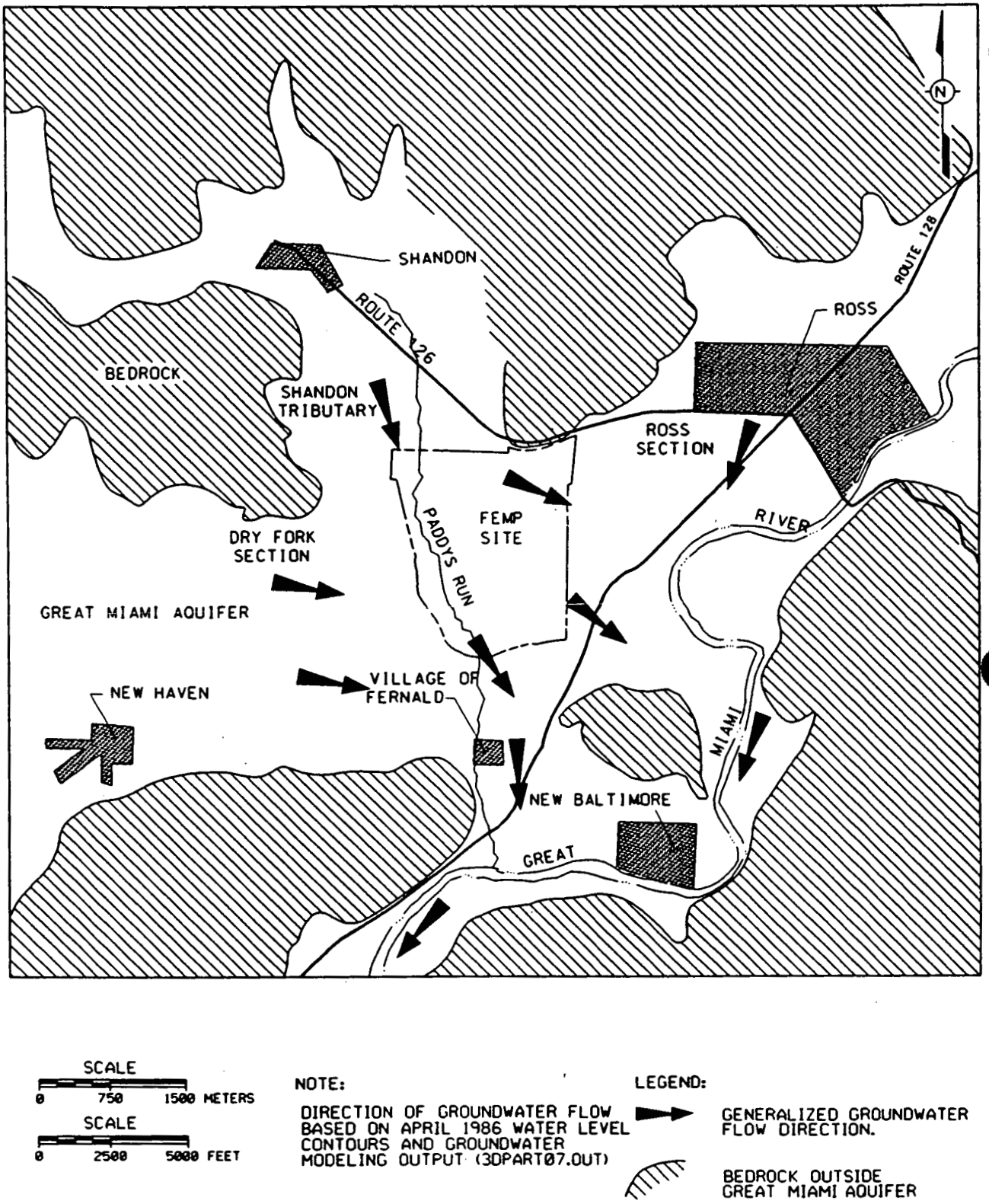


409194-A-12 OU4 KNOX
FIG1-8A.DGN FERMCO [RES-2236] 3/15/94 GES

FIGURE 1-8 GENERALIZED GROUNDWATER FLOW IN BURIED CHANNEL AQUIFER

000069

1.5.2.4 Surface Water

Maximum elevation along the northern boundary of the FEMP property is a little more than 213.3 m (700 ft) above MSL. The former Production Area and Waste Storage Area rest on a relatively level plain at about 176.7 m (580 ft) MSL. The site is located within the Great Miami River drainage basin above the river's present-day floodplain. The Great Miami River flows within 1.2 km (0.75 mi) of the site's eastern boundary and ends in the Ohio River approximately 38.6 km (24 mi) from the main effluent line discharge point, which is located at river mile (RM) 24.1. Tributaries to the Great Miami River in the region include Four Mile Creek at RM 38.4, approximately 14.0 river miles upstream from the site; Banklick Creek, located just south of RM 28; Owl Creek, located at RM 22.0; and Blue Rock Creek, which enters the river at RM 21.0. Paddys Run, which flows along the site's western boundary, joins the Great Miami River at approximately RM 19.5, and Taylor Creek enters the river at approximately RM 14.4. The Whitewater River combines with the Great Miami River at RM 6.0.

Surface waters on and adjacent to the FEMP site are the Storm Sewer Outfall Ditch, Paddys Run, and the Great Miami River (Figure 1-9). The Storm Sewer Outfall Ditch originates south 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. Much of the stream bottom of this drainage course, which collects runoff from an area east of the former Production Area and storm water retention basin overflow, is composed of sand and gravel and is highly permeable. Paddys Run originates north of the FEMP site, flows southward along the western boundary of the facility, and enters the Great Miami River approximately 2.4 km (1.5 mi) south of the southwest corner of the site property. The stream is approximately 14.1 km (8.8 mi) long and drains an area of approximately 25.4 square (sq) km (15.8 sq mi).

1.5.3 Biotic Resources

1.5.3.1 Terrestrial Habitats

Ecosystems at the FEMP site are diverse, with leased pasture and woodlots grazed by cattle, ungrazed grasslands, pine plantations, early and mid-successional woodlots, and riparian areas along Paddys Run (Facemire et al. 1990) (Figure 1-10). Mammal and bird species are found in all of these habitats, which are described below. Abundant mammals throughout the FEMP include the white-tailed deer (*Odocoileus virginianus*) and the eastern cottontail rabbit (*Sylvilagus floridanus*). Many

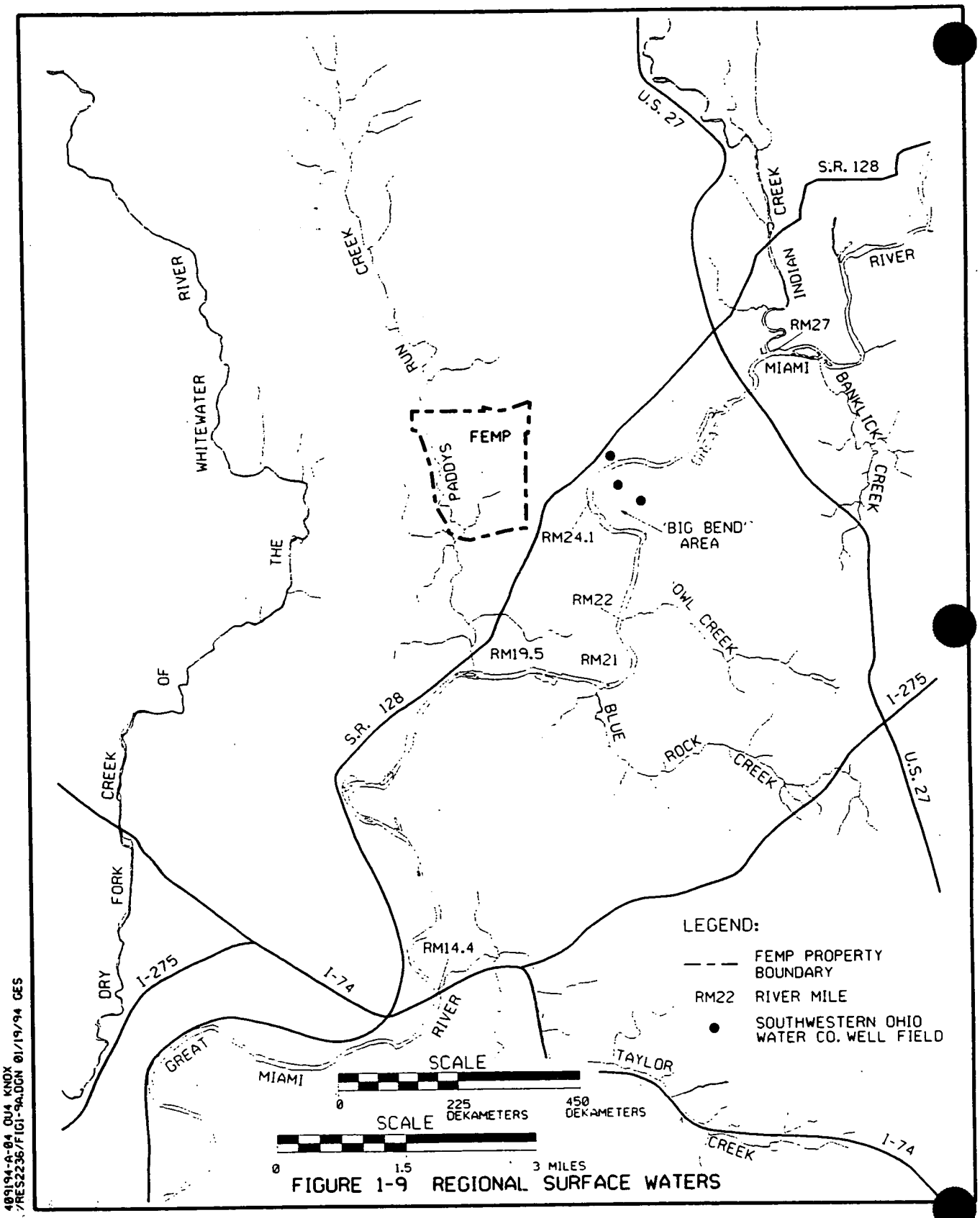
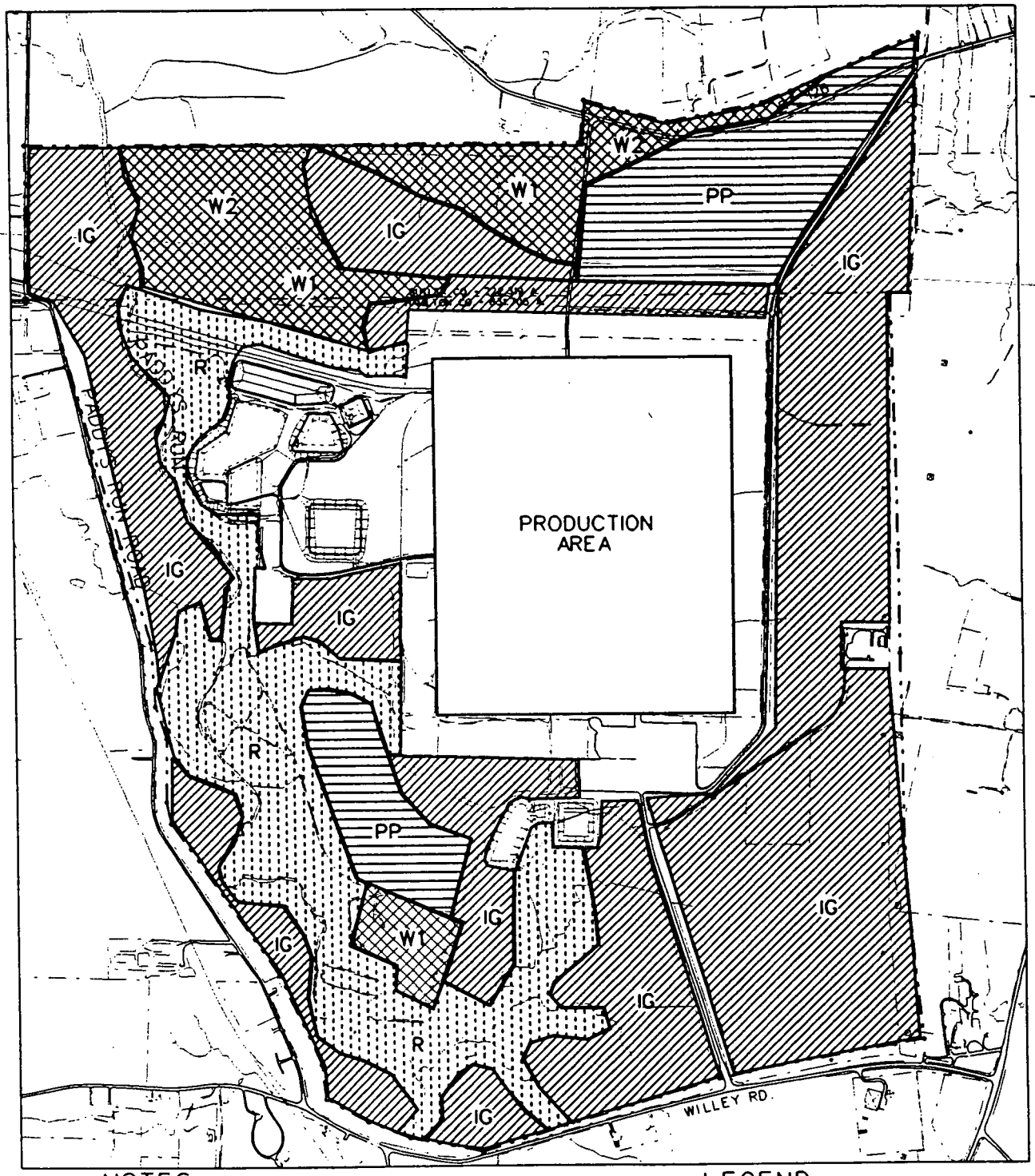


FIGURE 1-9 REGIONAL SURFACE WATERS

000072



NOTES

HABITAT BOUNDARIES ARE APPROXIMATE.

SCALE

0 800 1600 FEET

SCALE

0 225 450 METERS

LEGEND

INTRODUCED GRASSLAND (IG)

PLANTED PINE (PP)

RIPARAIN (R)

WOODLANDS
EARLY SUCCESSION (W1)
MID-SUCCESSION (W2)

000072

FIGURE 1-10 HABITAT TYPES PRESENT ON THE FEMP

RES2236 8x11 fig1-10a.dgn cru2 GES 3-15-94

birds are common throughout the site, including the common grackle (*Quiscalus quiscula*), eastern meadowlark (*Sturnella magna*), mourning dove (*Zenaida macroura*), barn swallow (*Hirundo rustica*), American robin (*Turdus migratorius*), American goldfinch (*Carduelis tristis*), indigo bunting (*Passerina cyanea*), northern cardinal (*Cardinalis cardinalis*), field sparrow (*Spizella pusilla*), song sparrow (*Melospiza melodia*), and the red-winged blackbird (*Agelaius phoeniceus*).

- Grasslands. The grassland communities at the FEMP are non-native and are composed of timothy (*Phleum pratense*), red top (*Agrostis* sp.), ragweed (*Ambrosia* sp.), moth mullein (*Verbascum blatteria*), and wild parsnip (*Pastinaca sativa*) in undisturbed areas. Several previously mowed grasslands have been left unmowed permanently or will be mowed biennially. Disturbed areas have been created by cattle grazing on 172 ha (425 ac) of land leased to local landowners, as well as mowed areas at different locations on site. These communities are composed of red fescue (*Festuca rubra*) and other fescue species, Kentucky bluegrass (*Poa pratensis*) and other bluegrass species, and orchard grass (*Dactylis glomerata*). Other species include brome grass (*Bromus* sp.), red top (*Agostis stoloniferous* var. *major*), timothy, chickweed (*Stellaria media*), buttercup (*Ranunculus* sp.), winter cress (*Barbarea vulgaris*), red and white clover (*Trifolium pratense* and *T. repens*), ironweed (*Vernonia* sp.), thistle (*Cirsium* sp.), yarrow (*Achillea millefolium*), and goldenrod (*Solidago* sp.).

  The grassland areas are generally inhabited by small mammals and several species of birds. Facemire et al. (1990) recorded taxa such as the white-footed mouse (*Peromyscus leucopus*), which was the most abundant of the five non-game small mammals identified on site, as well as the short-tailed shrew (*Blarina brevicauda*), meadow vole (*Microtus pennsylvanicus*), meadow jumping mouse (*Zapus hudsonius*), and the eastern chipmunk (*Tamias striatus*). The birds common in these habitats include the eastern kingbird (*Tyrannus tyrannus*), American crow (*Corvus brachyrhynchos*), European starling (*Sturnus vulgaris*), killdeer (*Charadrius vociferous*), eastern meadowlark, red-winged blackbird, Savannah sparrow (*Passerculus sandwichensis*), and bobwhite quail (*Colinus virginianus*).

- Pine Plantations. The 21-year old pine plantations cover approximately 40.5 ha (100 ac) and were planted with alternating blocks of white pine (*Pinus strobus*) and Austrian pine (*Pinus nigra*), with occasional Norway spruce (*Picea excelsa*). In recent years, the Austrian pines have become infected with Tipblight (*Diplodia pinea*), a parasitic fungus which blocks the tree's xylem (tubes for nutrient transport). Many of the Austrian pines have died but remain standing in the plantation. Mammal species in the pine plantations are dominated by white-tailed deer. Densities are estimated at 15 to 18 deer per ha (37 to 45 deer per ac) in 1986 by Facemire et al. (1990). Small mammal populations are primarily composed of deer mice (*Peromyscus maniculatus*), with occasional meadow voles. This is also the optimal habitat for the eastern cottontail rabbit, with an estimated population of 1.4 to 4 rabbits per ha (3.5 to 10 rabbits per ac). The most common bird taxa are the gray catbird (*Dumetella carolinensis*), cedar waxwings (*Bombycilla cedrorum*), common yellowthroat (*Geothlypis trichas*), field sparrow, eastern wood-pewee (*Contopus virens*), and the willow flycatcher (*Empidonax traillii*).

- Early and Mid-Successional Woodlands. Early successional woodlots, located at the north section of the site and the Inactive Flyash Pile, cover approximately 51 ha (127 ac) and are dominated by white ash (*Fraxinus americana*) and American elm. Typical pioneer successional species such as Japanese honeysuckle (*Lonicera japonica*), blackberry (*Rubus* sp.), and multiflora rose (*Rosa multiflora*) are also present. Mid-successional woodlands located in the northwestern section of the site are characteristically dominated by American elm (*Ulmus americana*) in the canopy. Other species include slippery elm (*Ulmus rubra*), box elder (*Acer negundo*), sugar maple (*Acer saccharum*), and Ohio buckeye (*Aesculus glabra*). The understory is composed of sugar maple and Ohio buckeye.

  Many species of birds are common to both the early and mid-successional woodlands. Although the early woodlands can often support grassland species, most of the birds are found only in the woodland areas. The common species include red-bellied woodpecker (*Melanerpes carolinus*), downy woodpecker (*Picoides pubescens*), northern flicker (*Colaptes auratus*), chimney swift (*Chaetura pelagica*), eastern wood-pewee, yellow-billed cuckoo (*Coccyzus americanus*), Carolina chickadee (*Parus carolinensis*), tufted titmouse (*Parus bicolor*), white-breasted nuthatch (*Sitta carolinensis*), house wren (*Troglodytes aedon*), common yellowthroat, and the rufous-sided towhee (*Pipilo eyrthrophthalmus*).

  Mammals using the woodlots for food and shelter include the eastern cottontail, white-tailed deer, short-tailed shrew, and the deer mouse.

- Riparian woodlands. The riparian woodland area is the corridor along Paddys Run and the Storm Sewer Outfall Ditch and covers approximately 24 ha (60 ac). The area is characterized as a maple-cottonwood-sycamore floodplain forest (Anderson 1982) based on the dominant species [hackberry (*Celtis occidentalis*), eastern cottonwood (*Populus deltoids*), and American elm]. The species' composition in the riparian woodlot is similar to that of other woodlots. Areas bordering the streambed are characteristically supported by cattails (*Typha* sp.) and sedges (*Carex* sp.) that grow along the banks.

  Although this habitat is utilized by most bird species found in the FEMP site woodlands, several taxa are primarily found only in the riparian area. The most common taxa include the belted kingfisher (*Megaceryle alcyon*), blue jay (*Cyanocitta cristata*), Carolina wren (*Thryothorus ludovicianus*), eastern phoebe (*Sayomis phoebe*), warbling vireo (*Vireo gilvus*), orchard oriole (*Icterus spurius*), and the northern oriole (*Icterus galbula*) (Facemire et al. 1990). Based on incidental observations, Facemire et al. (1990) reported typical woodland amphibians and reptiles such as the eastern box turtle (*Terrapene carolina*), spring peeper (*Hyla crucifer*), American toad (*Bufo americanus*), northern water snake (*Nerodia sipedeon*), and snapping turtle (*Chelydra serpintina*) in the riparian area of Paddys Run. Bats are common in the riparian area and include the big brown bat (*Eptesicus fuscus*), red bat (*Lasiurus borealis*), and the little brown bat (*Myotis lucifugus*). These species reside in dead trees and under loose bark and feed on insects found in the riparian area. Mammal diversity is similar to the woodland community with respect to species composition.

1.5.3.2 Aquatic Habitats

Aquatic habitats on or adjacent to the FEMP site include wetlands throughout the site, Great Miami River, and Paddys Run, as described below.

- Wetlands. The forested wetlands located within the early successional woodland area are dominated by woody plants such as green ash (*Fraxinus pennsylvanica*), black willow (*Salix nigra*), shellbark hickory (*Carya laciniosa*), American sycamore (*Planatus occidentalis*), eastern cottonwood, American elm, and shrub layers [roughleaf dogwood (*Cornus drummondii*), multiflora rose, Tartarian honeysuckle (*Lonicera tartarica*), and riverbank and frost grape (*Vitis riparia* and *V. vulpina,* respectively). Site-wide herbaceous plants in wetlands include red fescue, yellow nutgrass (*Cyperus esculentus*), soft rush (*Juncus offusus*), broad-leaf cattail (*Typha latifolia*), green bulrush (*Scirpus atrovirens*), swamp milkweed (*Asclepias incarnata*), moneywort (*Lysimachia nummularia*), Pennsylvania smartweed (*Polygonum pennsylvanica*), and marsh marigold (*Caltha palustris*). The wooded wetlands and persistent shrub/scrub wetlands are inhabited by the same species common in the FEMP site woodlands and ungrazed grasslands. Waterfowl such as mallards (*Anas platyrhynchos*), wood ducks (*Aix sponsa*), and spotted sandpipers (*Actitus macularia*) have been sighted in the wetland areas, in the riparian woodlots, and in the storm water retention basins.

- Great Miami River. The Great Miami River, a tributary of the Ohio River, supports a diverse aquatic ecosystem. Eighty genera of algae have been recorded in the Great Miami River over an eight-year period (1974 to 1982) [U.S. Geological Survey (USGS) 1992]. Most of the genera were represented by blue-green algae (Cyanophyta), green algae (Chlorophyta), and diatoms (Chrysophyta). The genera in the greatest abundance included the diatoms *Cyclotella* and *Nitzschia*, the green algae *Cosmarium*, *Dictyosphaerium*, *Micratinium*, and *Scenedesmus*, and the blue green algae *Agmenellum*, *Anacystis*, and *Oscillatoria*.

  The river also supports a diverse macroinvertebrate community represented by 60 taxa collected for the RI/FS. Abundant insects include caddisflies (family Hydropsychidae), non-biting midges (family Chironominae), blackflies (family Simulidae), and mayflies (families Baetidae and Heptageniidae). Other invertebrate taxa include segmented worms (families Naidiae and Tubificidae), clams (families Corbiculidae and Sphaeriidae) and snails (families Lymnaeidae, Physidae, and Pleuroceridae).

  In the Great Miami River, 106 species of fish were recorded from 1900 to 1978 (Trautman 1981). Annual electrofishing surveys were conducted from 1984 to 1992 by University of Cincinnati researchers (Miller et al. 1993). Thirty-four species from nine genera were collected in 1992, with the most common species being gizzard shad (*Dorosoma cepidianum*). Other common families included carp and shiners (Cyprinidae), catfish (Ictaluridae), drum (Sciaenidae), sunfish (Centrarchidae), and suckers (Castosomidae).

- Paddys Run and Associated Tributaries. Ephemeral in sections, Paddys Run and its tributaries (including the Storm Sewer Outfall Ditch) support a diverse community of macroinvertebrates and fish. Although there is no record of algal populations, the macroinvertebrate community is typical of a stream of its size in this region. During the 1988 to 89 RI/FS sampling, 70 taxa of invertebrates were collected; most were insects.

Common inhabitants include non-biting midges, caddisflies, mayflies (families Baetidae, Caenidae, Ephemeridae, and Heptageniidae), and stoneflies (families Nemouridae and Perlodidae). Riffle beetles (*Stenelmis* sp.) and isopods (*Lirceus* sp.) were also present. In an additional survey of Paddys Run, Facemire et al. (1990) found similar results in diversity and identified 56 taxa at ten sampling sites. Present at all ten sites sampled along Paddys Run, the most abundant species were non-biting midges (*Chironomus* sp.), riffle beetles, mayflies (*Caenis* sp.), and stoneflies (*Allocarpia* sp.). Other common taxa were mayflies (*Stenonema bipunctatum*), isopods (*Lirceus fontinalis*), caddisflies (*Cheumatopsyche* sp. and *Hydropsyche* sp.), segmented worms (family Oligochaete), blackflies (*Simulium* sp.), and stoneflies (family Nemouridae).

Facemire et al. (1990) recorded 23 species of fish in Paddys Run on the FEMP site. The most common species were the bluntnose minnow (*Pimephales notatus*), creek chub (*Semotilus atromaculatus*), and the stone roller minnow (*Campostoma anomalum*). Other abundant species include rosefin shiner (*Notropis ardens*), Johnny darter (*Etheostoma nigrum*), orangethroat darter (*Etheostoma spectabile*), fantail darter (*Etheostoma flabellare*), and spotfin shiner (*Notropis spilopterus*). In a similar study, Miller et al. (1993) found similar diversities with 13 species at one sample site at the New Haven bridge. Most majority of the fish were represented by minnows (*Pimephales*) and darters (*Etheostoma*).

1.5.3.3 Threatened and Endangered Species

Indiana Bat (*Myotis sodalis*)

The Indiana bat was placed on the federal endangered species list in 1967. This bat typically hibernates during the winter in limestone caves with standing water. During the summer, the Indiana bat colonizes in hollow trees and under loose bark. These colonies are usually found near streams, where the bats feed on flying insects at night.

In 1988, a survey was conducted to determine whether or not the Indiana bat was present at the FEMP site (DOE 1993c). The survey concentrated on the riparian areas along Paddys Run. While no Indiana bats were found at the FEMP site, it was determined that excellent habitat did exist on site along one stretch of Paddys Run. In addition, echo-location identified species from the same genus inhabiting Paddys Run. This 1988 survey also included locations other than the FEMP site. A population of Indiana bats was found along Banklick Creek, a tributary of the Great Miami River located approximately 5.31 km (3.3 mi) northeast of the site.

Running Buffalo Clover (*Trifolium stoloniferum*)

This species of clover can be found in disturbed habitat between open forests and pastures. Running buffalo clover was listed on the federal endangered species list in 1987. At that time, the clover was

known to occur at only one location in West Virginia. This species has since been reported in Hamilton County, Ohio.

Surveys in 1986 and 1987 did not record running buffalo clover at the FEMP site (Facemire et al. 1990). However, the Ohio Department of Natural Resources (ODNR) indicates that this species inhabits Miami Whitewater Forest, located approximately 8 km (5 mi) from the site.

Cave Salamander (*Eurycea lucifuga*)

These salamanders are listed as endangered by the State of Ohio. They prefer to live in the dimly lit entrances to limestone caves, but can also be found in forested areas or along narrow, intermittent streams and in spring houses and wells.

The ODNR has recorded three locations within Miami Whitewater Forest that contain populations of cave salamanders. A 1988 survey of the salamander in and around the FEMP site located a population of cave salamanders at the Ross Trails Girl Scout Camp 0.5 km north of the FEMP site, but none within the FEMP property itself (DOE 1993c). A survey completed in 1993 found moderate habitat in one on-property well and minimal habitat in a ravine in the north woodlot. No individuals were found on FEMP property, and only two were found at the Ross Trails Control site. However, this may have been a result of the severe drought in 1993.

Sloan's Crayfish (*Orconectes sloanii*)

The Sloan's crayfish is listed as threatened by the ODNR. Like all crayfish, this macroinvertebrate spends most of its time in streams and other bodies of water. Data from a 1993 survey show populations residing in northern sections of Paddys Run on site and southern sections of Paddys Run off site near New Haven Road (St. John 1993, 1994).

Slender Finger-Grass (*Digitaria filiformis*)

This state endangered crabgrass blooms from August to October and prefers full sun in sterile, sandy soils. In Ohio, slender finger-grass is confined to sandy native prairie habitat. The 1986 survey located this species at the FEMP site in the riparian habitat (Facemire et al. 1990).

000077

Mountain Bindweed (*Polygonum cilinode*)

This plant species is recorded by the State of Ohio as endangered. It blooms from June through August and can be found in openings and clearings in forested areas. ODNR recordings have been limited to the northeastern counties of Ohio. However, the 1986 survey reported mountain bindweed inhabiting the riparian woods and pine plantations of the FEMP site (Facemire et al. 1990).

Spring Coral-Root (*Corallorhiza wisteriana*)

This is an orchid that is listed as threatened by ODNR. It blooms from April through May and is found in forested wetlands and wooded ravines. Spring coral-root was not found at the FEMP site during the 1986 and 1987 surveys (Facemire et al. 1990), but ODNR has reported a population within Miami Whitewater Forest.

Migratory Birds

There are several species of threatened and endangered migratory birds that pass through the FEMP site in the spring and fall or winter. This list of birds does not represent all threatened or endangered birds that inhabit the FEMP site, but rather birds that have actually been spotted on site. These birds include:

- northern harrier (*Circus cyaneus*)
- northern waterthrush (*Seiurus noveboracensis*)
- dark-eyed junco (*Junco hyemalis*)
- bald eagle (*Haliaeetus leucocephalus*)

1.5.4 Wetlands

A wetlands delineation was conducted on the FEMP site during December 11 to 18, 1992, and January 7 to 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 COE, Louisville District (Ebasco 1993).

A total of 14.5 ha (35.9 ac) of freshwater wetlands were delineated on the FEMP site. Delineated wetlands included 10.76 ha (26.58 ac) of palustrine forested wetlands, 2.8 ha (6.95 ac) of drainage ditches/swales, and 0.96 ha (2.37 ac) of isolated persistent emergent and scrub/shrub wetlands (Figure 1-11).

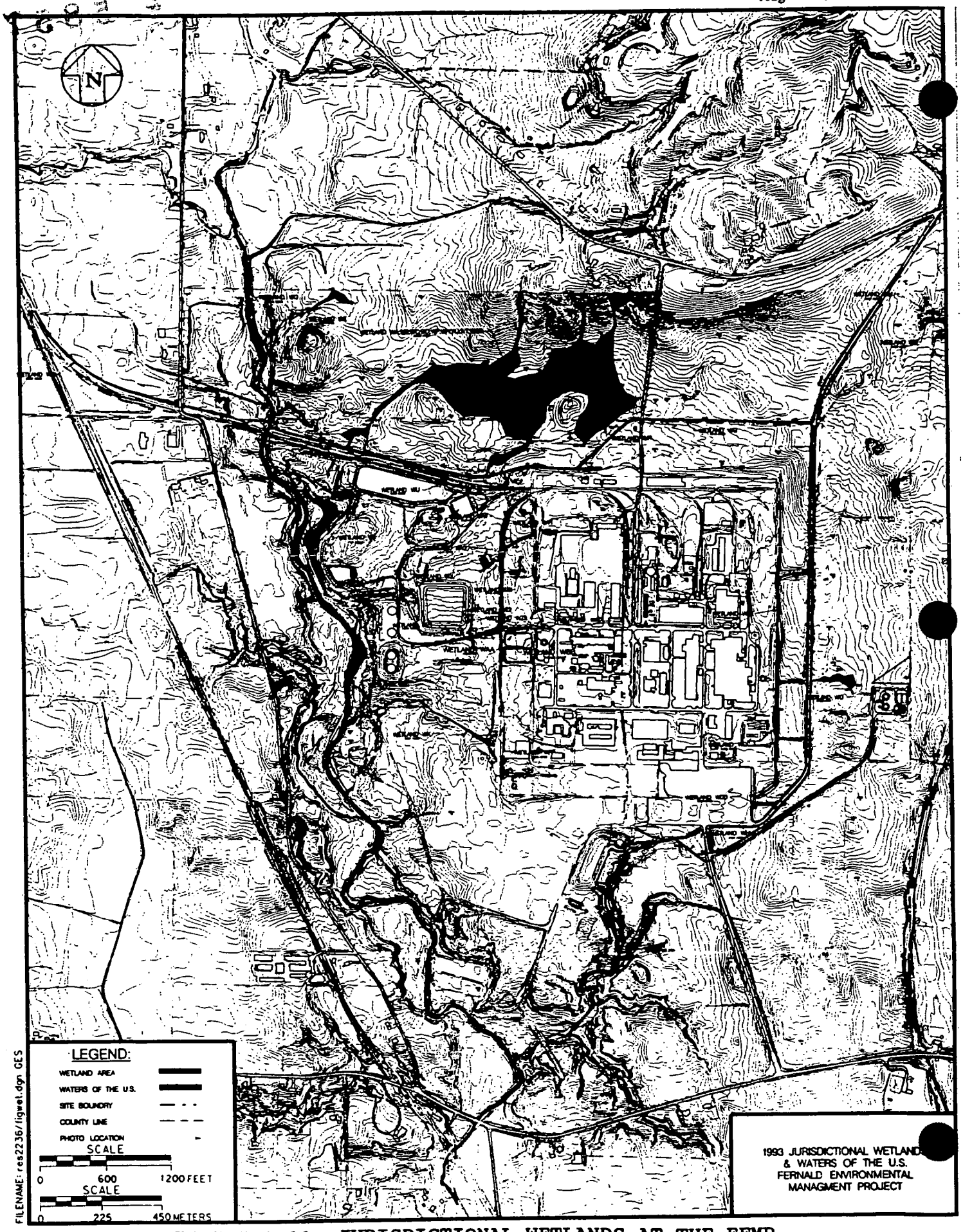


FIGURE 1-11 JURISDICTIONAL WETLANDS AT THE FEMP

1.5.4.1 Palustrine Forested Wetlands

A total of 10.76 ha (26.58 ac) of palustrine forested wetlands were delineated in the north central portion of the site. Poor drainage results in a water table either at or within one foot of the surface during spring and winter. Dominant vegetation consists of woody plants such as American elm (*Ulmus americana*) and Tartarian honeysuckle (*Lonicera tartarica*), with shrub layers consisting of roughleaf dogwood (*Cornus drummondii*) and multiflora rose (*Rosa multiflora*).

1.5.4.2 Drainage Ditches/Swales

Man-made drainage ditches and man-made and naturally occurring swales are located north and northwest of the former Production Area. Water tends to occur during or immediately after precipitation in the drainage ditches. On-site drainage ditches and swales support shrub and/or emergent vegetation. Broad-leaf cattail (*Typha latifolia*) is the most common species. Numerous woody species in shrub growth include black willow (*Salix nigra*), roughleaf dogwood, and American elm.

1.5.4.3 Isolated Wetlands

Isolated emergent and scrub/shrub-emergent wetlands are located along the northern property boundary just east of Paddys Run and near the northeast corner of the site. These wetlands are part of six major drainage systems on site. Dominant vegetation includes yellow nutgrass (*Cyperus esculentus*), soft-rush (*Juncus effusus*), Pennsylvania smartweed (*Polygonum pennsylvania*), red fescue (*Festuca rubra*), and marsh marigold (*Caltha palustris*).

1.5.5 Floodplains

Floodplains within the FEMP site property are confined to the north-south corridor containing Paddys Run, which has also been designated as a water of the United States (Figure 1-12). Note that 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 extend west of the "Big Bend" area (Figure 1-13). The 100- and 500-year floodplains of the river also extends northward along Paddys Run from the confluence of the two streams past the southern boundary of the FEMP property (Figure 1-12).

A study by Parsons (1993a) examined the 100- and 500-year floodplains along Paddys Run. The results of this study predicted a 100-year-flood flow of approximately 616 cubic meters per second

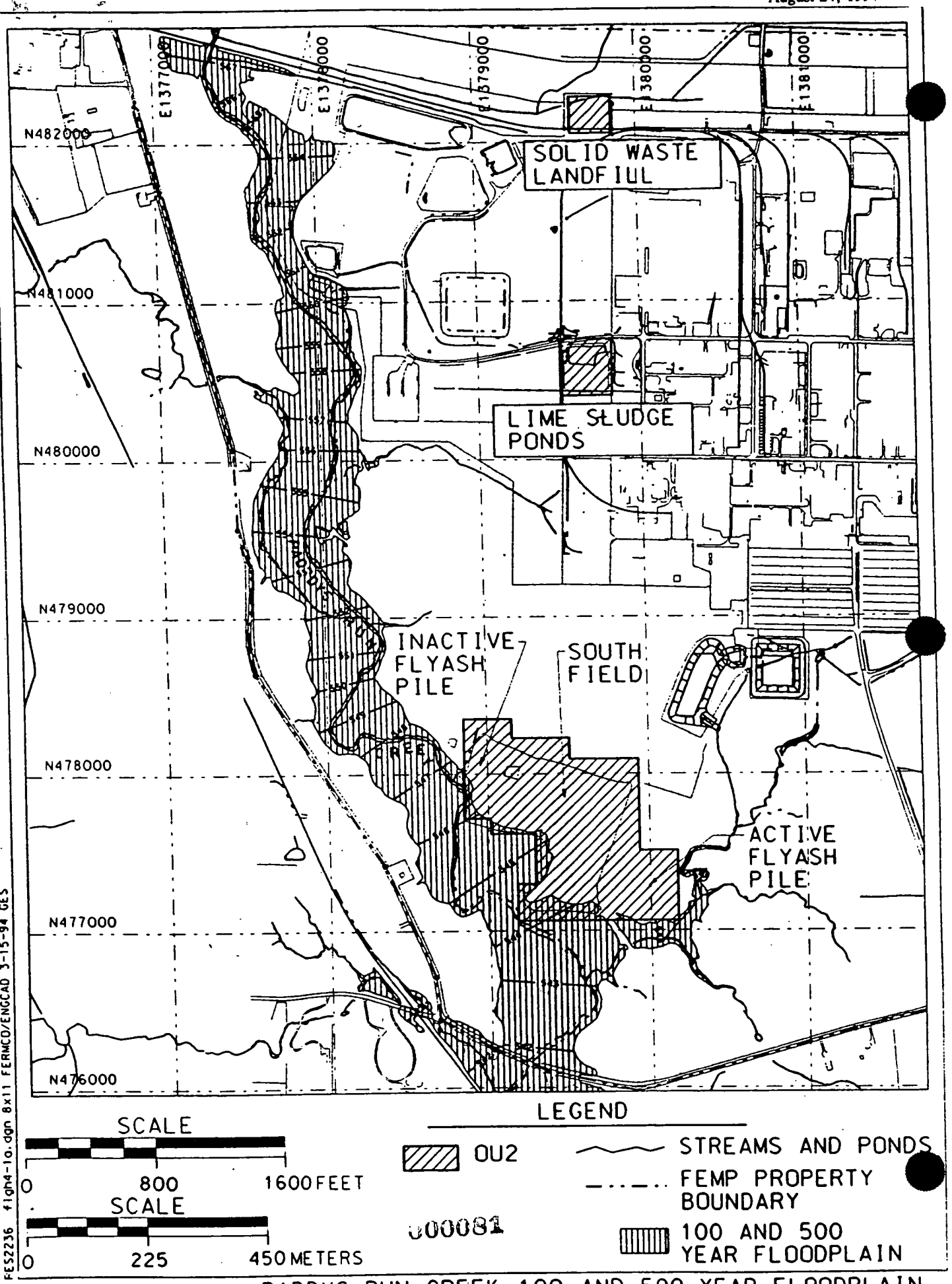
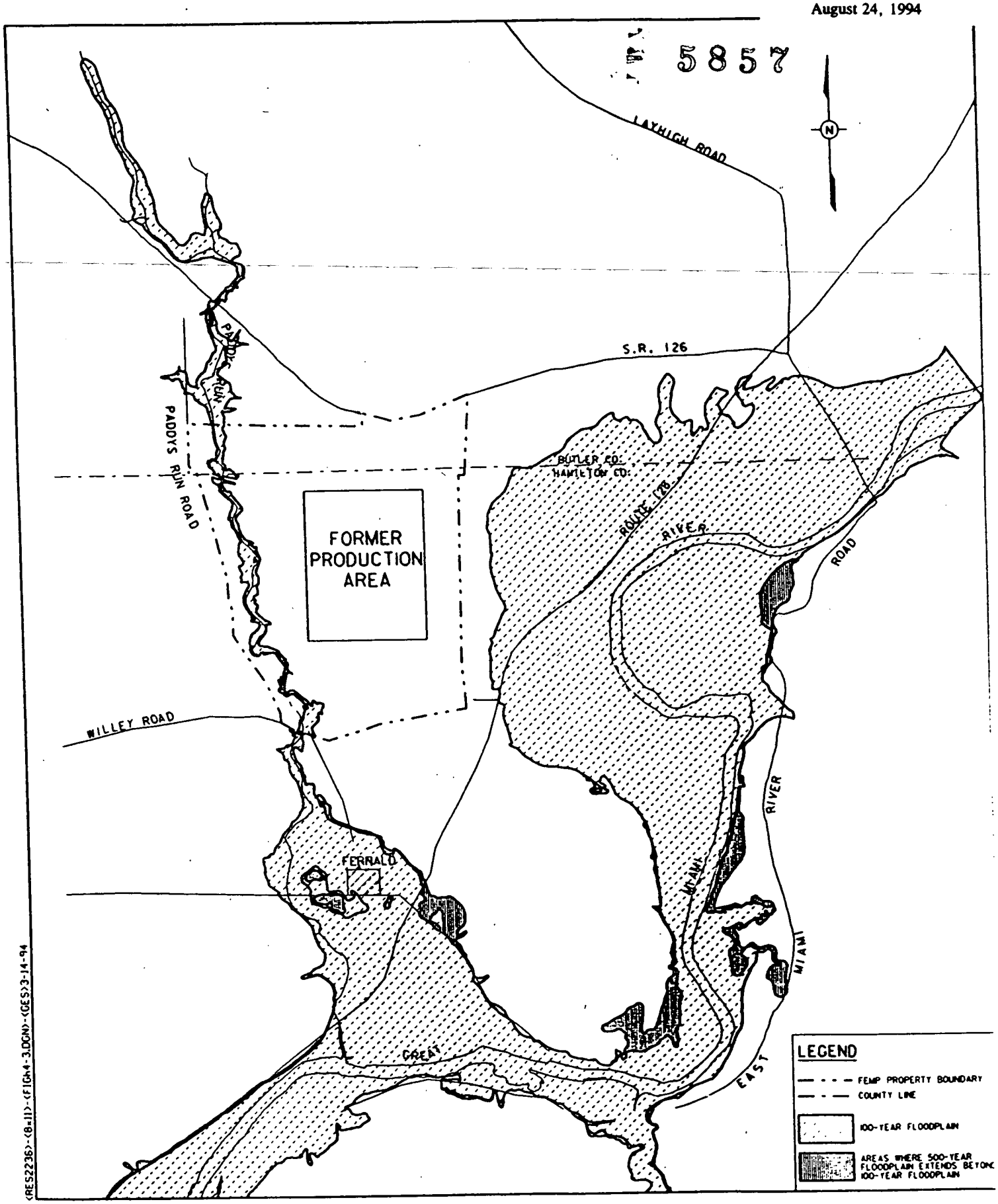


FIGURE 1-12 PADDYS RUN CREEK 100 AND 500 YEAR FLOODPLAIN



(RES2236)-(8:11)-(FIG4-3.DGN)-(GES)3-14-94

SCALE
0 3500 FEET
SCALE
0 1000 METERS

FIGURE 1-13 GREAT MIAMI RIVER AND PADDYS RUN 100-YEAR AND 500-YEAR FLOODPLAIN

000082

(cu m/sec) (11,150 cubic feet per second (cu ft/sec). Elevations range from 165 m (542 ft) MSL at the southern boundary of the floodplain studied to 173 m (567 ft) MSL at the northern tip.

1.5.6 Socioeconomics and Land Use

1.5.6.1 Population

The FEMP site is located approximately 27 km (17 mi) northwest of downtown Cincinnati, within Hamilton and Butler counties in Ohio. Cincinnati is the focal point of a regional market encompassing 13 counties in Ohio, Kentucky, and Indiana. Referred to as a Consolidated Metropolitan Statistical Area (CMSA), the 13-county region 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. Population within the 13 counties was 1.8 million in 1991. Population within an 8 km (5 mi) radius of the FEMP site was estimated at 22,927 residents in 1990 (DOE 1993c). Population density throughout the CMSA varies from 796 residents/sq km (2,062 residents/sq mi) in Hamilton County to 17 residents/sq km (44 residents/sq mi) in Pendleton County. Excluding the heavily urbanized area in Hamilton County (Cincinnati), the average population density in the 13-county region is 108 residents/sq km (280 residents/sq mi). Population density within the 8 km (5 mi) radius of the site is 352 residents/sq km (912 residents/sq mi).

1.5.6.2 Land Use

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 4.8 km (3 mi) northeast of the facility, and along State Route (SR) 128 just south of the village. 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 Road and New Haven Road. 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 prior to the establishment of the FEMP site, there is no land on or in the vicinity of the FEMP site where a predevelopment natural environment remains intact. The land closest to this description is the recreated prairie lands on the Miami Whitewater Forest property, located 8 km (5 mi) south of the FEMP site.

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1.5.7 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 site and surrounding area are located within a 4.8 km (3 mi) wide subterranean valley formed as a result of Pleistocene glaciation. The remaining glacial outreach 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. Historically, these combined factors made the FEMP site and surrounding area desirable as a settlement place.

As a result of this desirability, the area is rich with diverse cultural resources. This desirability is further evidenced by the number of periods represented in the area's history. From prehistoric times to the late 18th century, several different periods of peoples have been identified as living within the FEMP site and surrounding areas. These periods are discussed below in more detail.

1.5.7.1 Paleo-Indian Occupation

The earliest people believed to have inhabited the area were the nomadic Paleo-Indian people (12,000 BC to 8000 BC). The earliest Paleo-Indian material was found at the Meadowcroft Rockshelter in Pennsylvania and ranged from 14,555 BC to 13,955 BC. These first inhabitants of the FEMP site migrated from the south and moved across the state as the glacier retreated and the area began to support large mammals. Paleo-subsistence was based on hunting of such large mammals as the musk ox, giant beaver, and woolly mammoth. Paleo-sites are typically located on bluffs or hilltops overlooking main river valleys. Artifacts recovered from these sites include fluted points made with good quality cherts.

1.5.7.2 Archaic Occupation

Early Archaic People (8000 BC) settlement patterns reflect the change in environment to warmer and drier conditions. This warmer climate increased the forest and plant development in this area. Smaller animals, such as the white-tailed deer, became the subsistent species hunted by the early archaic people. Woodworking tools (celts) and grinding stones were added to the assemblages. They also used axes, gauges, drills, bifurcate and Kanawha points, and knives. Early Archaic sites tend to be small and scattered, located in uplands near secondary stream valleys.

During the Middle Archaic period (6000 BC), climatic improvements led to a diversification in the economy of the Middle Archaic people. Emphasis was still on hunting the white-tailed deer, while a wider variety of plant foods were consumed. The material remnants of Middle Archaic culture include side-notched points, polished stone tools, fully grooved axes, pendants, and winged and cylindrical hammerstones used as atlatl weights. Bone tools were also added to the artifact assemblage.

The Late Archaic period began about 3000 BC and lasted until about 2000 BC in this area. Specialized objects such as sandstone bowls, stone tubes, polished plummets, net sinkers, whistles, birdstones, boatstones, and bone awls were used. Ceremonialism became important and more elaborate. Mortuary practices began and exotic burial goods were produced. Late Archaic sites are large in size and represent occupation over long periods of time. The first cultigens (or cultivated organisms) are associated with this time period.

1.5.7.3 Early Woodland Period (Adena 1000 BC)

The Adena People are associated with the Early Woodland Period in this area. The territory occupied by the Adena Indians extended from southeastern Indiana to southwestern Pennsylvania, and from north central Ohio to central Kentucky. Three major innovations took place in the Late Archaic, Early Woodland Period: the making of pottery, horticulture, and the burial of the dead in earthen mounds. Ritualized status, such as ranked burials, were part of the Adena ceremonial complex.

Two types of Adena ceramics, plain and cardmarked, are common in this area. Projectile points on the ceramics were finely made with a variety of stemmed bases. Leaf-shaped blades were also produced. Copper was used in ornaments such as beads, bracelets, gorgets, and reels. Other assemblages include tubular pipes, quadraconcave gorgets, pendants of slate, hematite celts, and incised stone tablets. The Adena People lived in semi-permanent villages.

The Middle Woodland culture period has been characterized as the Hopewell People (100 BC to 500 AD) complex in southern Ohio. Information about the Hopewellian culture has been obtained through mound excavations. This information reflects elaborate ceremonialism. Mortuary sites are concentrated in the larger villages. Some archaeologists view Hopewell as a religious cult. About three-fourths of the Hopewell burials were cremations, with burials in the flesh presumably reserved for the highest social class. The dead were prepared for burial in charnel houses. The corpses were

dismembered and cremated in shallow crematory basins. The undestroyed bones were deposited in graves in the charnel house floor. When the house became full, the house was dismantled and a mound built over the crematory and graves.

Hopewellian grave goods consisted of materials traded with other people from great distances. Funerary objects consisted of fresh-water pearls, copper, gold, mica, conch shells, and abidian. A Hopewellian village and earthworks is located in the area of the FEMP site. This site is known as the Colerain Earthworks. At one time, the walls of the earthworks were about 2.7 m (9 ft) high and enclosed an area of 38.5 ha (95 ac). The Hopewellian people remained in the area of the FEMP site until about 500 AD.

Late Woodland is represented by the Woodland Indians (500 AD to 1000 AD). Much of the characterization of the Woodland Indians is based on ceramic assemblages that have been found. Different pottery types, distinguished by tempering techniques, define these assemblages. Cordmarked and limestone-tempered techniques were commonly used in the area of the FEMP site. Woodland lithic assemblage is represented by chesser notched points, chipped stone celts, slate or bone gorgets, awls, flaking tools, and flutes. The Woodland Indian villages were used as a base camp in the summer months to permit crop cultivation. After the harvest of crops, the base villages were abandoned for hunting camps in the nearby forests. At approximately 1000 AD, the Woodland Period ended in the area of the FEMP site.

1.5.7.4 Mississippian Tradition (1000 AD to 1660 AD)

The Turpin Phase, Fort Ancient (AD 1000 to 1250), takes its name from the Turpin site located on the Little Miami River in Hamilton County, Ohio. Turpin Phase sites are located in the Great Miami and Whitewater drainage area. Sites occur as far west as Laughing Creek in Ohio County, Indiana. Turpin Phase villages were oval in shape and some contained central plazas. Wall-trench style architecture has been recorded at three Turpin Phase sites. One site is located north of the FEMP site in the Great Miami River Valley.

Two modes of disposal of the dead were practiced by the Fort Ancient people. Mounds were used for at least a portion of the population, while others were interred in shallow graves within the village area. Other burials took place in box-like coffins made of large slabs of limestone. Artifacts used by the Turpin people include shell-tempered pottery, elk antler spades, shell hoes, axes, drills, scrapers,

knives, and awls. The Fort Ancient people were the first pre-historic group to use the bow and arrow in their area. They are also considered to be the first farmers of the Ohio Valley.

The Schomaker Phase, Fort Ancient (AD 1250 to 1450), is represented by Schomaker village, located along the Great Miami River in Hamilton County, Ohio. Schomaker Phase villages are fewer in number than Turpin Phase villages. By AD 1350, only one major village was located in the lower Great Miami Valley.

The Schomaker village site is situated on a low rise along the Great Miami River and encompasses about 1.6 ha (4 ac) of land. Several hundred people occupied this village. Houses were arranged in a broad circle around a central plaza and were constructed partially underground. These semi-subterranean dwellings provided villagers with warmth in the winter and coolness in the hot summers. Schomaker Phase farmers discovered new techniques for storing agriculture products, such as underground silos constructed to store products like maize.

Burial patterns during the Schomaker Phase are different from those of the Turpin Phase. Mound building ceased after AD 1250. Schomaker Phase burials are located in the belt circling the village plaza or among the circle of houses. Pottery from the Schomaker Phase is decorated with curvilinear guilloche or line-filled triangles. At 1450 AD, ceramics changed drastically; decorated pottery all but disappeared. These changes mark the beginning of the Mariemont Phase, Fort Ancient.

Mariemont Phase, Fort Ancient (AD 1450 to 1660), is represented by only one or two sites which were occupied in the lower Miami Valley. The best known of these Mariemont Phase sites is Madisonville village. Mariemont Phase sites have a number of unique material traits such as distinctive ceramics, bone and stone tools, mortuary customs, and the presence of European-manufactured goods. Mariemont graves contain one or more small pots placed by the hand or waist of the body. These pots probably contained food to sustain the individual in the after life. Village houses constructed around a central plaza during the Schomaker Phase had been abandoned by the Mariemont Phase. The Mariemont houses are three to four times larger than Turpin or Schomaker structures. This suggests that several families lived together in one structure. The Mariemont Phase of the Fort Ancient people ended at the Madisonville site about 1660 AD.

1.5.7.5 Historic Times (1660 AD)

The Wyandot Indians lived on the southern shore of Georgia Bay in Canada. These villages were subject to attacks by the Iroquois Confederacy. By the mid-1600s, the Wyandot Indians were forced to abandon their villages and settle in northern Ohio. Wyandot County became their tribal center. One of their major villages was at the site of the present day Columbus, Ohio. The Wyandot aided the British during the Revolutionary War.

The Shawnee resided in southern Ohio until 1672, when the Iroquois forced the Shawnee to abandon their land and move to eastern Pennsylvania with the Delaware Indians. Both the Delaware and Shawnee moved back into Ohio between 1720 and 1745. The Shawnee town of Chillicothe (the first town with this name) was established at the mouth of the Scioto River near present-day Portsmouth, Ohio. In 1758, a large flood forced the Shawnee to move up the Scioto River to one of the towns known in Ohio as Chillicothe (the second town with this name). Old Chillicothe (or the third Chillicothe) on the Little Miami River and Chillicothe at Piqua (or the fourth Chillicothe) on the Mad River were destroyed by George Rogers Clark in 1780. The Shawnee then established the fifth Chillicothe on the Great Miami River. In 1794, General Anthony Wayne defeated the Shawnee at the Battle of Fallen Timbers. The Treaty of Greenville ceded Shawnee lands in most of Ohio, southern Indiana, and south of the Ohio River to the United States. In 1832, all Shawnee lands east of the Missouri River were ceded to the United States. All remaining Shawnee were removed to west of the Mississippi River.

1.6 DESCRIPTION AND HISTORY OF OPERABLE UNIT 2 WASTE AREAS

The RI/FS Work Plan ultimately addressed 39 separate units at the FEMP that required investigation. These units were originally categorized and grouped into five operable units to expedite remedial planning and implementation. As previously indicated, a sixth operable unit was added, pursuant to the Amended Consent Agreement. Operable Unit 2, referred to as Other Waste Units, consists of five subunits:

- Solid Waste Landfill
- Lime Sludge Ponds
- Inactive Flyash Pile
- South Field
- Active Flyash Pile

These areas were used for the storage/disposal of sanitary waste, spent lime sludge, flyash, and construction rubble. The primary characteristic of these waste areas is that they contain large volumes of waste with relatively low concentrations of chemical and/or radionuclide contaminants. The five Operable Unit 2 subunits are described in the following sections.

1.6.1 Solid Waste Landfill

The Solid Waste Landfill is located in the northeast corner of the Waste Storage Area (Figure 1-14). This landfill covers a flat, rectangular area of approximately .41 ha (1 ac) and has been inactive since 1986. A drainage ditch serving the northwest portion of the former Production Area is located north of the Solid Waste Landfill. This drainage ditch has been identified as a jurisdictional wetlands (Ebasco 1993).

1.6.1.1 Description and History

The operational history of the Solid Waste Landfill is not well documented. The facility was planned as a sanitary landfill for non-burnable trash; it would have up to five cells and an evaporation pond according to design drawings. According to the records, the evaporation pond was designed to collect drainage from the exposed dumping area. A review of historical site aerial photographs indicates that activity at the Solid Waste Landfill may have occurred as early as 1954. One disposal cell has been confirmed from an aerial photograph taken in November 1974. Historical aerial photographs from November 1974 to April 1976 show a drainage pond on the west side of the landfill area; however, it is not present in photographs later than 1980. A stockpile of an aggregate material was seen covering the northeast quarter of the site in aerial photographs from November 1974 to 1976.

Limited operation records state that dumping commenced on June 19, 1974, with dumping planned for two to three times weekly. Materials reportedly buried at the Solid Waste Landfill include non-burnable and nonradioactive solid wastes (cafeteria wastes, rubbish, etc.) generated on FEMP property, nonradioactive construction-related rubble, and double-bagged and bulk quantities of nonradioactive asbestos. Field investigation results indicate that a variety of waste materials have been historically disposed of at the Solid Waste Landfill. Interviews with former FMPC employees

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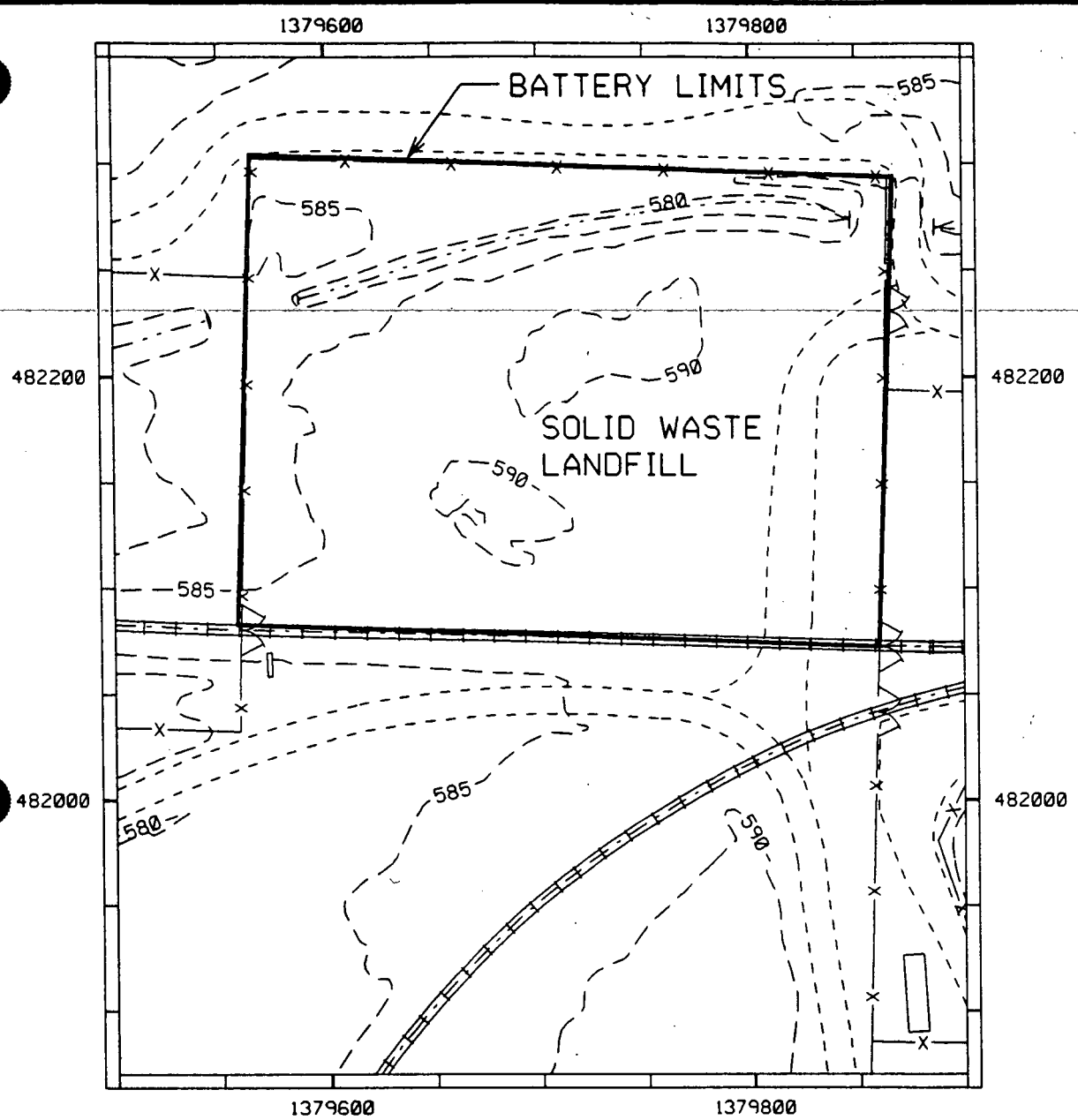

LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- STREAM
- BATTERY LIMITS
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FEET)
0 40 80 160

SCALE (METER)
0 4.8 9.6 19.2

FIGURE 1-14
TOPOGRAPHY OF THE
SOLID WASTE LANDFILL

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000090

revealed no new relevant information. The following wastes were encountered during a trenching investigation in 1992:

- Burnable wastes - bagged trash and wood
- Possible burnable wastes - respirator cartridges, asphalt roofing materials, medical wastes, firehoses, and rubber hoses/belts
- Non-burnable wastes - unidentified high-activity waste, medicine vials, bagged asbestos, ceramic tiles, possible magnesium fluoride, glass acid bottles, steel cables/cans, paint cans, and copper tubing

Nonradioactive, nonhazardous general refuse is now shipped for disposal at approved off-site locations.

1.6.1.2 Geology and Hydrogeology

The Solid Waste Landfill is underlain by the glacial overburden (fill or overburden), which has an approximate thickness of 7.6 m (25 ft) and consists of interbedded layers of stiff to hard, light yellowish brown to brown, silty clay with varying amounts of sand and gravel, as shown in Figure 1-15. Color variations to gray or light olive brown were observed in overburden samples.

The overburden is underlain by the Upper Great Miami Aquifer, which has an approximate thickness of 27.5 m (90 ft) and consists of very dense, dark yellowish-brown sands and gravels. The Upper Great Miami Aquifer is separated from the Lower Great Miami Aquifer by a dark gray clay aquitard.

Groundwater (perched water) seepage was observed during excavation of characterization trenches at depths ranging from 0.75 to 2.75 m (2.5 to 9 ft) below ground surface. These perched water zones were found in areas of significant porosity or within the fill's void spaces.

Groundwater elevation within the overburden varies from approximately 177 to 171 m (580 to 560 ft) MSL [2 to 6 m (7 to 20 ft) below ground surface]. Lower water levels observed in Well No. 1037 were discounted due to faulty well construction. Groundwater within the overburden was found to be present in small isolated and discontinuous pockets of saturated materials. Horizontal groundwater movement is restricted and hydraulic gradients within the overburden can be steep.

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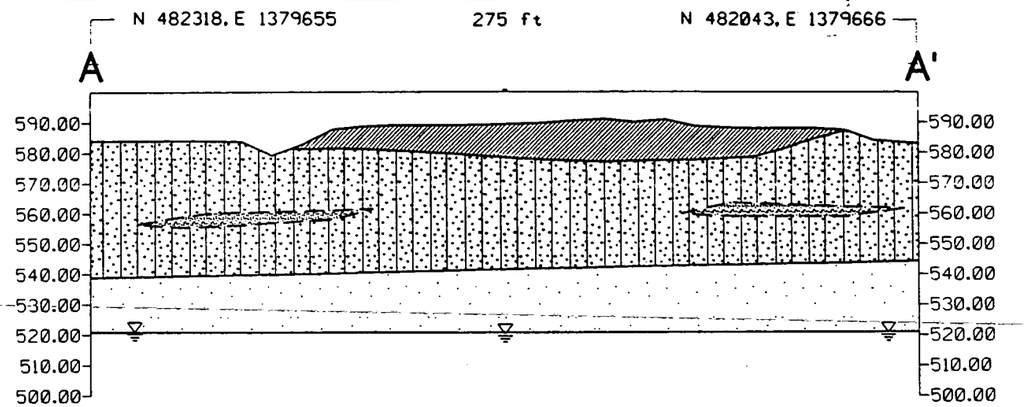
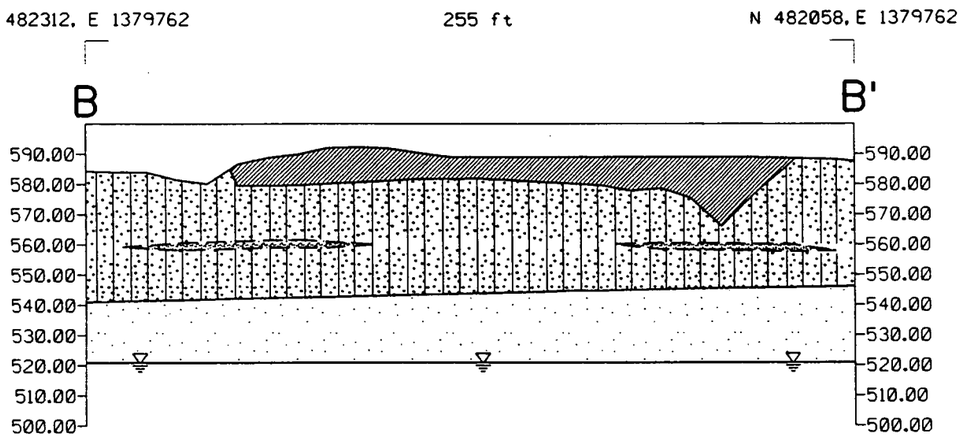
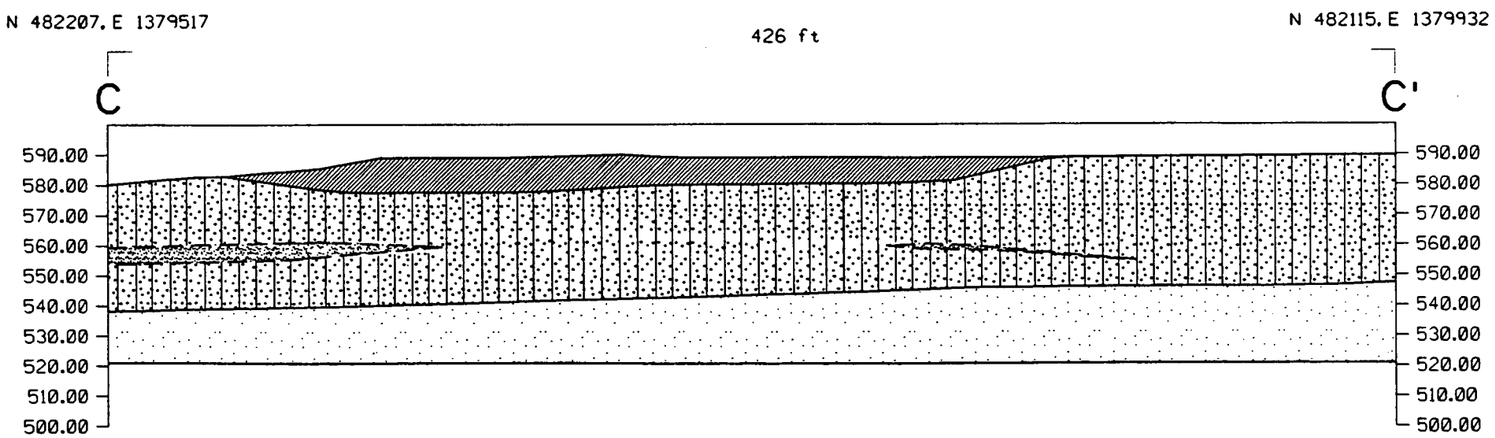
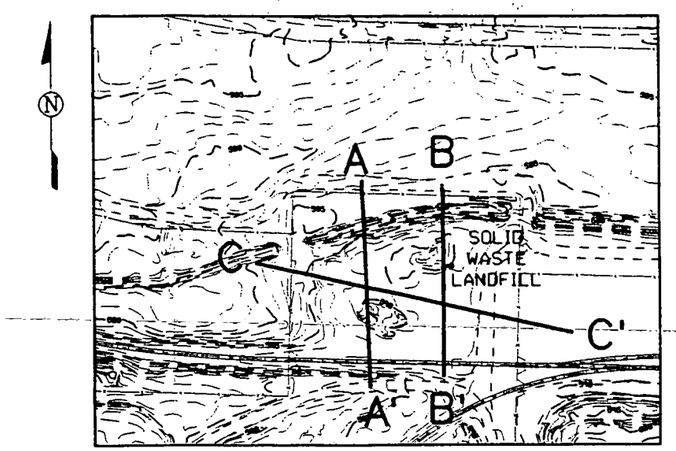








LOCATION KEY (1" = 200')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 50'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

000092

FIGURE 1-15
GEOLOGIC CROSS SECTIONS
SOLID WASTE LANDFILL

fall47.dgn

Groundwater elevation data from wells installed within the Upper Great Miami Aquifer indicate an easterly flow direction with a slight hydraulic gradient. Groundwater elevation within the Upper Great Miami Aquifer is approximately 160 to 158 m (525 to 520 ft) MSL [19 to 20.5 m (62 to 67 ft) below ground surface].

1.6.2 Lime Sludge Ponds

The Lime Sludge Ponds are located immediately west of the former Production Area, as shown in Figure 1-16. A north-south railway is located along the western boundary of this waste area and access roads lie to the north and east. On the southern boundary, a portion of the K-65 slurry line, which is considered part of Operable Unit 3, lies in a covered, concrete trench. Generally, the topography in the vicinity of the ponds slopes very gently to the west.

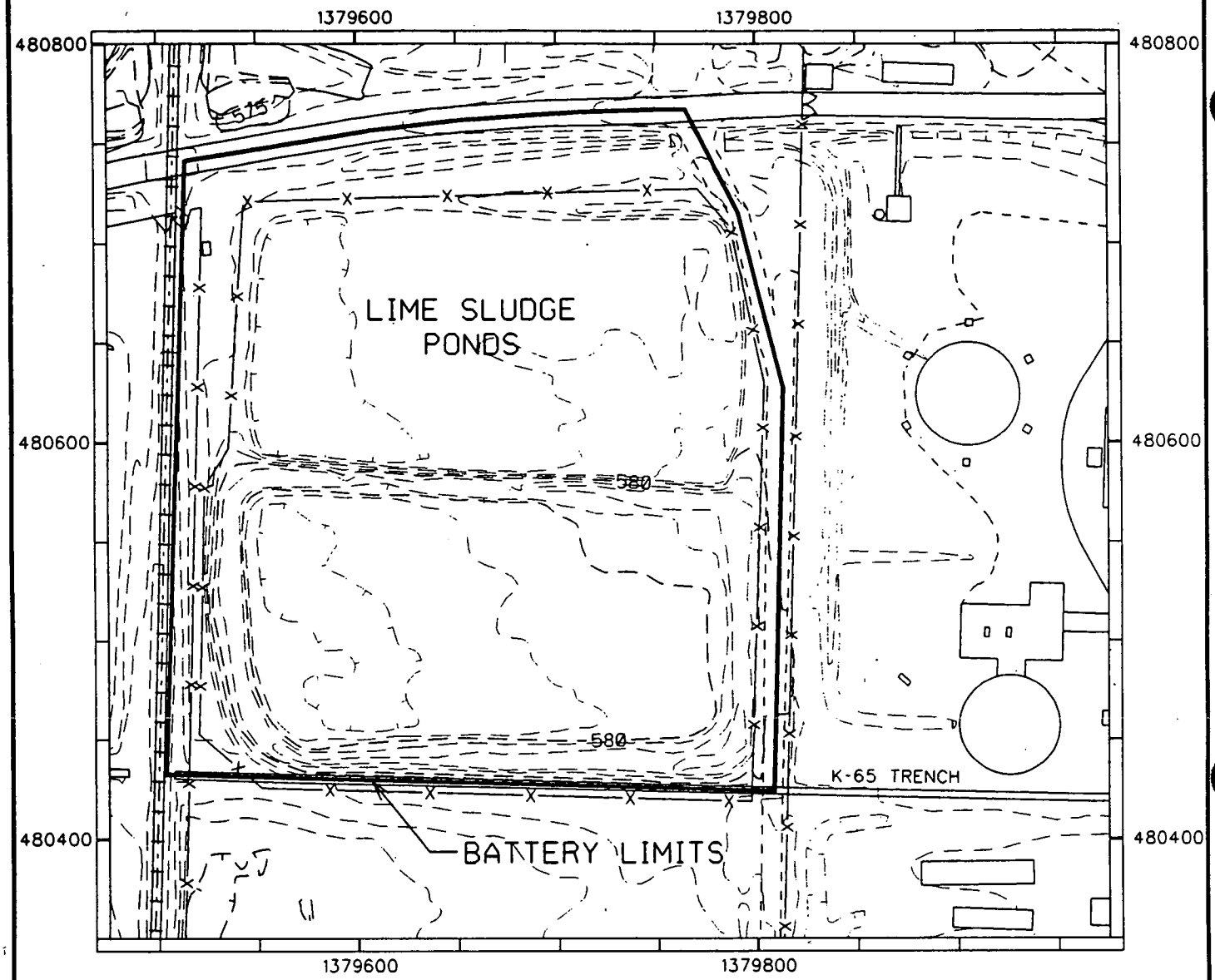
1.6.2.1 Description and History

The North Lime Sludge Pond is an unlined pond with dimensions of approximately 38 by 69 m (125 by 226 ft). The North Lime Sludge Pond began operations in 1984 and is still active. The residual lime sludge is estimated to have an average depth of 1.6 m (5.3 ft). Typically, the pond contains free-standing water above the lime sludge, with the depth depending on precipitation and plant operations. Often, water collects in the western portion of the pond, which is its topographic low point.

The South Lime Sludge Pond is a dry, unlined pond which also has dimensions of approximately 38 by 69 m (125 by 225 ft), as shown in Figure 1-16. The South Lime Sludge Pond began operations in 1952 and continued until 1964. The residual lime sludge has an estimated average depth of 3.4 m (11.2 ft). Currently, the South Pond is overgrown with grass and shrubs.

Lime sludge, which was disposed of in the North and South Lime Sludge Ponds, was generated from three waste streams. These waste streams originated from the (1) water plant operations, (2) coal pile storm water runoff, and (3) boiler plant blowdown.

The waste stream from the water plant operations originates from a water-softening process which consists of lime precipitation of calcium and magnesium salts. Aluminum sulfate is also added in the softening process to induce colloid entrapment and charge neutralization. Approximately 0.76 cubic meter (cu m) [1 cubic yd (cu yd)] of lime sludge is generated and pumped from the water-softening



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- BATTERY LIMITS

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100

SCALE (FT)
0 12 24

000094

fs0334.dgn

FIGURE 1-16
TOPOGRAPHY OF THE LIME SLUDGE PONDS

clarifiers to the General Sump daily. The existing water-softening system has been in operation since the early 1950s and has provided the site with potable water and boiler feed water.

The waste stream from the coal pile storm water runoff control system consists of storm water runoff collected from the coal pile. Storm water runoff from the coal pile is collected in the storm water retention basin, which is a small unlined pond. The solids in the basin are allowed to settle and the water is decanted to Tanks 6 and 7 of the General Sump as needed.

The waste stream from the boiler plant blowdown consists of backflush water from the boilers at the coal plant. The boilers are backflushed to prevent scale build-up. This waste stream is sent to Tanks 6 and 7 of the General Sump.

Currently, sludge from the above three sources is allowed to accumulate in the General Sump for approximately two weeks. While there, the sludge is circulated through Tanks 6 and 7, where it is partially de-watered. Polymers are also added to induce sludge thickening. At the end of two weeks, the resultant slurry batch of approximately 20,000 gallons is pumped to the North Lime Sludge Pond. Over time, the solids in the slurry settle by gravity and the remaining decant is pumped from the pond back through the General Sump (Tank 14), where it is sampled and analyzed. Based on the analytical results, the water is discharged to the Great Miami River via Manhole 175 or treated, as required, prior to discharge.

The Lime Sludge Ponds were identified as RCRA Subtitle C Hazardous Waste Management Units (HWMUs) in the FEMP RCRA permit application of June 1991, based on the belief that the ponds received a F-listed hazardous waste, 1,1,1-trichloroethane (TCA), after July 26, 1982. This belief was based on an assumption that TCA was discharged to the water treatment system at a concentration greater than 25 parts per million (ppm). Based upon revised calculations, on May 13, 1993, FERMCO proposed that the FEMP permit application be modified to reclassify the Lime Sludge Ponds as Solid Waste Management Units (SWMUs). OEPA concurred with the reclassification on June 7, 1993.

1.6.2.2 Geology and Hydrogeology

Borings and monitoring wells were completed to record the lithology of the subsurface strata, determine concentrations of various chemical constituents in groundwater, and determine groundwater

elevations. Based on the lithologic descriptions from the boring logs, a general description of the strata below the Lime Sludge Ponds was determined and is shown in Figure 1-17.

The geology of Lime Sludge Ponds area consists of a 9 to 12 m (30 to 40 ft) thick layer of glacial till which overlays the Great Miami Aquifer and consists primarily of clay containing some sand and gravel. The clay appears as a stiff yellowish-brown clay that grades downward into a stiff gray clay. The depth at which this transition occurs is approximately 2 m (7 ft) at Boring Nos. 1039 and 2042.

A sand lens, detected in the glacial till at Boring Nos. 1039 and 2042, may extend continuously beneath the Lime Sludge Ponds. The sand lens occurs at a depth of 5.7 m (19 ft) at Boring No. 1039 and at a depth of approximately 5 m (16.5 ft) at Boring No. 2042. This zone is approximately 1.22 m (4 ft) thick and appears to be continuous from northeast to southwest beneath the entire North Pond and through the western portion of the South Pond.

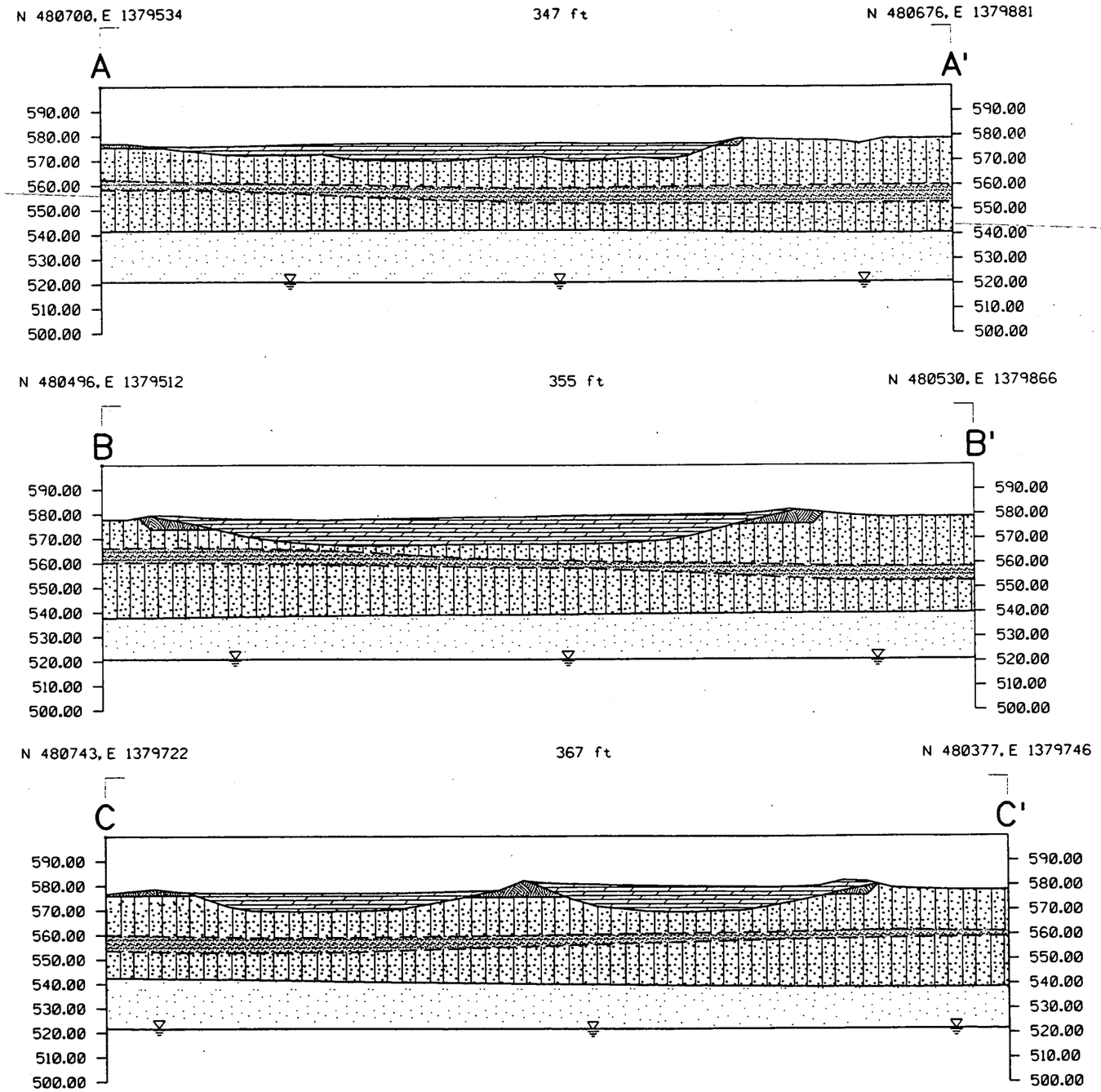
The Great Miami Aquifer underlies the glacial till deposits and consists of glacial outwash deposits containing sand and gravel. The Great Miami Aquifer consists of both an upper and a lower unit, but only the upper aquifer was penetrated by borings or monitor wells in the Lime Sludge Ponds area. The deepest boring in the area, Boring No. 2042, terminated at a depth of 20.7 m (68.0 ft) in the upper aquifer.

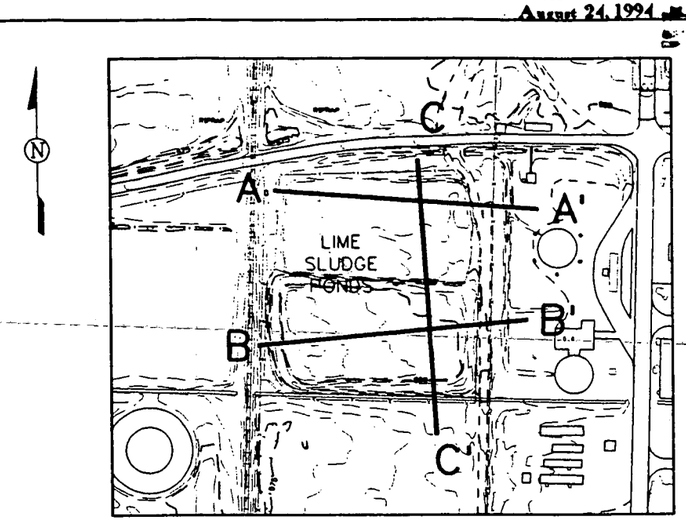
In the vicinity of the Lime Sludge Ponds, the groundwater elevation of the Great Miami Aquifer averages approximately 157 to 158 m (515 to 520 ft) MSL throughout the year [approximately 16 m (52 ft) below the ground surface]. Groundwater flow is to the east/southeast.

1.6.3 Inactive Flyash Pile

The Inactive Flyash Pile is located approximately 610 m (2,000 ft) southwest of the former Production Area and is shown in Figure 1-18. Its western boundary is defined by Paddys Run, which parallels the area for approximately 61 m (200 ft). An access road (Access Road B) and a natural drainage ditch leading to Paddys Run form the Inactive Flyash Pile's northern border. The Inactive Flyash Pile is bordered on the east by the South Field. The running track/firing range area forms the southern boundary of the Inactive Flyash Pile.

000096





LOCATION KEY (1" = 200')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- BERM
- LIME SLUDGE
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface Contours based on 1992 flyover.

SCALE:
HORIZONTAL 1' = 50'
VERTICAL 1' = 50'

0 25 50 100

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

0 6 12 24

000097

FIGURE 1-17
GEOLOGIC CROSS SECTIONS
LIME SLUDGE PONDS

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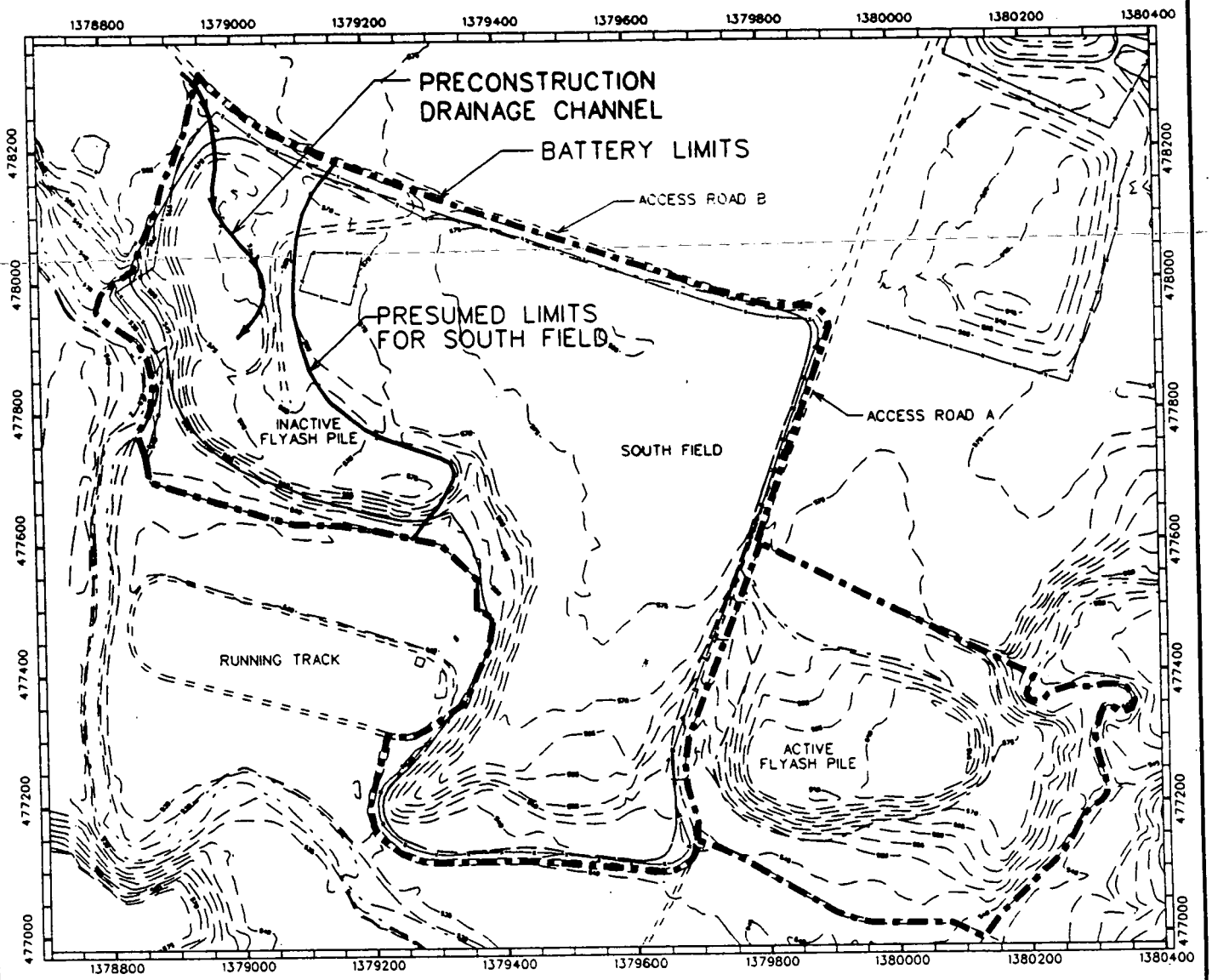
5857



LEGEND
- 575 ELEVATION CONTOURS
- ROADS
- STREAM
- BATTERY LIMITS
- FENCE

N

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FEET)
0 250 500

SCALE (METER)
0 60 120

fig0110.dgn

FIGURE 1-18
SOUTH FIELD AND FLYASH PILES

000038

1.6.3.1 Description and History

The Inactive Flyash Pile received flyash and bottom ash from boiler plant operations starting in 1951. It has been inactive since the mid-1960s and is covered with soil and natural vegetation. The total quantity of ash disposed in this area has been estimated at 33,300 cu m (43,600 cu yd). Materials such as building rubble, concrete, asphalt, steel rebar, and asbestos containing transite were also discarded in this area. These materials are visible at the surface along the Inactive Flyash Pile's western and southern edge.

In accordance with the Amended Consent Agreement, a removal action was completed on December 23, 1991, to establish institutional controls at the Inactive Flyash Pile to prevent unauthorized entry. These controls included installation of chain barrier fencing and posting of radiological "Controlled Area" signs around the perimeter of the Inactive Flyash Pile and the adjacent South Field. Additional removal activities were conducted during the spring of 1992 and the summer of 1993. The 1992 action was performed to control radioactive "hot spots" located within the boundary of the chain barrier fence. These activities, described in greater detail in Section 1.8, included field surveys to identify radioactive hot spot areas and retrieve contaminated debris. The 1993 action was performed to stabilize a portion of Paddys Run stream bank to prevent Paddys Run from undercutting the Inactive Flyash Pile.

Natural ground-surface elevations range from approximately 177 m to 165 m (580 ft to 540 ft) MSL across the Inactive Flyash Pile and South Field from the north to the south and southwest. The western and southern edges of the Inactive Flyash Pile slope steeply toward Paddys Run and the running track, respectively. The south-central portion of the Inactive Flyash Pile slopes gently toward the South Field in an area where a man-made drainage feature forms a mutual border. Historical photographs and pre-site topographical surveys indicate that ash and soil fill were disposed on top of the natural ground surface in the Inactive Flyash Pile to depths of approximately 0.5 m to 7.6 m (1.5 to 25 ft), thereby raising the ground surface elevation in these areas to approximately 175 m (575 ft) MSL. Soil fill of approximately 0.3 to 1 m (1 to 3 ft) was then placed as cover over the disposed material. As a result of this recontouring, the primary surface water runoff pattern is to the south and the west.

1.6.3.2 Geology and Hydrogeology

Boring logs indicate that the glacial till beneath the Inactive Flyash Pile is composed primarily of silty clay interbedded with lenses of clay, and silt, sandy clay, and silty sand. Measured from the natural ground surface, the till is approximately 6 to 9 m (20 to 30 ft) thick along the Inactive Flyash Pile's northern perimeter (Boring Nos. 1047 and 1046). Till thickness generally decreases to the south and west perimeters, at which point sand and gravel outcrops from the Great Miami Aquifer are exposed at the surface. Geologic cross-sections are provided in Figures 1-19 and 1-20. Figure 1-21 depicts the thickness of till within the Inactive Flyash Pile.

Based on water-level measurements obtained from Well Nos. 1711, 2047, 2046, 2385, and 1516, groundwater elevations within the Great Miami Aquifer can range from approximately 158 to 160 m (520 to 525 ft) MSL beneath the Inactive Flyash Pile area. Flow direction is generally to the east. Perched groundwater has also been observed in the northwest portion of the area and can range annually from approximately 171 to 175 m (560 ft to 574 ft) MSL. The flow direction in the perched zone is to the south and west.

1.6.4 South Field

The South Field disposal area is located approximately 610 m (2,000 ft) southwest of the former Production Area and covers approximately 4.5 ha (11 ac). The area is shown in Figure 1-18. Its western boundary is defined by the Inactive Flyash Pile. Access Road B and a natural drainage ditch leading to Paddys Run form the South Field's northern border. The South Field is bordered on the east by Access Road A. Access Road A runs from the parking lot south of the former Production Area to the running track/firing range area and separates the Active Flyash Pile to the east from the South Field to the west. The running track/firing range area forms the southwestern boundary of the South Field.

1.6.4.1 Description and History

The South Field was used as a burial site for construction rubble and as a disposal area for soil excavated from the former Production Area. Disposal activity ceased during the mid 1960s. Soil, building rubble, concrete, asphalt, flyash, and steel rebar were encountered during sampling operations within the soil fill in the South Field. Historical photographs, topographical maps, and borehole logs have been used to estimate the volume of fill disposed in the South Field at approximately 91,800 cu m (120,000 cu yd).

The southwest edge of the South Field forms a soil embankment that is located adjacent to the FEMP firing range. The embankment is down range from the target area which, until 1989 when range use ceased, had been used for over 35 years by FEMP site security as a catchment area for lead ammunition. Based on sample recovery, the embankment includes an estimated 230 cu m (300 cu yd) of soil containing spent lead ammunition.

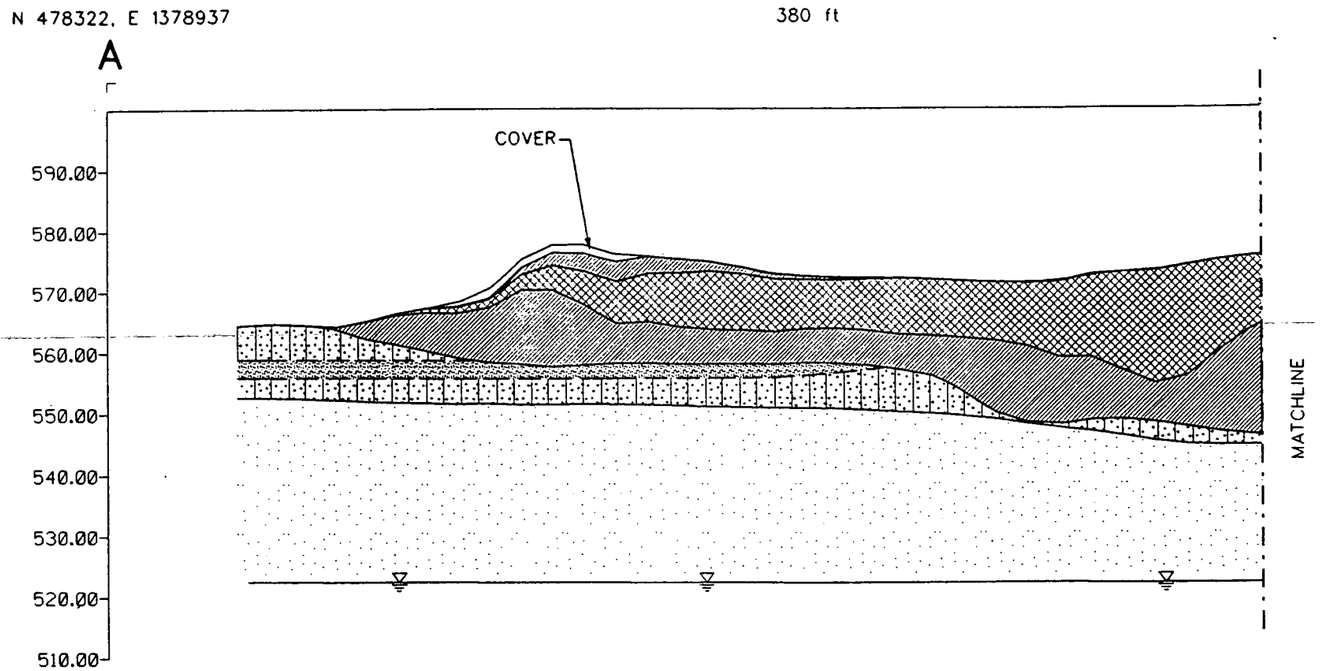
In accordance with the Consent Agreement, a removal action was completed on December 23, 1991, to establish institutional controls in the South Field to prevent unauthorized entry. These controls included installation of chain barrier fencing and posting of radiological "Controlled Area" signs around the perimeter of the adjacent Inactive Flyash Pile and the South Field. Additional activities were conducted during the spring of 1992 to control radioactive hot spots located within the boundary of the chain barrier fence. These activities, described in greater detail in Section 1.8, included field surveys to identify radioactive hot spot areas and retrieve contaminated debris.

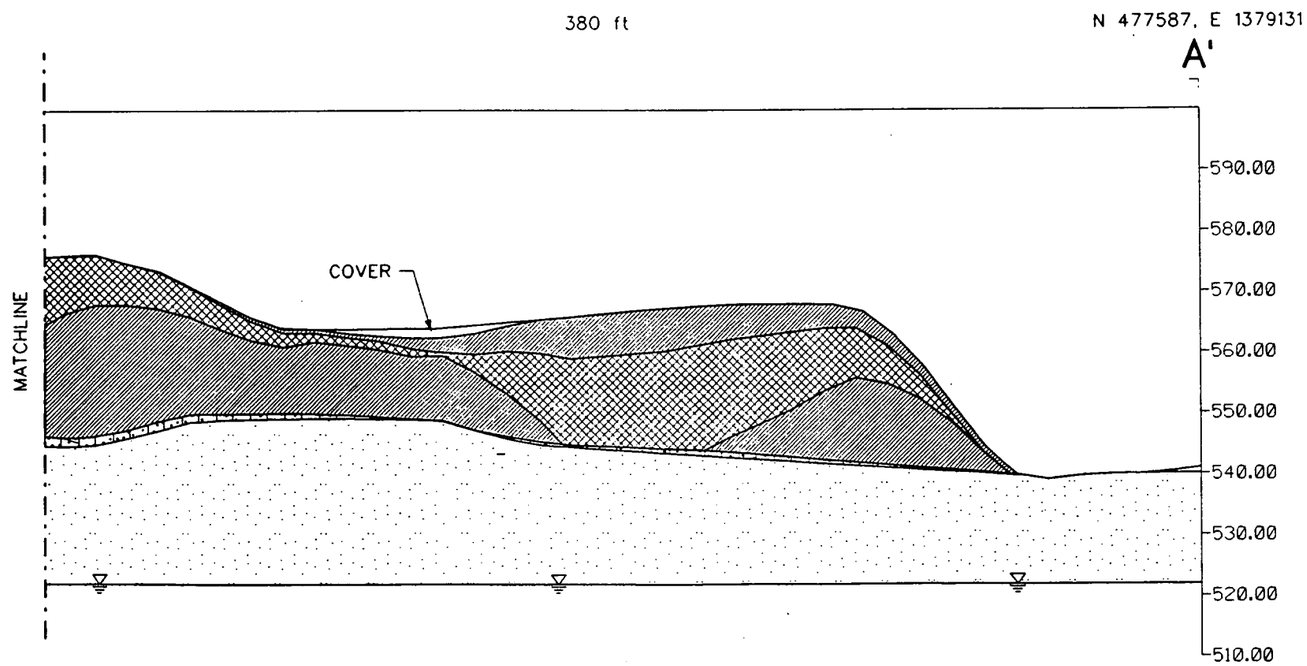
Natural ground-surface elevations range from approximately 177 to 165 m (580 to 540 ft) MSL across the South Field from the north to the south and southwest. The north-central portion of the South Field also slopes gently toward the Inactive Flyash Pile in an area where a man-made drainage feature forms a mutual border. Historical photographs and pre-site topographical surveys indicate that rubble/soil fill was disposed on top of the natural ground surface in the South Field's western and southern areas to depths of approximately 0.5 to 1.2 m (1.5 to 4 ft), thereby raising the ground-surface elevation in these areas to approximately 175 m (575 ft) MSL. Soil fill of approximately 0.3 to 1 m (1 to 3 ft) was then placed as cover over the disposed material. As a result of this recontouring, the primary surface water runoff pattern is to the south and the east.

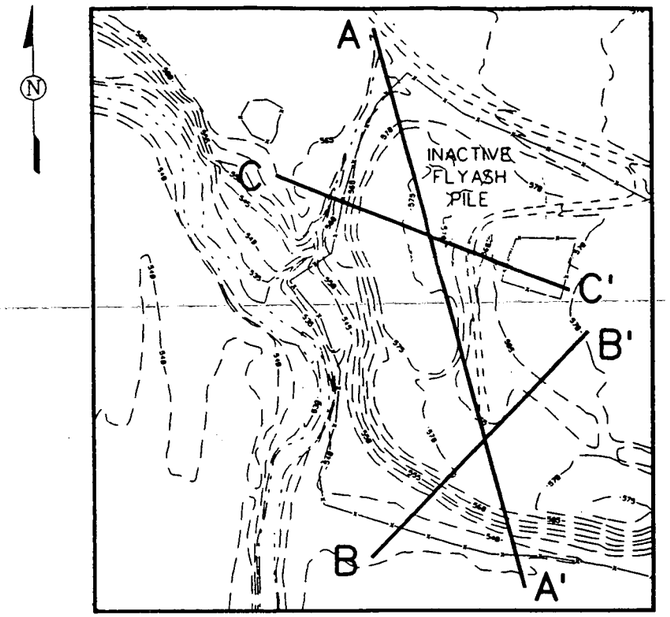
1.6.4.2 Geology and Hydrogeology

Boring logs indicate that the glacial till beneath the South Field is composed primarily of silty clay interbedded with lenses of clay and silt, sandy clay, and silty sand. Measured from the natural ground surface, the till is approximately 6.1 to 9.2 m (20 to 30 ft) thick along the South Field's northern perimeter (Boring Nos. 1047 and 1046). Till thickness generally decreases to the south and west perimeters, at which point sand and gravel outcrops from the Great Miami Aquifer are exposed at the surface. Figure 1-21 provides the thickness of till for the South Field. Figures 1-22 through 1-26 show geologic cross sections of the South Field.

000101







LOCATION KEY (1" = 200')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

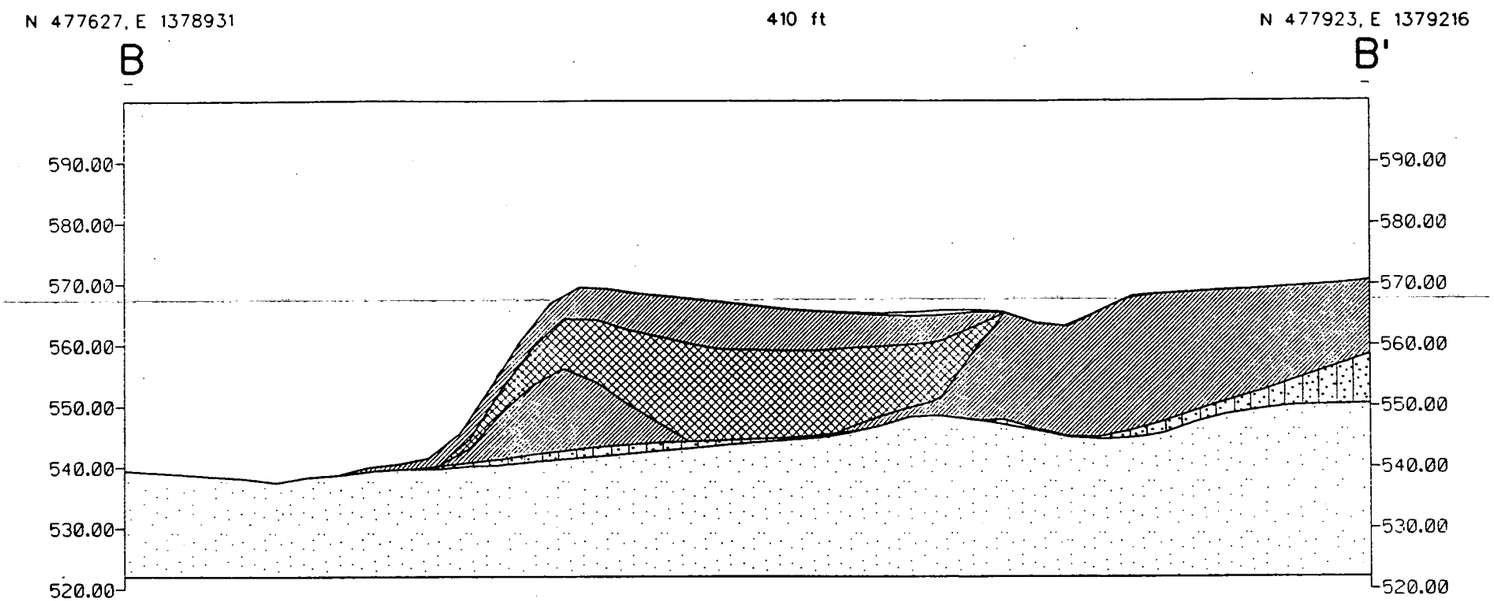
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

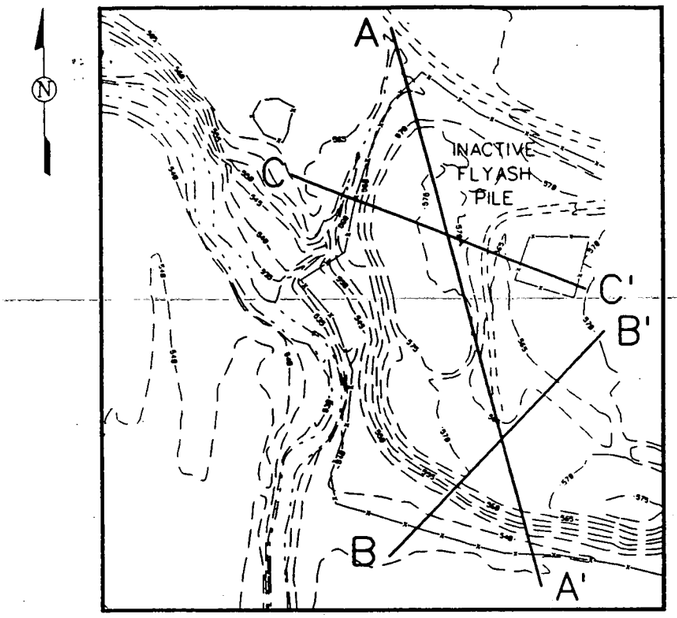
0 6 12 24

fs1129.dgn

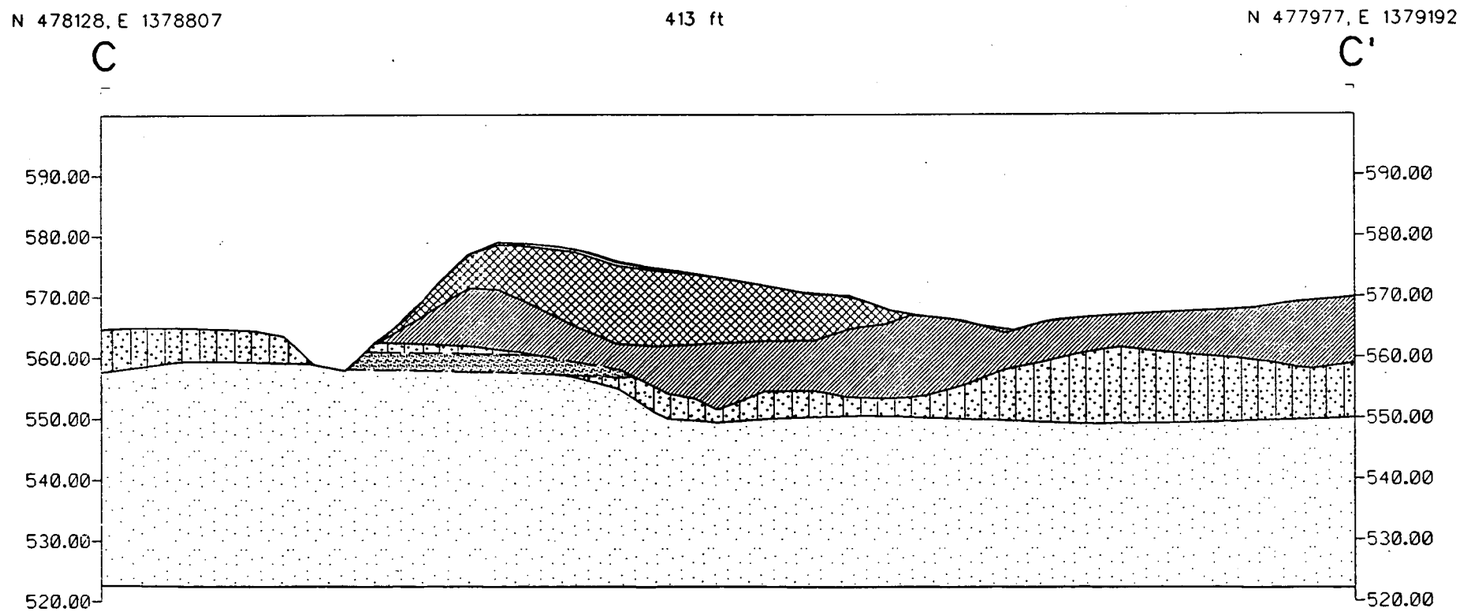
000102

FIGURE 1-19
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 1 OF 2





LOCATION KEY (1" = 200')



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

000103

HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

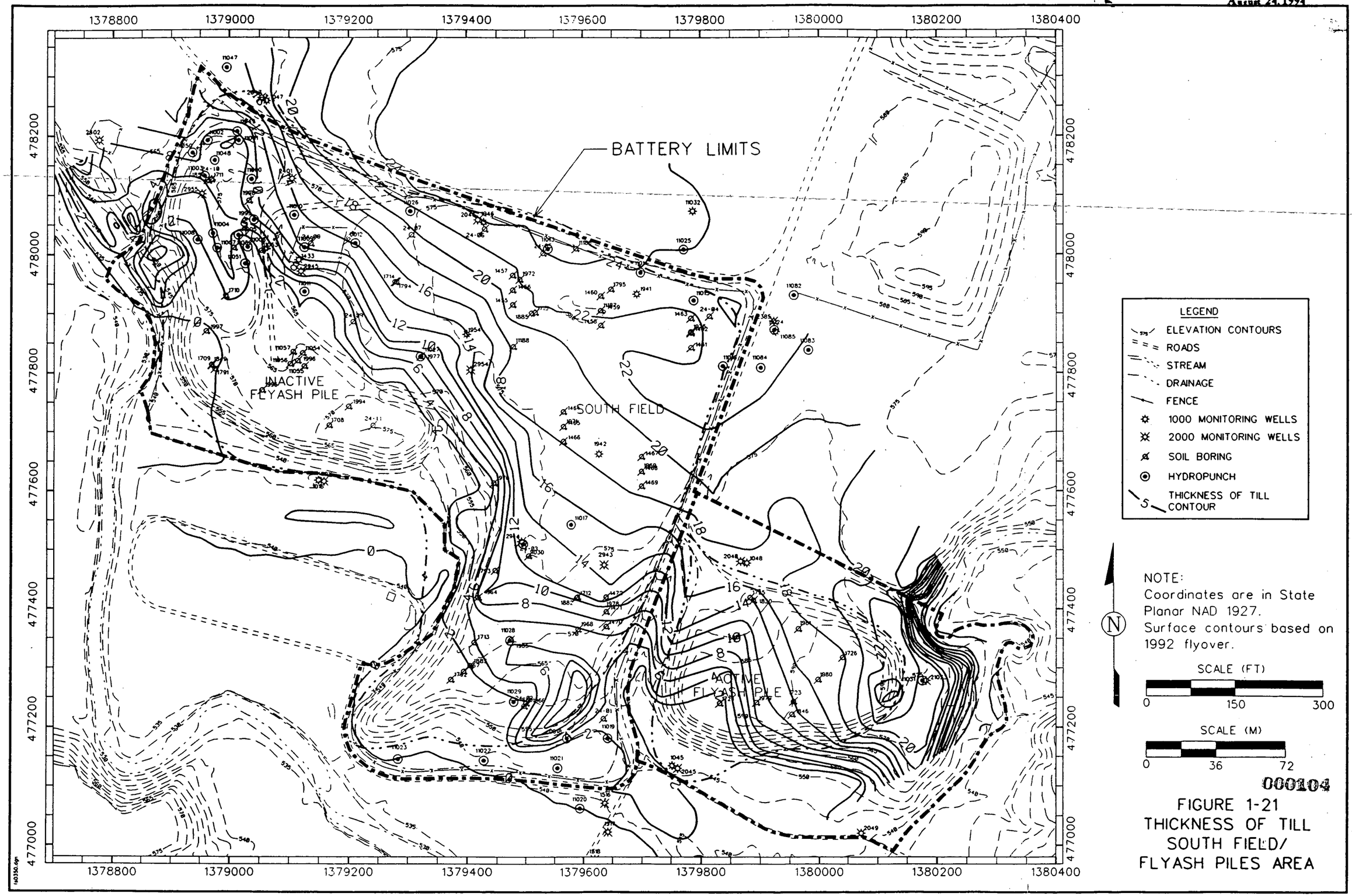
0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

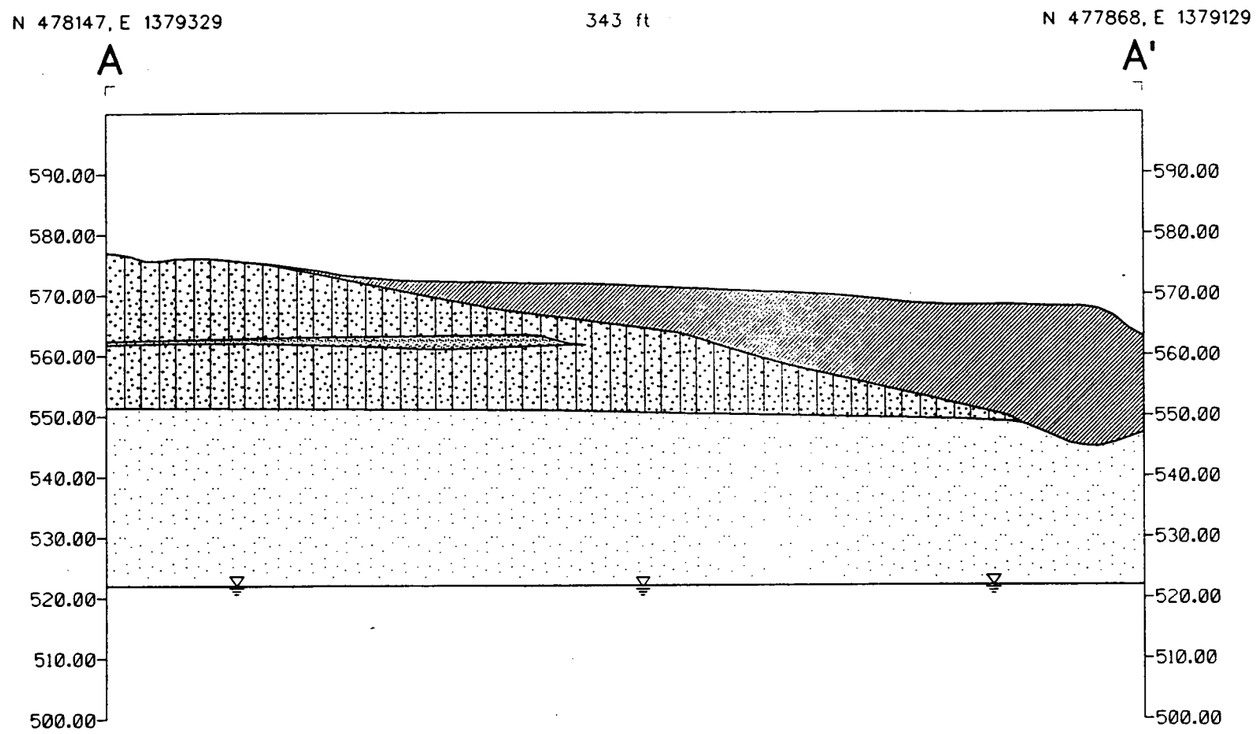
FIGURE 1-20
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 2 OF 2

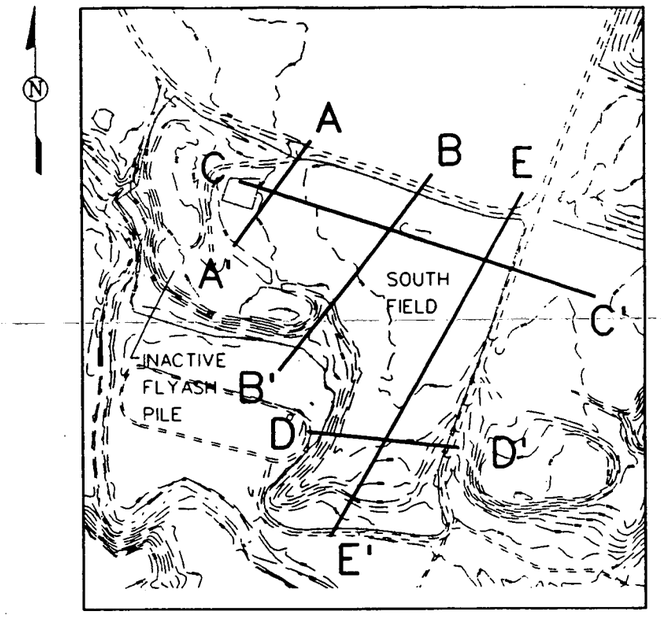
fs1128.dgn



000104

FIGURE 1-21
THICKNESS OF TILL
SOUTH FIELD/
FLYASH PILES AREA





LOCATION KEY (1" = 400')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

000105

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

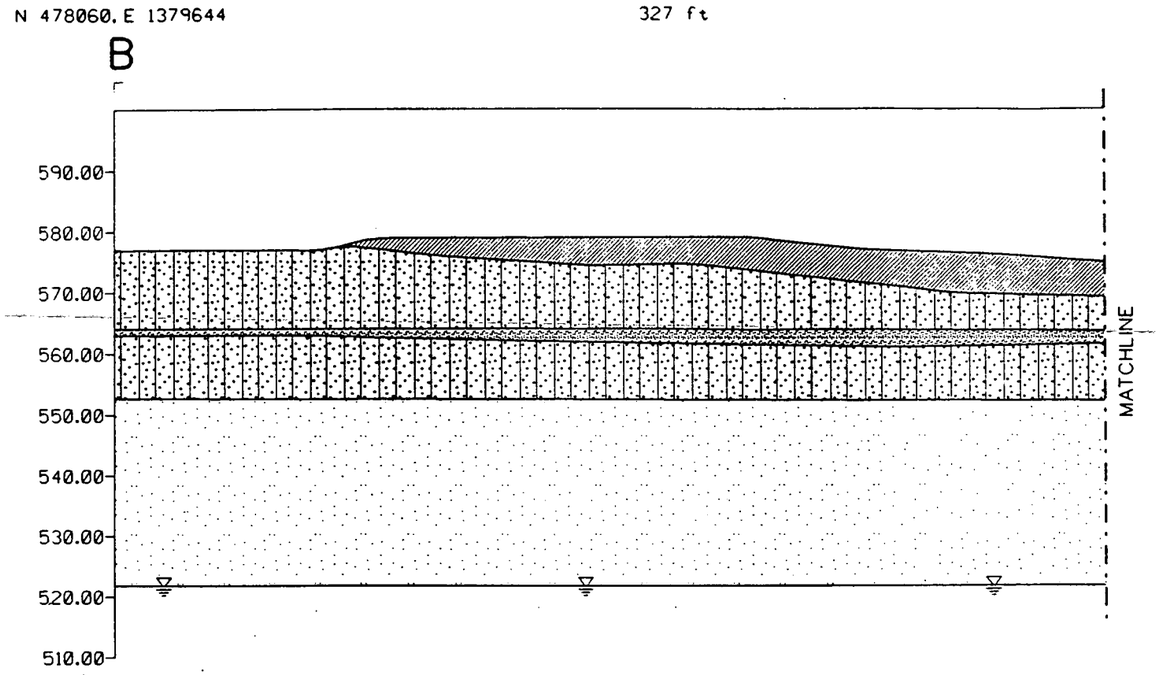
0 25 50 100

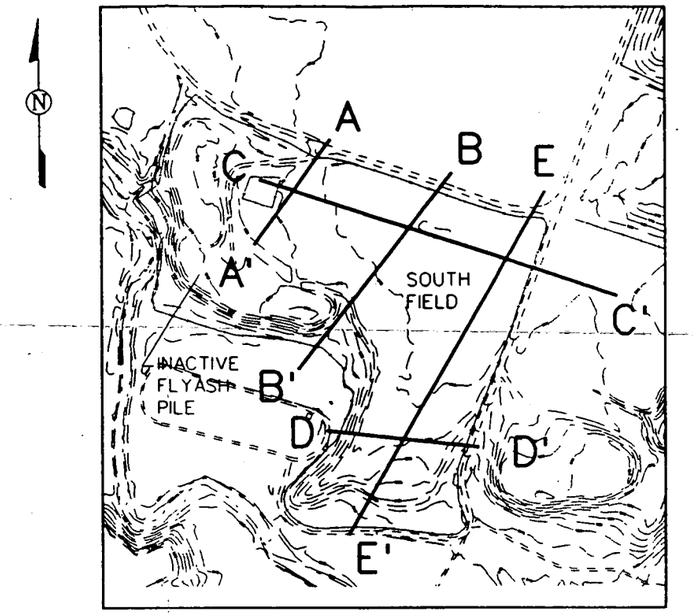
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

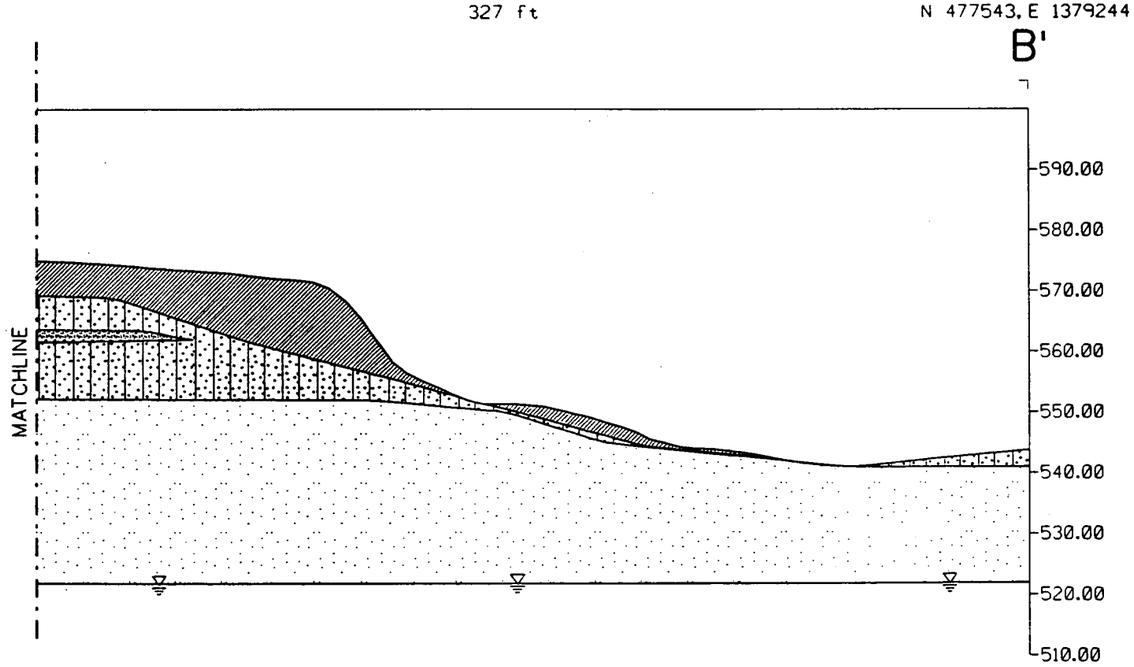
FIGURE 1-22
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 1 OF 5

fs1145.dgn





LOCATION KEY (1" = 400')



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

000106

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

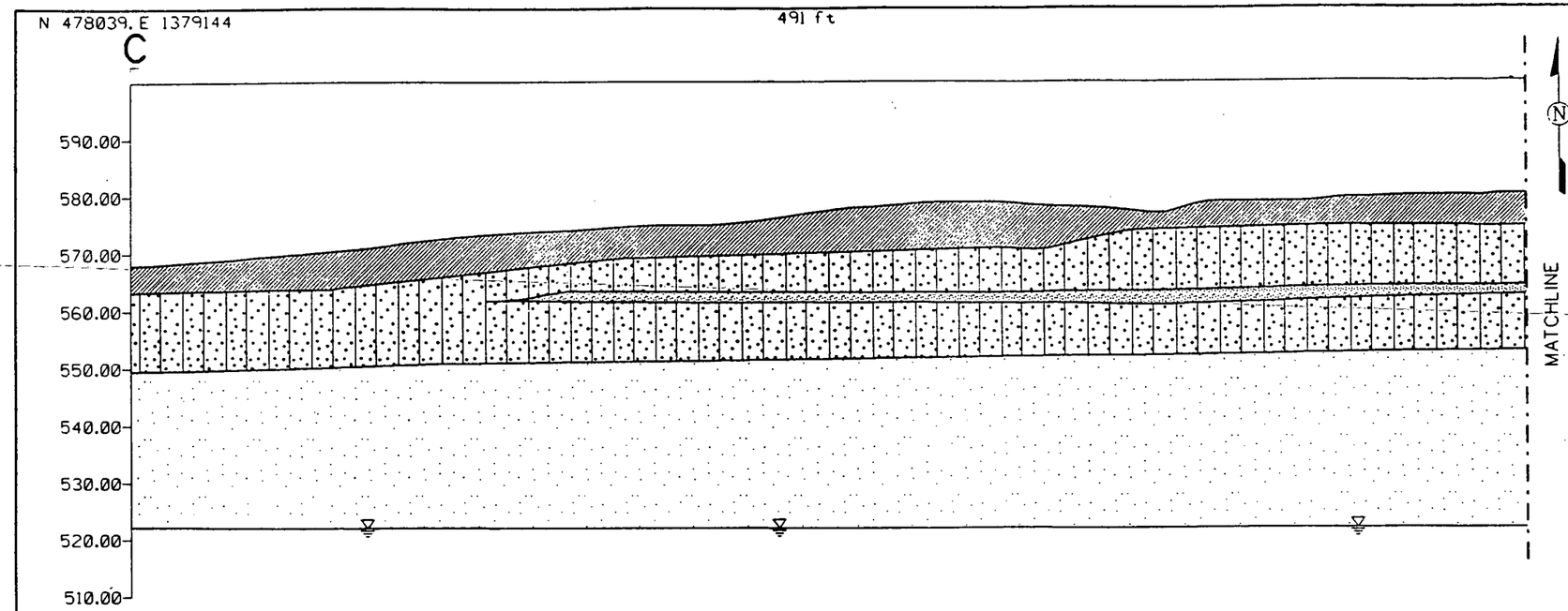
0 25 50 100

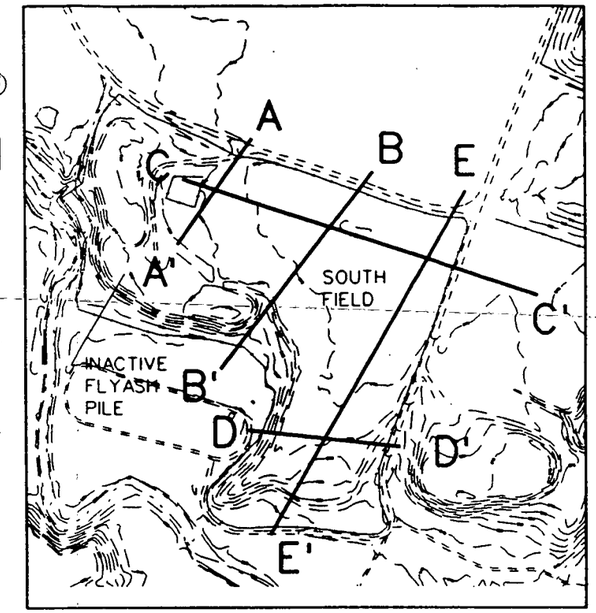
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

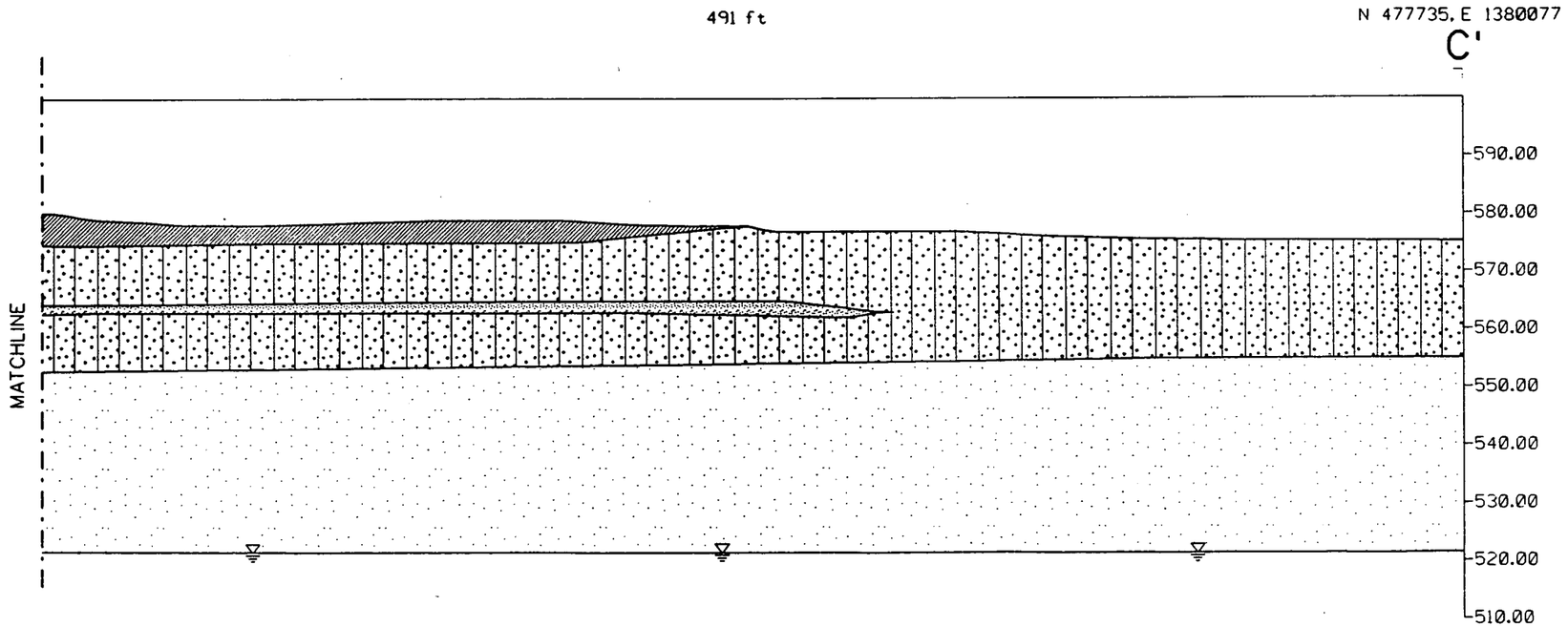
FIGURE 1-23
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 2 OF 5

fs1130.dgn





LOCATION KEY (1" = 400')



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

000107

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

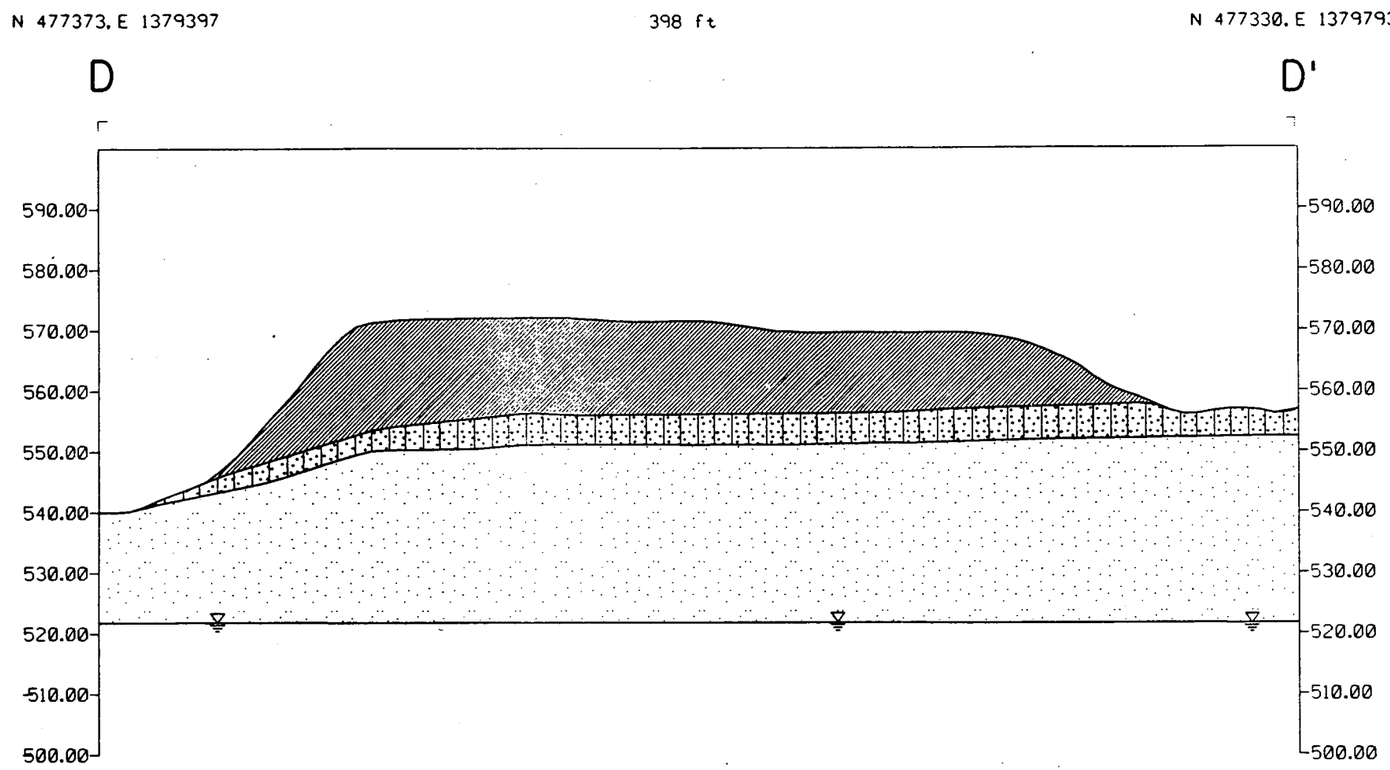
0 25 50 100

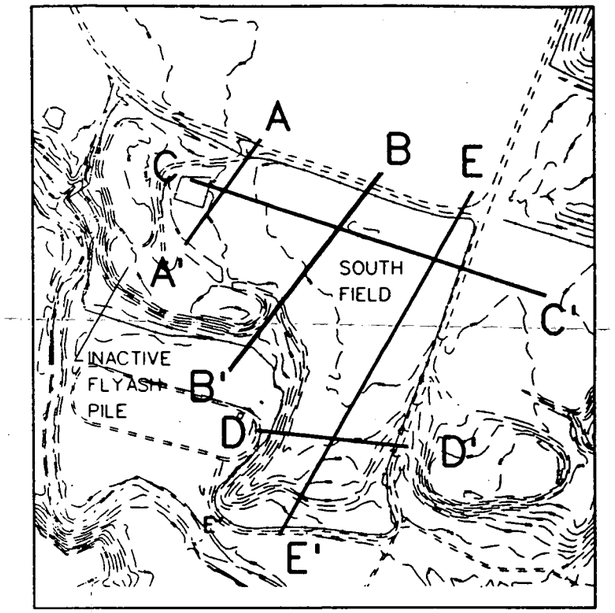
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

FIGURE 1-24
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 3 OF 5

fs1131.dgn





LOCATION KEY (1" = 400')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

000108

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

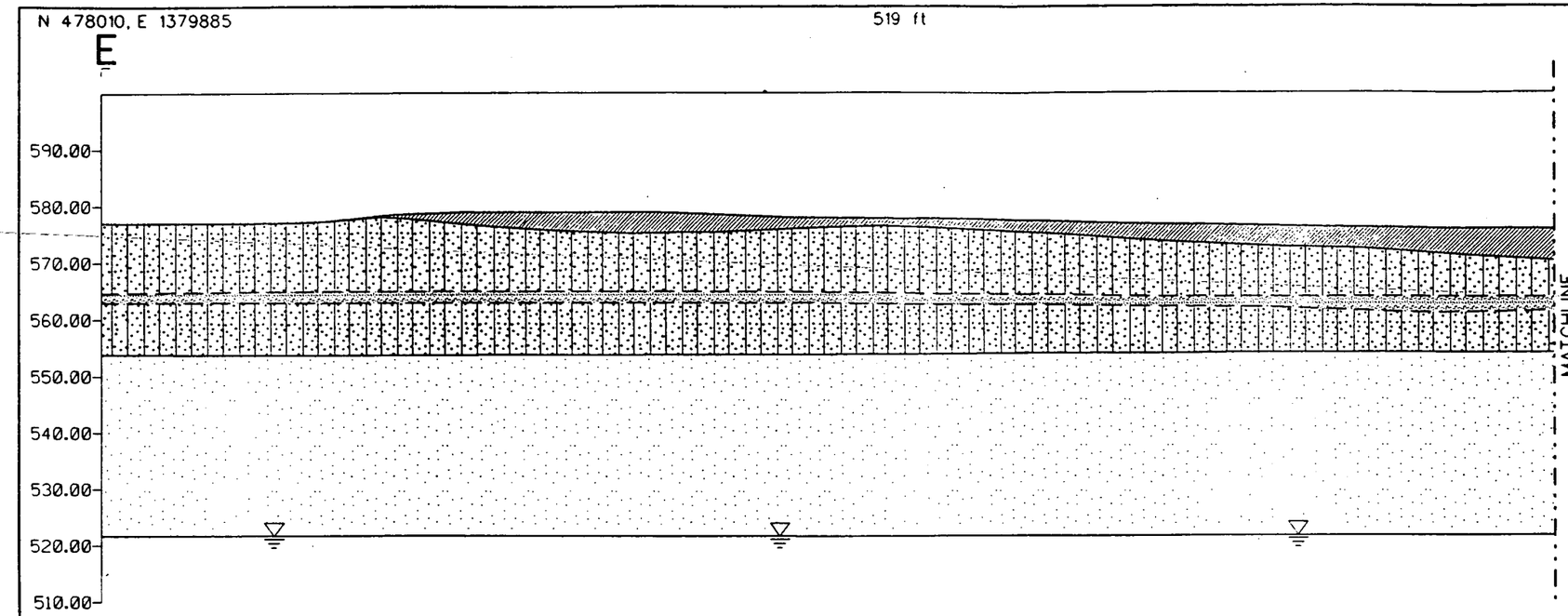
0 25 50 100

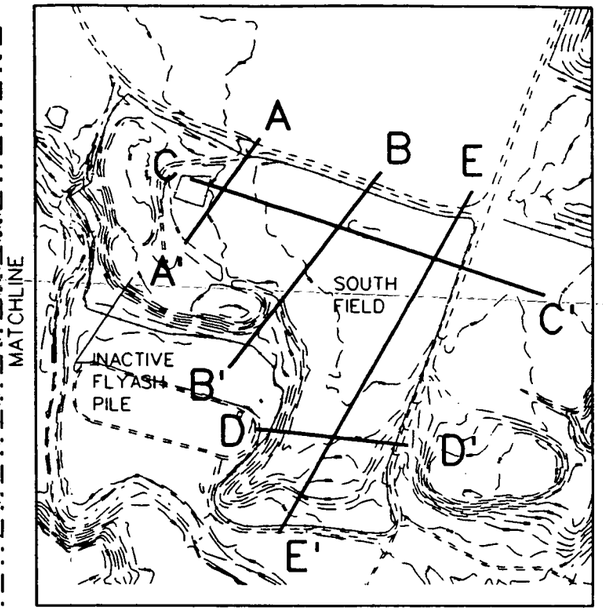
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

FIGURE 1-25
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 4 OF 5

fs1146.dgn





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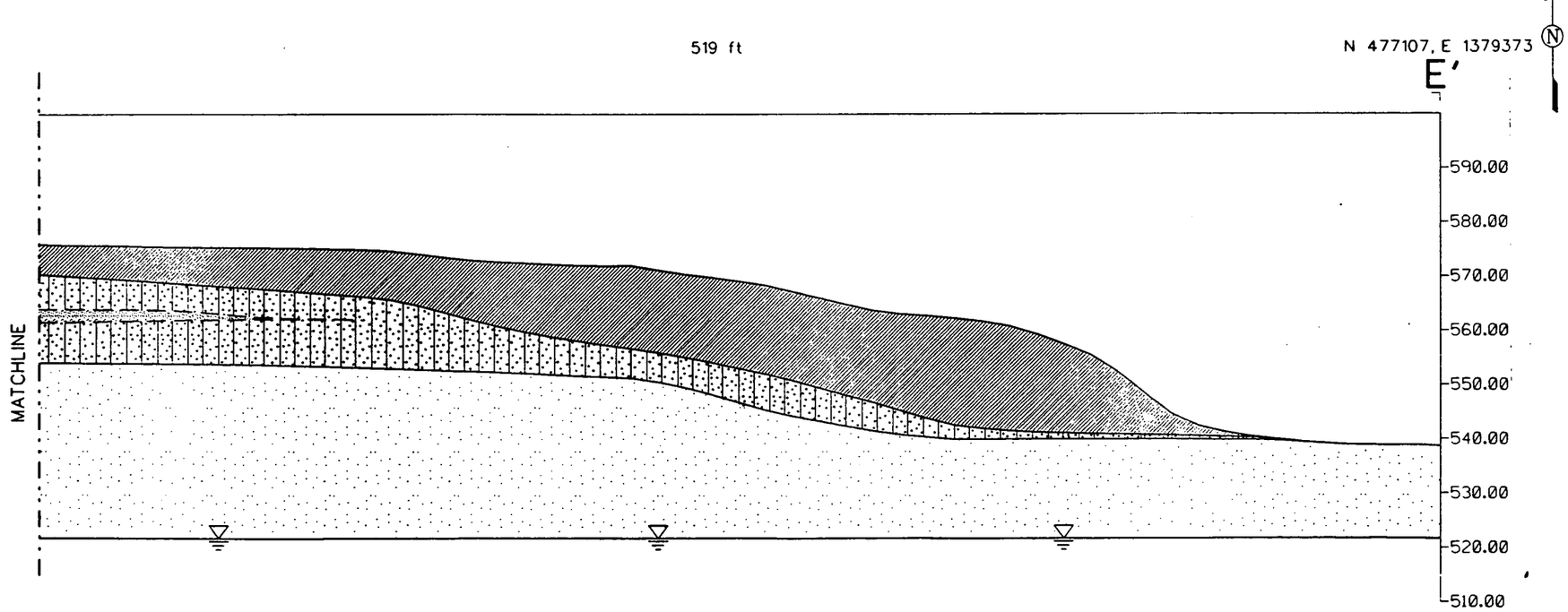


LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

000109

FIGURE 1-26
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 5 OF 5

Based on water-level measurements obtained from Well Nos. 1711, 2047, 2046, 2385, and 1516 groundwater elevations within the Great Miami Aquifer range from approximately 158 to 160 m (520 to 525 ft) MSL in the South Field area. Flow direction is generally to the east. Perched groundwater has also been observed in the northwest portion of the area and can range annually from approximately 171 to 175 m (560 to 574 ft) MSL. The flow direction in the perched zone is to the south and west.

1.6.5 Active Flyash Pile

The Active Flyash Pile disposal area is located about 914 m (3,000 ft) southwest of the former Production Area and east of the South Field, as shown on Figure 1-18.

1.6.5.1 Description and History

Past operations at the FEMP have relied on boiler-produced steam for heat and laundry facility operation and to support uranium metal production. In 1989, uranium metal production was discontinued. Since that time, steam production has been used for heating purposes only. The FEMP's two coal-fired boilers combust an average of 40 tons of coal per day during the spring/summer and 87 tons of coal per day during the fall/winter.

Coal analysis indicates that the Kentucky bituminous coal purchased for use at the FEMP has an ash content of approximately 8 percent. Ash is a by-product of combustion, produces no heat, and must be periodically removed from the boiler-plant furnace. Coal combustion at the FEMP generates approximately seven tons of ash waste per day during the fall/winter and approximately three tons per day during the spring/summer. Ash waste is comprised primarily (70 percent) of bottom ash collected below the boilers. Precipitator ash collected from pollution control devices and flyash removed from the middle levels of the boiler comprise the remaining 30 percent of the ash waste. Until recently, ash waste had been loaded into dump trucks and transported to the Active Flyash Pile disposal area.

The Active Flyash Pile has received ash waste since the mid-1960s. Estimates established for inclusion in the Operable Unit 2 RI indicate that approximately 49,700 cu m (65,000 cu yd) of ash have been disposed in this area. The pile has a surface area of approximately 1.6 ha (4 ac), with an exposed working surface gently sloping downward in a northerly direction and steeply sloped sides (greater then 45 degrees) on its eastern and southern ends. Ash pile thickness ranges from 1 to 12 m

(3 to 40 ft). The Storm Sewer Outfall Ditch, a natural drainage course that formerly received uncontrolled plant storm water runoff, borders the Active Flyash Pile on the east and south and lies along steeply sloped terrain just beyond the Active Flyash Pile perimeter (Figure 1-18). The Active Flyash Pile has never been covered and surface vegetation is negligible.

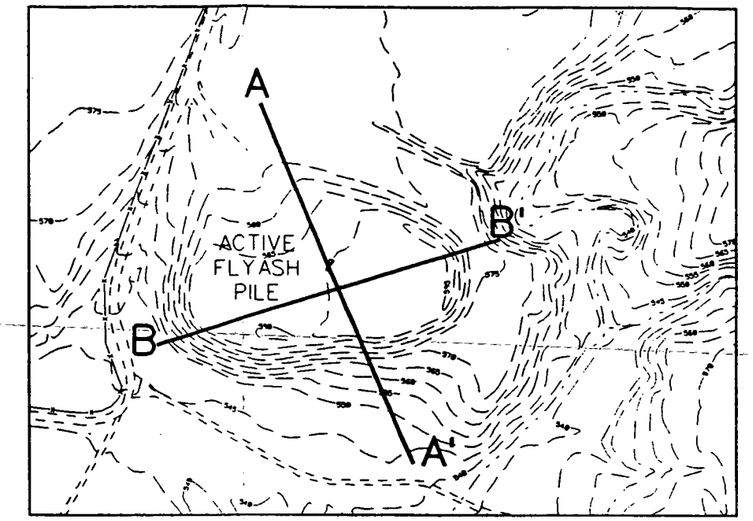
On June 4, 1992, interim control activities to provide protection against wind and storm water erosion from the piles surface were initiated. These control activities, described in greater detail in Section 1.8, included surface crusting agent application on the pile's steep side slopes and misting of the pile's working face with a dust control binder during regrading and compaction operations. Following completion of these activities, installation of silt fencing and wind barriers was completed on June 28, 1992.

1.6.5.2 Geology and Hydrogeology

Boring logs from outside of the Active Flyash Pile's northern and southern perimeters indicate that a series of glacial till deposits overlie the Great Miami Aquifer to a maximum depth of approximately 6.1 m (20 ft) at the northern end. The till deposits are comprised primarily of silty clay interbedded with lenses of clay and silt, sandy clay, silty sand, and poorly sorted gravels. The deposits generally decrease in thickness toward the Active Flyash Pile's southern end and have been eroded away along the channel of the Storm Sewer Outfall Ditch. Figures 1-27 and 1-28 show cross sections of the geology for the Active Flyash Pile. Thickness of till is presented in Figure 1-21.

Perched groundwater zones have been observed within small beds of well sorted sands and gravels that form part of the glacial till beneath and adjacent to the pile. These water zones vary in terms of areal extent, thickness, and volume. Well Nos. 1048 and 1045 extending into these perched zones indicate that perched water can range from 0.3 to 2.7 m (1 to 9 ft) below the natural ground surface at the pile's northern perimeter and from 0.6 to 2.1 m (2 to 7 ft) at the southern end. These measurements correspond to annual fluctuations of piezometric head of 1.5 and 2.4 m (5 and 7 ft), respectively. Natural ground surface is 174 m (571 ft) MSL at the north end of the Active Flyash Pile and 166 m (545 ft) MSL at the south end.

The Dry Fork and Shandon Tributary portions of the Great Miami Aquifer converge in the vicinity of the Active Flyash Pile and form a natural groundwater flow divide line. Although the location of the divide line fluctuates depending on flow conditions, groundwater flow in the area generally occurs in

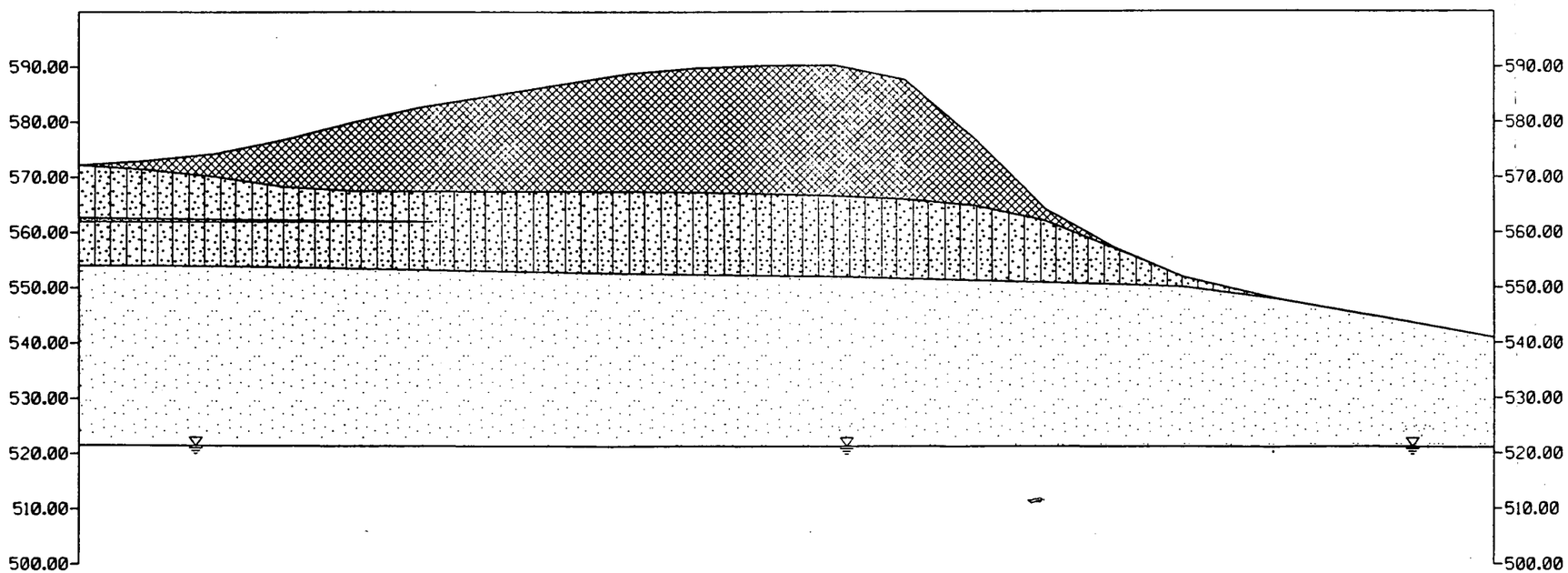


LOCATION KEY (1" = 200')

1379864.477485

513 ft

1380065.477013



SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- FLYASH
- GLACIAL OVERBURDEN/TILL
- SAND/GRAVEL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

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FIGURE 1-27
GEOLOGIC CROSS SECTIONS
ACTIVE FLYASH PILE
SHEET 1 OF 2

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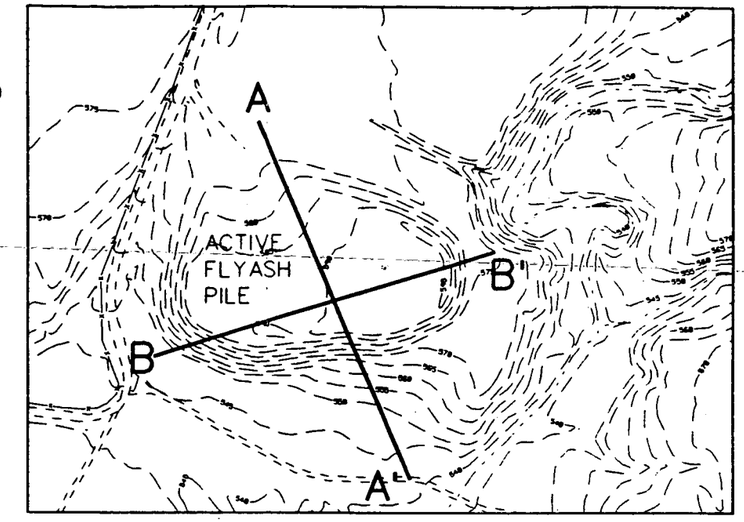
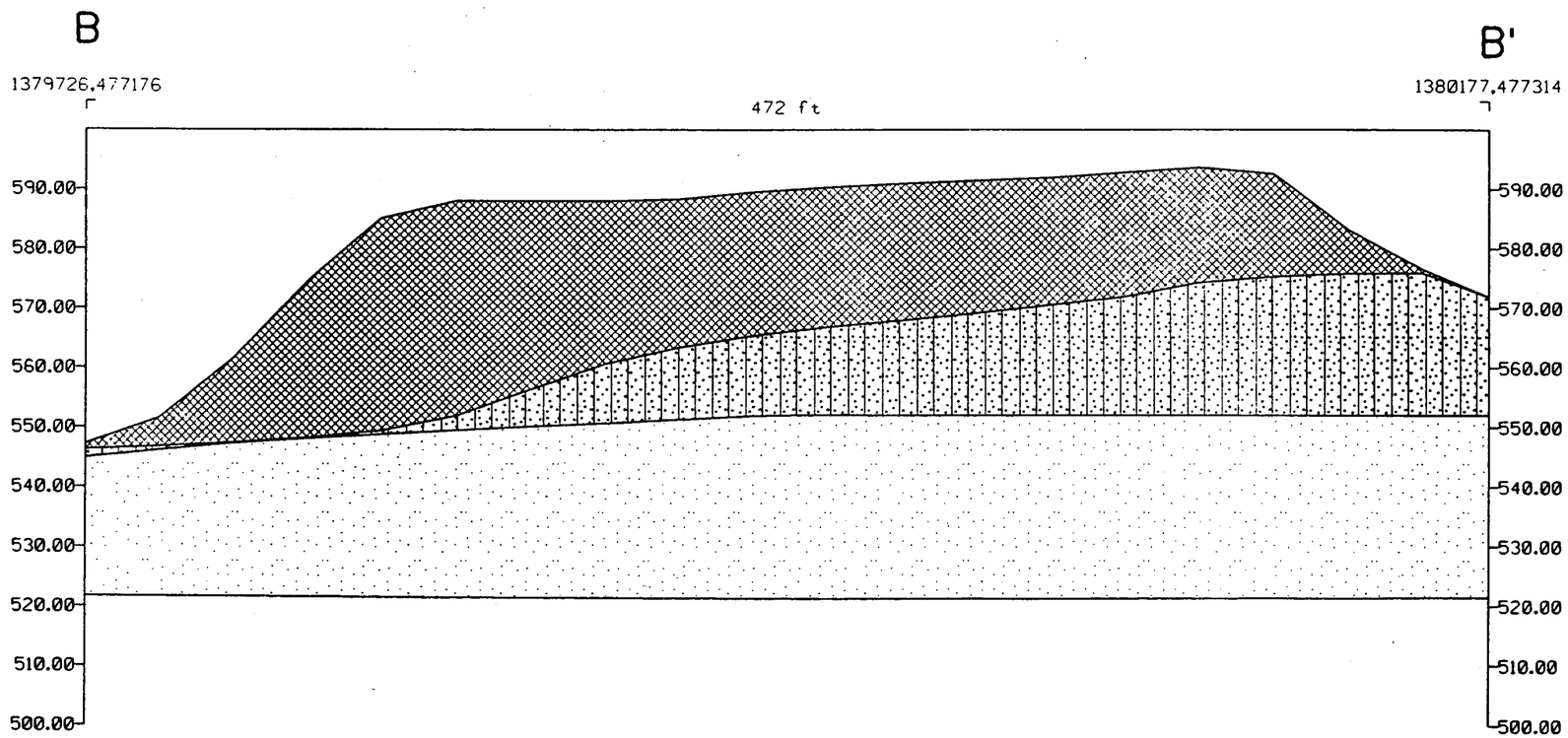


LOCATION KEY (1" = 200')



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- FLYASH
- GLACIAL OVERBURDEN/TILL
- SAND/GRAVEL
- GREAT MIAMI AQUIFER
- LOWER BOUNDARY OF IMPACTED TILL

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

000113

FIGURE 1-28
GEOLOGIC CROSS SECTION
ACTIVE FLYASH PILE
SHEET 2 OF 2

fs1143.dgn

a southeasterly direction. Groundwater Monitoring Wells Nos. 2048 and 2045, which extend into the upper portion of the Great Miami Aquifer, indicate a potentiometric surface that can vary annually from 158 to 161 m (517 to 525 ft) MSL.

1.7 SUMMARY OF OPERABLE UNIT 2 REMEDIAL INVESTIGATION

1.7.1 Summary of Nature and Extent of Contamination

The nature and extent of radiological and chemical constituents within Operable Unit 2 are summarized in this section, based on data collected during Phase I and Phase II of the RI field investigation activities. Data generated prior to RI field activities, namely the Environmental Survey and Characterization Investigation Studies, were used to define data objectives for the RI and for supplementary data. Readers are referred to the Operable Unit 2 RI Report for complete listings and a discussion of analytical results. Contaminants of concern (COCs) are presented in Section 6.0 of the Operable Unit 2 RI Report. Select samples and analytical results for individual analytes are presented in Appendix A of this FS, including graphical summaries of analyte distribution by percent.

For this FS, the environmental samples have been organized according to the media classifications defined in Table 1-2. Note that several of these classifications apply to only one or two of the Operable Unit 2 subunits. For example, the sludge classification applies only to the Lime Sludge Ponds. Lists of samples associated with each classification are presented in Appendix A, along with further information concerning the media classifications. In the Operable Unit 2 RI Report, the environmental samples were classified as surface soil, subsurface soil, surface water, and groundwater. Because of this difference in the way the data is organized between the RI Report and this FS, the statistical summaries are not directly comparable, even though the raw data sets are identical.

The 95th percentile of the validated background concentrations of selected analytes in the environmental media was used to distinguish waste-related contaminants from naturally occurring or other non-site related levels of radiological or chemical constituents. Background concentrations are presented for radiological and inorganic constituents in surface soil, subsurface soil, perched groundwater, and Great Miami Aquifer groundwater in Table 1-3 and in Flyash in Table 1-4. Organic compounds in the soil and groundwater were considered to be waste-related regardless of their concentration. No validated background data for surface water in Paddys Run are available. A

TABLE 1-2

DEFINITION OF MEDIA CLASSIFICATIONS

Media Classification	Description
Surface Soil	Soil samples collected on the surface at a depth of 0 to 0.5 feet. Two surface samples at the Lime Sludge Ponds subunit were taken from the road running along the north side of the subunit. Because these samples were in the road itself, the statistics for the Lime Sludge Ponds surface soil presented in Appendix A are calculated both with and without these road samples.
Fill	Surface soil and subsurface soil samples of material that has been deposited on top of the native soil layer, or has been in some way disturbed.
Ash	Soil samples from either the Inactive Flyash Pile or Active Flyash Pile, that have been identified as being flyash material.
Sludge	Samples from the Lime Sludge Ponds that are taken from the actual sludge material.
Berm	Soil samples from the Lime Sludge Ponds that have been taken from the berms that form the perimeter of the Lime Sludge Ponds.
K65 Trench Vicincity	This area encompasses soil samples that have been taken in locations close to both the K65 Trench and the Lime Sludge Ponds. Samples in this vicinity may have been impacted by constituent migration from the K65 Trench.
Cover	Surface soil samples taken from the Inactive Flyash Pile subunit that have been identified as being from the soil cover over the ash material. The Inactive Flyash Pile cover has been identified in only a limited area of the subunit.
Till	Soil samples taken from undisturbed native soils below the interpreted location of the fill/till interface.
Impacted Till	Soil samples taken from directly below fill or ash material, in which there is evidence that contaminant migration has occurred from the source material to the underlying till. The depth of the impacted till layer is defined in section 1.7.1 of the FS.
Other Till	Soil samples classified as till, but which are below or outside the impacted till layer. Other till samples may be further classified as either inside or outside the subunit battery limits.
Source	A combination of surface soil, fill, ash, cover, and impacted till samples, as applicable for each subunit.
Sediment	Surface soil samples taken from surface water drainage areas.
GMA Soil	Subsurface soil samples taken from the unsaturated Great Miami Aquifer soils.
Perched Groundwater	Groundwater samples taken from the 1000-series groundwater monitoring wells that are screened in the vadose zone. The perched groundwater samples may be further classified as coming from wells that are either inside or outside the subunit battery limits.

TABLE 1-3

BACKGROUND CONCENTRATIONS FOR SOILS AND GROUNDWATER

Analyte	Background Concentration[a]			
	Soils		Groundwater	
	Surface (0-6 inches)	Subsurface (36-42 and 48-54 inches combined)	Perched	Great Miami Aquifer
Radionuclides	(pCi/g)	(pCi/g)	(pCi/L)	(pCi/L)
Actinium-227	0.090	0.6[b]	0.0[c]	0.0[c]
Bismuth-210	1.003	0.564	0.0[c]	0.0[c]
Bismuth-214	1.003	0.564	0.0[c]	0.0[c]
Cesium-137	0.849	0.0[d,e]	0.0[d,e]	0.0[d,e]
Lead-210	1.459	0.857	0.0[c]	0.0[c]
Neptunium-237	0.0	0.0[c]	0.0[d]	0.0[d]
Plutonium-238	0.0	0.0[c]	0.0[d]	0.0[d]
Plutonium-239	0.0	0.0[c]	0.0[d]	0.0[d]
Plutonium-240	0.0	0.0[c]	0.0[e]	0.0[d]
Polonium-210	1.003	0.564	0.0[c]	0.0[c]
Potassium-40	20.692	28.034	0.0[c]	0.0[c]
Protactinium-231	0.090	0.6	0.0[c]	0.0[c]
Radium-224	0.900	1.019	0.0[c]	0.0[c]
Radium-226	1.528	1.470	1.0[b]	1.20
Radium-228	1.170	1.325	5.2	4.50
Ruthenium-106	0.0[d]	0.0	0.0[d]	0.0[d]
Strontium-90	0.0[d]	0.56[b]	0.0[d]	0.0[d]
Technetium-99	0.0[d]	0.0[d]	0.0[d]	36.0
Thorium-228	1.519	1.341	1.04[b]	1.52
Thorium-230	2.112	1.897	2.0[b]	1.79
Thorium-232	1.469	1.269	0.0[d]	0.0[d]
Total Thorium	10.70μg/g[g]	9.470μg/g[g]	3.0μg/L[b]	2.0μg/L[b]
Uranium-234	1.319	1.037	1.9	1.9
Uranium-235/236	0.181	0.142	0.0[d]	0.0[d]

See footnotes at end of table.

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TABLE 1-3
(Continued)

Analyte	Background Concentration[a] Soils: Surface (0-6 inches)	Soils: Subsurface (36-42 and 48-54 inches combined)	Groundwater: Perched	Groundwater: Great Miami Aquifer
Radionuclides (Continued)	(pCi/g)	(pCi/g)	(pCi/L)	(pCi/L)
Uranium-238	1.270	1.122	1.07[b]	0.90[b]
Total Uranium	3.24mg/kg[g]	2.54mg/kg[g]	4.0μg/L[g]	2.92μg/L[g]
Metals	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)
Aluminum	13125.282	16277.291	0.123	0.184
Antimony	0.0[c]	0.0[c]	0.0[c]	0.038
Arsenic	11.608	9.704	0.122	0.30
Barium	88.500	121.064	0.459	0.413
Beryllium	0.6	0.620	0.0018	0.003
Boron	25.100	43.204	not analyzed	not analyzed
Cadmium	0.770	0.910	0.007	0.006
Calcium	5296.781	150000	125.574	135.163
Chromium	17.057	20.953	0.0345	0.042
Cobalt	16.913	15.929	0.0[c]	0.0[c]
Copper	15.700	20.23	0.03	0.130
Cyanide	0.230	0.17[b]	0.0[c]	0.0[c]
Iron	24788.749	31188.164	10.965	4.0
Lead	29.575	15.780	0.05	0.029
Magnesium	1460	43052.339	49.627	38.070
Manganese	2257.945	1045.407	0.165	0.80
Mercury	0.30	0.29	0.0037	0.001
Molybdenum	0.0[c]	0.27	0.028	0.027
Nickel	25.145	34.747	0.026	0.026
Potassium	1349.530	2007.519	29.736	3.087
Selenium	0.72	0.0[c]	0.0[c]	0.005[b]
Silicon	1914.313	1609.496	not analyzed	10.491
Silver	0.0[c]	0.0[c]	0.04	0.023
Sodium	55.145	227.947	49.178	51.918

See footnotes at end of table.

TABLE 1-3
(Continued)

Analyte	Background Concentration[a]			
	Soils		Groundwater	
	Surface (0-6 inches)	Subsurface (36-42 and 48-54 inches combined)	Perched	Great Miami Aquifer
Metals (Continued)	(mg/kg)	(mg/kg)	(mg/L)	(mg/L)
Thallium	0.58	0.49[b]	not analyzed	0.0[c]
Tin	not analyzed	not analyzed	not analyzed	0.0[c]
Vanadium	33.693	38.088	0.0195	0.027
Zinc	58.500	73.158	0.0317	0.105
All Organic Compounds	0.0	0.0	0.0	0.0
General Water Chemistry			(mg/L)	(mg/L)
Ammonia	NA[f]	NA	4.5	3.24
Chloride	NA	NA	110.159	145.065
Fluoride	NA	NA	1.352	0.938
Nitrate	NA	NA	0.522	11.40
Total Phosphorus	NA	NA	0.223	0.03
Sulfate	NA	NA	141.894	359.847

[a]Source: DOE1993b (Soils), DOE1993a (Groundwater.) Value presented represents 95 percentile from site-specific data, except as noted. Metal background values for groundwater are based on filtered samples; all other compounds are based on unfiltred samples.

[b]Value presented represents minimum detected value, since 95th percentile UCL would be a nondetect.

[c]All values in the data set are nondetects; value assumed to be zero.

[d]This radionuclide is a fission product, and its presence in the environment is due only to atmospheric releases of radiation (e.g., weapons testing). This radionuclide is not naturally occurring and is only expected to be present at or near detectable activities in the surface soil.

[e]Not analyzed; value assumed to be zero.

[f]NA = not applicable.

[g]Individual activity concentrations of the three isotopes for uranium and thorium were converted to mass concentrations. The three isotope mass concentrations were added to obtain the total thorium or uranium mass concentrations.

58 57

000118

TABLE 1-4

ELEMENTS COMPOSITION OF FLYASH (ppm)
TOTAL METALS

	Al	As	Sb	Ba	Be		Cd	Ca	Cr	Co	Cu	Fe	Pb
	14000	3.2	1	896	13		0.39	770	169	105	313	12250	96
	100000	74	1.5	3600	5.2		1.4	115000	5.6	127	43	21500	6.4
	140000	56.6	2.5	700	7.5		5.3	15900	3.6	15	113	109400	17
	13660	61	4.4	750	13.1		4.2	31270	28	5	59	28240	27
	132000	137	2.1	800	5.2		3.5	6220	8.9	7	238	7680	4
	110000	3.3	1	1000	2.3		7.3	24000	48	30	72	90000	85
	92700	20	10	1000	3.2		2	142000	0.114	10	105	36000	15
	100000	100	15	500	0.5		8	38000	62	72	30	48000	200
	140000	100	10	3000	1.5		10	9100	218		200	43000	150
	130000	30		1487	1.5		15	8200			300	39000	100
	130000	39		4920	10		2	7100			200	89000	70
	136000	24		1003	4.4	<	0.5	11200			115	37200	45
	119000	150		2770			1.6	21800			159	108000	114
	114000							34300			185	22500	118
	84000							150000			220	46000	210
	132000							10400			510	70900	
	110000							9800				47000	
	120000							20000				69000	
	129000							39500				24000	
	92000							28000				120000	
	135000							12300				56000	
	136000							6700				88900	
	79200							24700				107000	
	100000							97200				28000	
COUNT:	24	13	9	13	12		13	24	9	8	16	24	15
MEAN:	108273.33	61.39	5.28	1725.08	5.62		4.71	35977.50	60.36	46.38	178.88	56190.42	83.83
95%	140000	141	18.4	4920	19.9		20.6	134687.5	218.0	199.4	382.2	148364.4	194.0

TABLE 1-4
(Continued)

ELEMENTS COMPOSITION OF FLYASH (ppm)
TOTAL METALS

	Mg	Mn	Ni	Se		Ag		V	Zn		Hg	B	Sn	Sr	Mo
	1432	157	263	1.7	<	1		390	195		0.126	218	75	668	293
	350	242	34.2	3.27		0.0008	<	50	92	<	0.01	179	85	68	10
	14700	273	75.1	14.7	<	1	<	100	102		0.146	274	3	0.43	40
	4200	374	108	16.4		0.7		14.7	386	<	0.01	392	10	2000	70
	181	12	92.9	73		0.7		0.3	854		0.14	1040	10	200	70
	4200	1000	37	0.02		1		47	56		0.22	2.4	15	150	46
	6100	50	0.12	5		0.28		0.5	0.3	<	0.01	260		3000	25
	73100	300	50	20		14		195	20	<	1	100		947	
	8700	200	169	20				270	800	<	1	300		4390	
	5600	500	65	5					120	<	1	200			
	15000	290		0.28					300	<	1	400			
	5500	150		11					403		0.72	290			
	4630	1190							106			980			
	5510								254						
	9470								153						
	24000								320						
	4720														
	5200														
	5200														
	5910														
	6200														
	5000														
	4180														
	4530														
	40000														
COUNT:	25	13	10	12		8		9	16		12	13	6	9	7
MEAN:	10544.52	364.46	89.43	14.20		2.34		118.61	260.08		0.45	356.57	33.00	1269.27	79.14
95%	40000.0	1610.7	215.6	73.0		14.0		390.0	677.3		0.72	1040.0	85.0	4390.0	269.6

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TABLE 1-4
(Continued)

RADIONUCLIDE COMPOSITION OF FLYASH

	Th-232 (pCi/g)	U-238 (pCi/g)	Ra-226 (pCi/g)	Pb-210 (pCi/g)	Po-210 (pCi/g)	Escaping Rn-222 (pCi/L)	Total U (ug/g)	Total Th (ug/g)
	1.56	2.31	2.22	2.07	0.86	0.039	19	150
	2.35	3.09	3.2	5	2.6	0.018		16
	2.3	3.2	3.44	4.6	1.9	0.079		330
	4.12	6.46	5.65	9.28	5.32	0.011		
	2.25	3.45	4.06	6.3	5	0.025		
	2.41	3.78	3.72	4.4	3.1			
	0.87	2.42	3	3.12	2.06			
	0.73	1.2	1.37	12.7	10.6			
	1.41	2.23	2.27	2.53	0.94			
COUNT:	9	9	9	9	9	5	1	3
MEAN:	2.000	3.127	3.214	5.556	3.598	0.0344	19	165.333
95%	4.3	6.1	5.3	12.5	10.3	0.1	19.0	330.0

000423

complete discussion of the background data is provided in Section 4.1 of the Operable Unit RI Report.

1.7.1.1 Solid Waste Landfill

Analytical results for samples collected from the Solid Waste Landfill are presented in Section 4.2 and Appendix C of the Operable Unit RI Report. Individual sampling locations are shown on Figures 1-29 and 1-30.

Volume and Physical Characteristics

The volume of waste material at the Solid Waste Landfill was estimated by means of digitized topographic maps, boring log data, and interpolation completed using Intergraph Corporation Microstation PC software. The volume of waste material is calculated to be approximately 11,029 cu m (14,425 cu yd) (Figure 1-31).

A 1976 aerial photograph of the landfill shows the presence of the evaporation pond at the west edge of the landfill and one cell located parallel to the south boundary of the landfill. Soil gas sample collection and trenching were used to define additional waste disposal areas (Figure 1-32). Soil gas data from samples analyzed in the field indicate areas of elevated methane and volatile organic compounds (VOCs) in the southeast corner and the east side of the landfill. These results are consistent with the existence of one waste cell and the evaporation pond shown in Figure 1-32. Aerial photographs also indicate that there may have been some randomly placed pits, which may have been deeper than 10 feet to accommodate waste disposal.

Visual identification of waste materials encountered in three trenches excavated in July 1992 and borings completed in 1993 was used to improve the conceptual model of the landfill construction. Visual examination of samples from excavations dug in the landfill detected waste in discrete locations at depths ranging from near the surface to 3 m (10 ft) below ground level. The waste materials found at a depth of 3 m (10 ft) appear to have been deposited close to the estimated original ground surface. The waste distribution appears to be consistent with face dumping practices and not waste disposal trenches. Waste materials were detected in a few borings at depths greater than 3 m (10 ft) below ground surface, particularly in the southeast corner of the landfill.

Detected organic compounds in samples from the landfill indicate that historical sources for the detected compounds include cafeteria wastes (benzoic acid), medical laboratory wastes (phenanthrene and pyrene), manufacturing waste (2-butanone and carbon disulfide), and construction and maintenance waste (pentachlorophenol, carbazole, and 4,4-DDE).

Surface and Subsurface Media

Seventeen metals/inorganics, isotopes of six elements, and 23 organic compounds exceeded background concentrations in samples of the surface media collected during the Phase II field programs. Beryllium and chromium were detected above background concentrations in surface soil samples. Arsenic, antimony, and beryllium were detected in surface soil samples above background. Molybdenum and silver were consistently detected at concentrations that were 10 times above background, suggesting that metallurgical wastes are part of the surface soil cover at the landfill. Isotopes of uranium exceeded five times background in most samples, and the isotopes of plutonium, cesium, and radium were detected at trace activity levels. In addition, neptunium-237, plutonium-238, thorium-228, thorium-230, thorium-232, and technetium-99 were detected above background. The distribution does not suggest a single hot spot source area.

Four volatiles and 18 semivolatile organic compounds were detected in 12 samples. Volatile organics were found at trace concentrations in surface soil samples. The widespread distribution of organic constituents suggests that organic chemical waste from production, metallurgy, medical laboratory, construction, and maintenance are incorporated in the surface soil cover.

Twenty-three metals/inorganics, 51 organic compounds, and radioisotopes of five elements were detected above background in 19 subsurface soil samples collected during Phase I from near the surface to 6 m (20 ft) deep. Twenty-two metals/inorganics, radioisotopes of eight elements and 44 organic compounds were detected in 37 subsurface samples collected during Phase II. Cesium-137, strontium-90, and technetium-99 were detected in samples, indicating the presence of materials from reprocessing activities at the FEMP. This suggests that organic compounds and radioisotopes have migrated approximately 10 ft into the glacial overburden beneath the landfill. Six dioxins/furans were detected in 19 analyses; all but one were detected at trace concentrations. Octoachlorodibenzo-p-dioxin was detected in 18 of 19 samples in concentrations that ranged from 0.5 milligram per kilogram (mg/kg) to 13.7 microgram per kilogram (μg/kg). Aroclor-1254 and Aroclor-1260 were detected above background in five samples.

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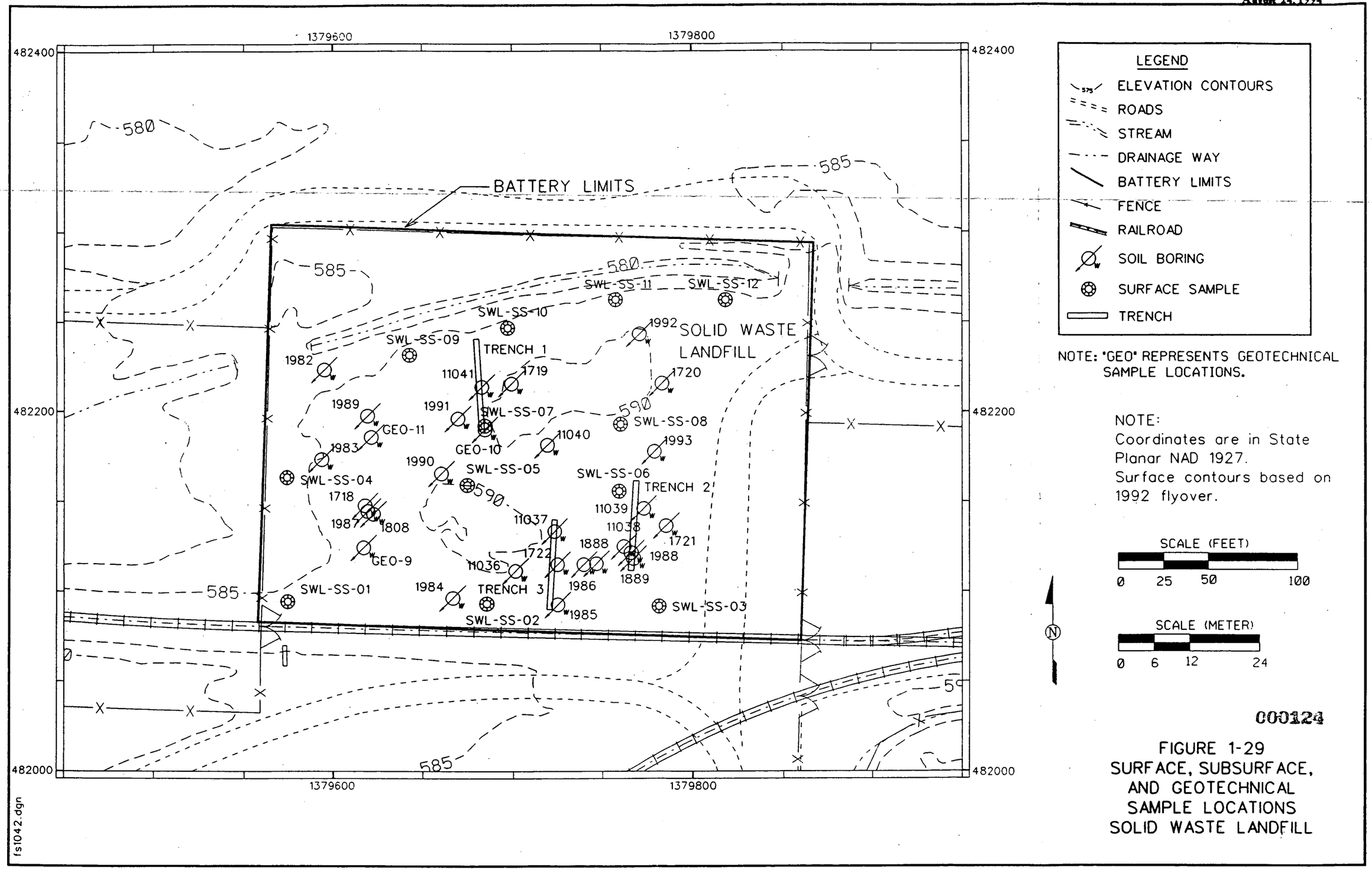
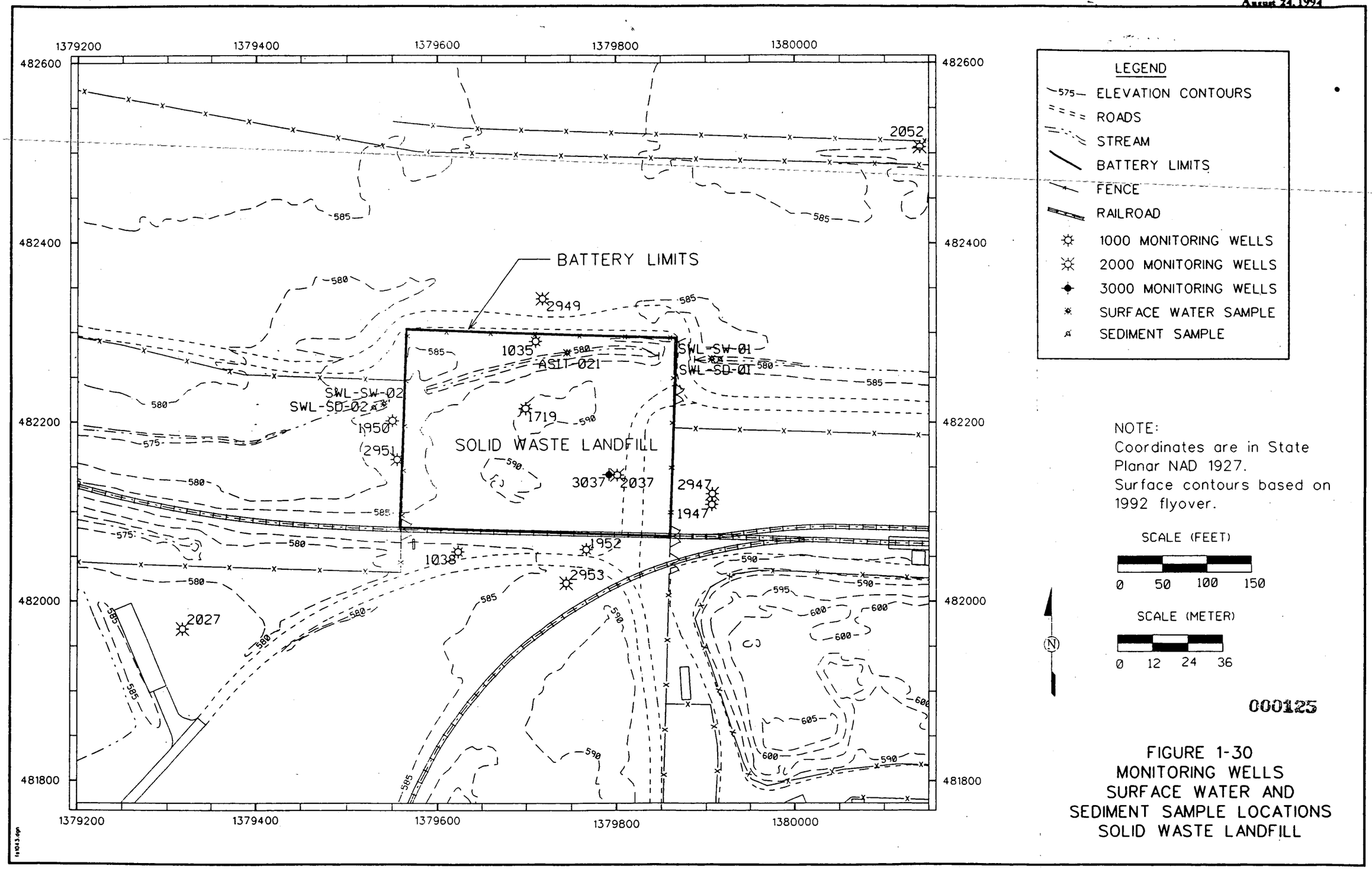


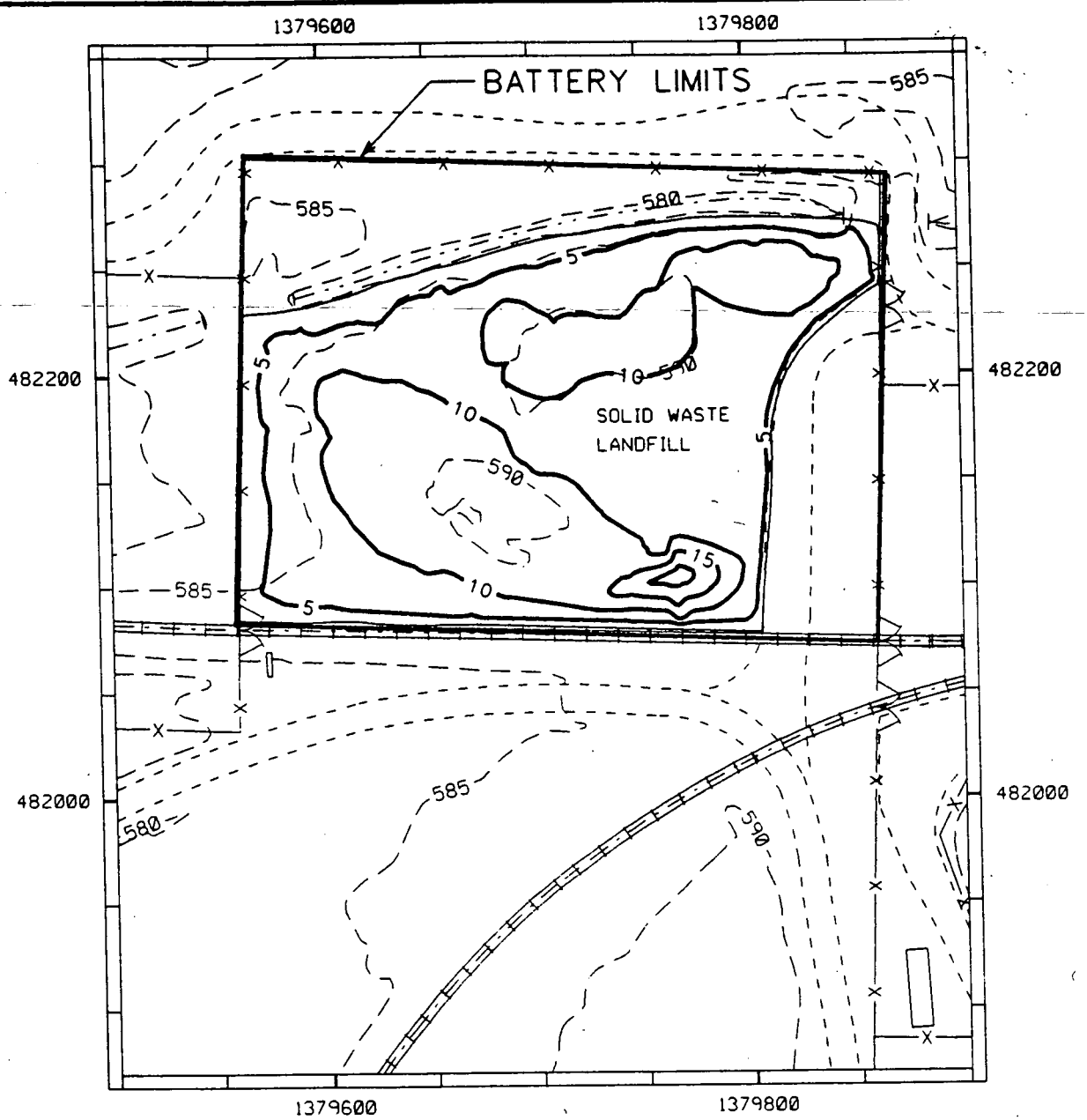
000124

FIGURE 1-29
SURFACE, SUBSURFACE, AND GEOTECHNICAL SAMPLE LOCATIONS
SOLID WASTE LANDFILL



000125

FIGURE 1-30
MONITORING WELLS
SURFACE WATER AND
SEDIMENT SAMPLE LOCATIONS
SOLID WASTE LANDFILL



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- DRAINAGE
- 5 THICKNESS OF CONTAMINATED FILL 5 FT CONTOUR
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 40 80 160

SCALE (METER)
0 9.6 19.2 38.4

TOTAL CONTAMINATED FILL VOLUME = 11,600 Cu. Meters (15,200 Cu.Yards.)

FIGURE 1-31
VOLUME OF CONTAMINATED FILL
SOLID WASTE LANDFILL

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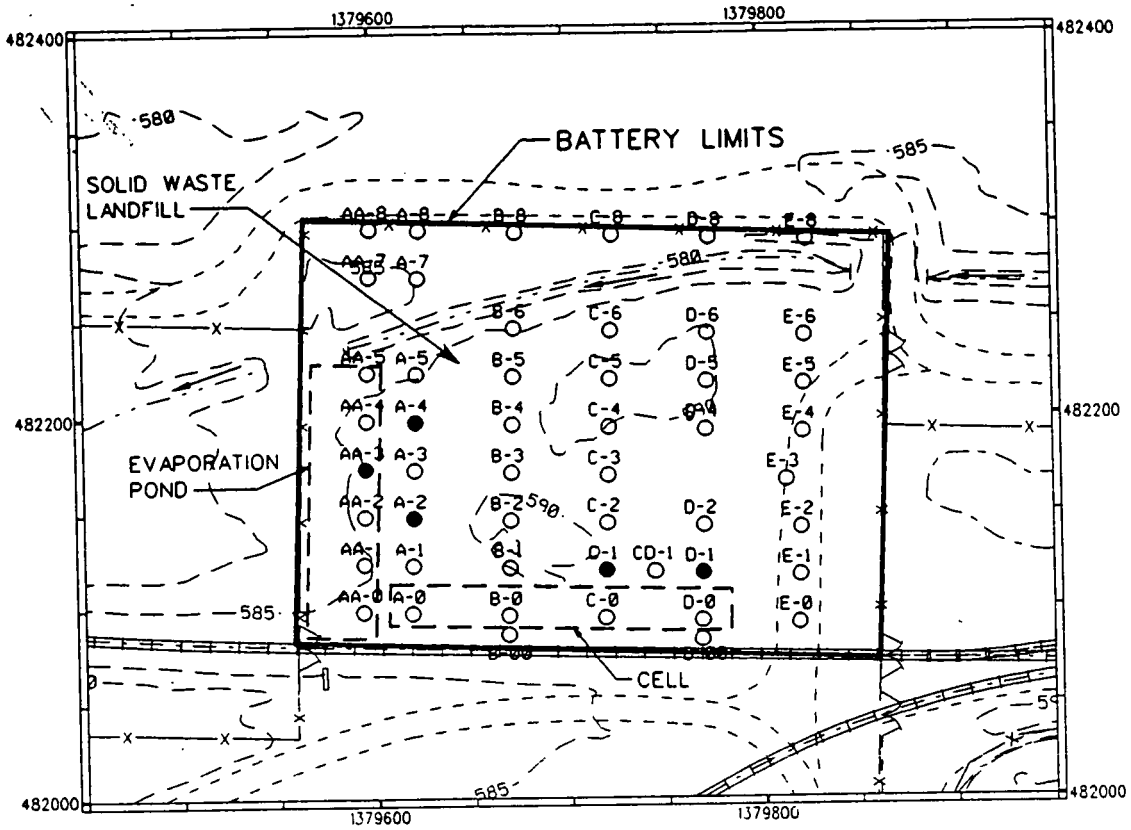

LEGEND

- 575 — ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- ○ SOIL GAS SURVEY SAMPLE LOCATIONS ANALYZED
- ● SOIL GAS SURVEY SAMPLE LOCATION SENT FOR LABORATORY ANALYSIS

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 25 50 100 150 200

SCALE (METER)
0 12 24 48 72 96

000127

FIGURE 1-32
SOIL GAS SURVEY SCREENING LOCATIONS FOR THE SOLID WASTE LANDFILL

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Figure 1-33 shows the distribution of uranium-238 concentrations for the Solid Waste Landfill subsurface till samples relative to the estimated fill/till interface. All of the uranium-238 detections that are more than 0.8 m (2.5 ft) below the fill/till interface are very near or below the background concentration, with the exception of two points. This concentration distribution indicates that the migration of uranium contamination into the till is largely confined to an impacted till layer that extends to 0.8 m (2.5 ft) from the fill/till interface.

One of the exceptions, a sample taken from a depth of 4.9 m (16 ft) in Boring No. 1721, has a concentration of 3.61 picoCuries per gram (pCi/g). The other exception, from a sample taken from a depth of 6.7 m (22 ft) in Boring No. 1035, has a uranium-238 concentration of 18.1 pCi/g. Boring No. 1035 is located north of the fill area, across the adjacent drainage ditch. No evidence has been found that any waste material was placed near this location. A review of the boring log shows that the field radiological screening instruments used during drilling detected no difference between the interval from which the sample was taken and the rest of the boring soils.

In order to determine the distribution of COCs in relation to the lithology of the Solid Waste Landfill, the soil data have been organized into samples in the surface soil, source material, other till material, and unsaturated Great Miami Aquifer soils. This type of analysis assists in the evaluation of technologies and process options for different media with various contaminant concentrations. Source material consists of samples from fill material (waste) and the impacted till [within 0.8 m (2.5 ft) of the fill/till interface]. The other till samples are those below the impacted till but within the battery limits. The unsaturated Great Miami Aquifer soils are located between the bottom of the till and the Great Miami Aquifer water table. Statistical summaries for the COCs within these subsets are given in Tables 1-5 through 1-8. It should be noted that this analysis separates soil into subsets that differ from those presented in the Operable Unit 2 RI Report. As a result, the summary statistics presented here are not directly comparable to those presented in the Operable Unit 2 RI Report, even though the raw data sets are identical.

Leachate samples from trenches and borings were analyzed for total uranium. A comparison of soil and leachate data from the south end of Trench 2 (located within the identified waste cell shown in Figure 1-32) indicates that similar isotopes and organic compounds were detected in the soil and in leachate collected from the trench. This suggests that water in contact with the buried waste material is a potential source for organic and radioisotope contamination migration to perched groundwater.

FIGURE 1-33
U-238 CONCENTRATION VS DEPTH RELATIVE TO FILL/TILL INTERFACE SOLID WASTE LANDFILL

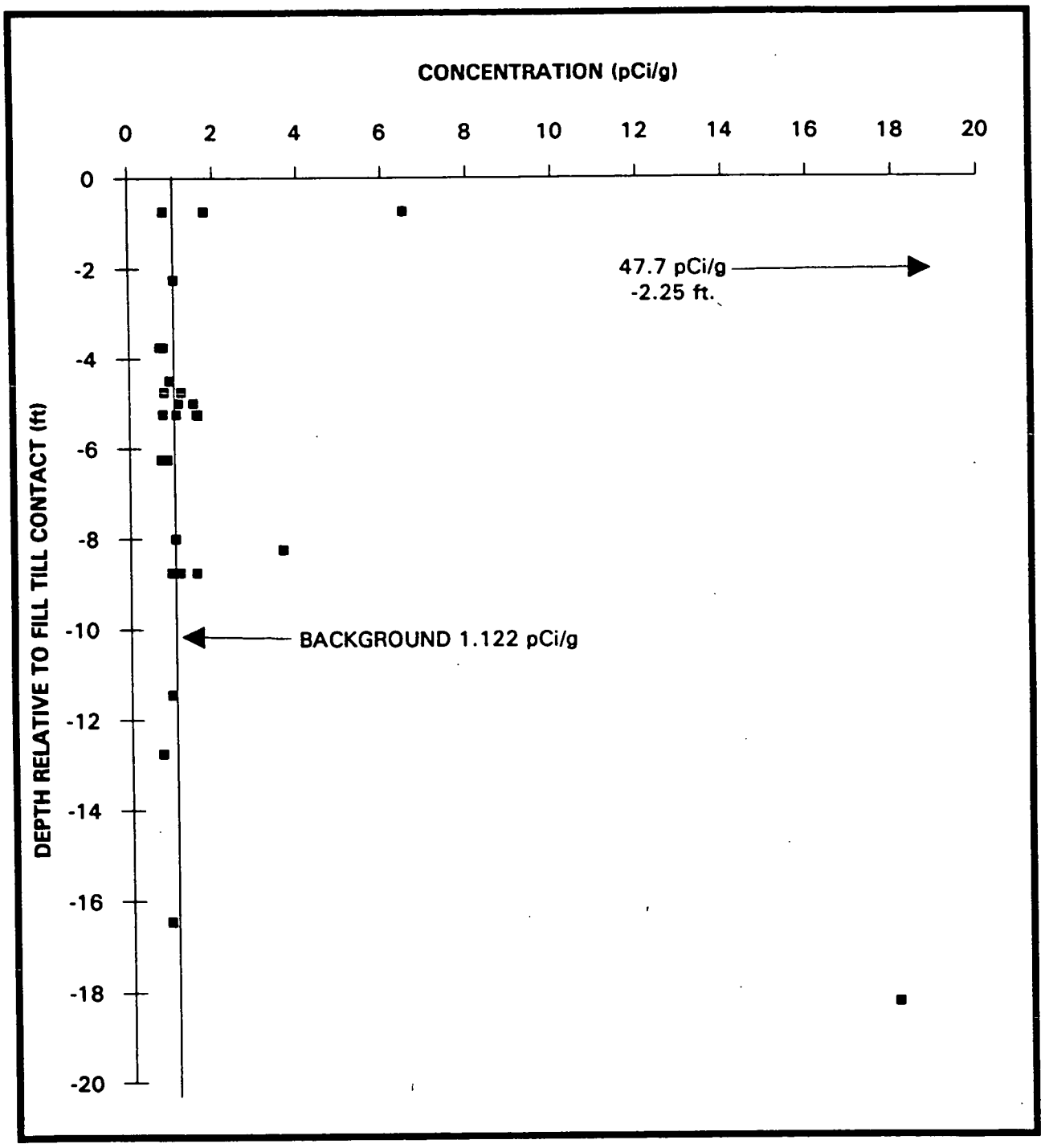

TABLE 1-5

CONTAMINANTS OF CONCERN, SURFACE SOILS
SOLID WASTE LANDFILL

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Antimony	12	0	-	-	0.5	mg/kg	NA
Arsenic	12	12	4.4	8.3	6.1	mg/kg	6.8
Beryllium	12	12	0.5	1.0	0.6[a]	mg/kg	0.7
Radionuclides							
Neptunium-237	8	8	0.05	3.1	0.3[a]	pCi/g	3.4
Plutonium-238	12	10	0.02	0.9	0.2[a]	pCi/g	0.8
Radium-226	12	12	0.9	2.3	1.2	pCi/g	2.3
Radium-228	12	12	0.7	3.0	1.3[a]	pCi/g	1.7
Strontium-90	12	8	0.5	1.4	0.7	pCi/g	1.0
Thorium-228	9	9	0.5	2.3	1.2[a]	pCi/g	1.6
Thorium-230	9	9	0.9	9.6	3.4[a]	pCi/g	6.4
Thorium-232	9	9	0.6	2.5	1.1[a]	pCi/g	1.5
Uranium-234	12	12	1.4	48.9	14.4[a]	pCi/g	42.1
Uranium-235/236	12	12	0.1	3.3	0.9[a]	pCi/g	2.8
Uranium-238	12	12	2.3	63.8	23.7[a]	pCi/g	77.1
Organics							
Benzo(a)anthracene	12	6	55	88	227.42	ug/kg	880
Benzo(a)pyrene	12	6	59.0	760.0	214.3	ug/kg	760.0
Benzo(b)fluoranthene	12	5	64.0	710.0	217.5	ug/kg	710.0
Dibenzo(a,h)anthracene	12	2	56.0	200.0	194.3	ug/kg	200.0
Indeno(1,2,3-cd)pyrene	12	5	46.0	480.0	186.7	ug/kg	480.0

[a]Estimated Mean
[b]NA = not applicable.

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TABLE 1-6

CONTAMINANTS OF CONCERN, SOURCE MATERIAL
SOLID WASTE LANDFILL

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Antimony	36	7	4.2	22	3.1	mg/kg	16.4
Arsenic	40	40	3.3	15.4	6.7[a]	mg/kg	7.4
Beryllium	40	38	0.2	1.8	0.9[a]	mg/kg	1.1
Radionuclides							
Neptunium-237	35	22	0.5	3.1	0.3	pCi/g	1.7
Plutonium-238	43	26	0.02	0.9	0.2	pCi/g	0.3
Radium-226	43	43	0.7	113.0	3.8	pCi/g	1.9
Radium-228	43	43	0.6	6.7	1.5	pCi/g	3.0
Strontium-90	41	20	0.2	3.1	0.6	pCi/g	1.6
Thorium-228	38	38	0.5	9.4	1.7	pCi/g	4.0
Thorium-230	38	38	0.9	720.0	22.2	pCi/g	15.4
Thorium-232	35	33	0.6	8.2	1.3[a]	pCi/g	1.6
Uranium-234	44	44	0.9	553.0	25.7[a]	pCi/g	49.7
Uranium-235/236	44	37	0.06	28.9	2.2	pCi/g	8.0
Uranium-238	44	44	1.1	577.0	46.3[a]	pCi/g	92.3
Organics							
Benzo(a)anthracene	39	28	43	310000	8900.7	µg/kg	18000
Benzo(a)pyrene	39	26	47.0	260000.0	7472.8	µg/kg	13000.0
Benzo(b)fluoranthene	39	26	49.0	220000.0	6403.7	µg/kg	15000.0
Dibenzo(a,h)anthracene	38	15	40.0	79000.0	2324.7	µg/kg	3000.0
Indeno(1,2,3-cd)pyrene	38	23	45.0	150000.0	4468.8	µg/kg	6500.0

[a]Estimated Mean

TABLE 1-7

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - OTHER TILL SOLID WASTE LANDFILL

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Antimony	24	4	3.8	27.3	3.8	mg/kg	22.6
Arsenic	25	25	2.2	13.8	6.6[a]	mg/kg	7.7
Beryllium	25	22	0.2	1.4	0.8[a]	mg/kg	1.0
Radionuclides							
Neptunium-237	17	11	0.05	0.4	0.2	pCi/g	0.4
Plutonium-238	24	12	0.01	0.1	0.1[a]	pCi/g	0.2
Radium-226	24	24	0.4	1.2	0.9	pCi/g	1.0
Radium-228	24	23	0.6	1.1	0.8	pCi/g	0.9
Strontium-90	22	4	0.7	1.2	0.3	pCi/g	0.7
Thorium-228	21	21	0.6	3.0	0.9[a]	pCi/g	1.1
Thorium-230	21	20	0.7	4.7	1.3	pCi/g	3.1
Thorium-232	21	19	0.5	5.2	0.9	pCi/g	0.9
Uranium-234	24	23	0.7	5.2	1.1[a]	pCi/g	1.3
Uranium-235/236	24	18	0.02	0.8	0.1	pCi/g	0.1
Uranium-238	24	24	0.7	18.1	1.9	pCi/g	3.6
Organics							
Benzo(a)anthracene	25	3	72	1000	226.1	µg/kg	290
Benzo(a)pyrene	25	2	290.0	760.0	221.0	µg/kg	290.0
Benzo(b)fluoranthene	25	3	150.0	1200.0	236.0	µg/kg	260.0
Dibenzo(a,h)anthracene	25	2	110.0	180.0	190.6	µg/kg	110.0
Indeno(1,2,3-cd)pyrene	25	2	210.0	410.0	203.8	µg/kg	210.0

[a]Estimated Mean

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TABLE 1-8

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - GREAT MIAMI AQUIFER SOLID WASTE LANDFILL

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Radionuclides							
Thorium-228	2	1	0.7	0.7	0.5	pCi/g	0.7
Thorium-230	2	1	0.7	0.7	0.5	pCi/g	0.7

Note: Soil samples were collected from the unsaturated zone beneath the till in the Great Miami Aquifer.

Six soil samples were collected for hazardous waste characteristic determination by toxicity characteristic leaching procedure (TCLP) analyses. The results did not exceed the RCRA standard for determining toxic characteristic hazardous waste.

Surface Water and Sediment

The one perennial source of surface water within the battery limits of the Solid Waste Landfill is a drainage ditch which flows from east to west along the northern boundary of the subunit. Two semivolatile compounds were detected in one incomplete surface water sample collected during Phase I. Eight metals, the isotopes of two elements, and one organic compound were detected in surface water samples collected from the Solid Waste Landfill during Phase II. Comparison of water-sample results from upstream and downstream locations indicates that the Solid Waste Landfill is not the only source for uranium detected in surface water samples from the drainage.

Eight metals/inorganics, isotopes of four elements, and 15 organic compounds exceeding the background concentrations were detected in sediment samples. Sediment samples collected from downstream of the Solid Waste Landfill contained elevated concentrations of inorganics (including silver, thallium, and zinc), organics [including the polynuclear aromatic hydrocarbons (PAHs) acenapthene, anthracene, benzo(a)pyrene, phenanthrene, and indeno(1,2,3-cd)pyrene], and radionuclides (including neptunium-237, plutonium-238, strontium-90, uranium-234, uranium-235/uranium-236, and uranium-238). These analytes were detected in samples collected from the Solid Waste Landfill and indicate that contaminants may have migrated from the landfill into the drainage. Except pyrene, none of the organics detected in the downstream sample (SWL-SD-02) were detected upstream from the landfill (SWL-SD-01).

Groundwater

Perched groundwater analytical data from the Phase I and Phase II sampling of 1000-series wells are included in Appendix C of the Operable Unit 2 RI Report. Phase I sampling of three 1000-series wells (eight samples) detected 13 metals/inorganics, isotopes of four elements, and no organic compounds that exceeded the background concentrations. During Phase II, concentrations of 16 metals/inorganics, isotopes of six elements, and one organic compound exceeded background concentrations in samples from four 1000-series wells.

The data indicate that analytes detected in surface and subsurface soil samples above background are detected in one downgradient Monitoring Well (No. 1952). Groundwater samples have not indicated the presence of PAHs or pesticides. The two organic compounds, acetone and butyl benzyl phthalate, were detected at concentrations of 2.0 microgram per liter (μg/L) and 1.0 μg/L, respectively.

Analytical results for groundwater samples collected from upgradient wells in the perched aquifer (Well Nos. 1035 and 1947) indicated concentrations of total uranium that ranged from 2.3 μg/L to 11 μg/L; groundwater samples collected from downgradient wells (Well Nos. 1038, 1952, and 1950) contained total uranium at concentrations that ranged from 4.11 μg/L to 55.8 μg/L. These data suggest that uranium has leached into the perched groundwater from the waste unit. A comparison of strontium-90 and total thorium values from upgradient and downgradient wells indicates an increase in the concentrations of these radionuclides in downgradient Well No. 1952. These data indicate that thorium and strontium-90 have leached from the waste subunit into perched groundwater.

Summary statistics for COCs in the perched groundwater are shown in Table 1-9.

Phase I groundwater sampling detected 16 metals/inorganics, isotopes of two elements, and eight organic compounds that exceeded background in samples from three 2000-series wells. Phase II sampling detected five metals, isotopes of seven elements, and two organic compounds that exceeded background values in six wells.

Total uranium was not detected above background in upgradient 2000-series wells (Well Nos. 2949 and 2951) or downgradient 2000-series wells (Well Nos. 2947 and 2953). This indicates that total uranium did not impact the regional aquifer outside the battery limits. Uranium-235/236 was detected at a concentration of 0.05 pCi/L in downgradient Well No. 2947 and at a maximum concentration of 0.277 pCi/L in Well No. 2037, which is within the boundaries of the landfill. This may indicate a minimal impact on the regional aquifer from the landfill outside the battery limits. A groundwater sample collected from Well No. 2037, located inside the limits of the Solid Waste Landfill, contained elevated concentrations of uranium isotopes, strontium-90, and carbon disulfide. These constituents were detected in samples collected from Well No. 1037, located adjacent to Well No. 2037. Construction information indicates that Well No. 1037 was improperly completed and may provide a pathway for contaminant leakage to the Great Miami Aquifer. A water level hydrograph prepared for Monitoring Well No. 1037 showed water levels varying from 167.6 to 169.4 m (549.86 to 555.8 ft)

TABLE 1-9

CONTAMINANTS OF CONCERN, PERCHED GROUNDWATER SOLID WASTE LANDFILL

Parameter	Filtered?	# of Samples	# of Hits	Min. Hit	Max. Hit	Min. SQL	Max. SQL	Mean	Units	Conc. Term
Radionuclides										
Uranium-234	Filtered	1	1	1.1	1.1	NA[a]	NA	1.1	pCi/L	1.1
Uranium-234	Unfiltered	5	3	1.1	4.6	1	1	1.6	pCi/L	4.6
Uranium-235/236	Filtered	6	0	NA	NA	0.1	1	NA	pCi/L	NA
Uranium-235/236	Unfiltered	1	0	NA	NA	0.2	0.2	NA	pCi/L	NA
Uranium-238	Filtered	1	1	0.8	0.8	NA	NA	0.9	pCi/L	0.8
Uranium-238	Unfiltered	6	5	0.7	3.9	1.0	1.0	1.7	pCi/L	3.9
Technetium-99	Filtered	1	0	NA	NA	9.6	9.6	NA	pCi/L	NA
Technetium-99	Unfiltered	6	0	NA	NA	11.1	30.3	NA	pCi/L	NA
Organics										
Carbazole	Unfiltered	1	0	NA	NA	NA	NA	NA	μg/L	NA
Uranium-total	Filtered	1	1	2.6	2.6	NA	NA	2.6	μg/L	2.6
Uranium-total	Unfiltered	6	6	2	17	NA	NA	5.9	μg/L	17

[a]NA = not applicable.

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MSL approximately 6.1 to 7.6 m (20 to 25 ft) below the perched water in the landfill. These data may indicate that leakage from Well No. 1037 is influencing water quality in Well No. 2037, and that concentrations of constituents detected above background are not a result of leakage through the matrix of the glacial till under the landfill. Well No. 1037 has been recently abandoned and plugged.

A comparison of analytical data from paired wells in the Solid Waste Landfill indicate that strontium-90, total uranium, and total thorium, which are detected in elevated concentrations in the perched zone, are detected below background concentrations in regional aquifer wells upgradient and downgradient of the Solid Waste Landfill. A comparison of analytical data from Well Nos. 1952 and 2953 indicates that vertical leakage from the perched zone to the regional aquifer is not indicated.

1.7.1.2 Lime Sludge Ponds

Analytical results for samples collected from the Lime Sludge Ponds are presented in Section 4.3 and Appendix D of the Operable Unit 2 RI Report. Individual sampling locations are shown on Figure 1-34. Monitoring well sampling locations are shown of Figure 1-35. The North Lime Sludge Pond was in use at the time of the Phase I and Phase II investigations. The South Lime Sludge Pond was no longer in use at the time of the Phase I and Phase II investigations.

Volume and Physical Characteristics

The volume of lime sludge material and berm material, estimated by means of digitized topographic maps, boring log data, preconstruction engineering drawings, and interpolation completed by using Intergraph Corporation Microstation PC software, is calculated to be approximately 12,615 cu m (16,500 cu yd) of sludge material and 4,248 cu m (5,556 cu yd) of berm material, making a total of 16,863 m (22,056 cu yd) of material (Figure 1-36). The K-65 slurry line trench on the southern boundary of the subunit has not been included in the estimate of waste material.

Surface and Subsurface Media

Surface soil samples were collected from the ponds, berms, and the roadway at the north boundary during Phase II sampling. Twenty-One metals/inorganics, isotopes of eight elements, and 21 organic compounds were detected in 14 surface soil samples. There were three detections of Aroclor-1254 in samples collected from the service road north of the Lime Sludge Ponds and from the northeast corner of the North Pond.

000137

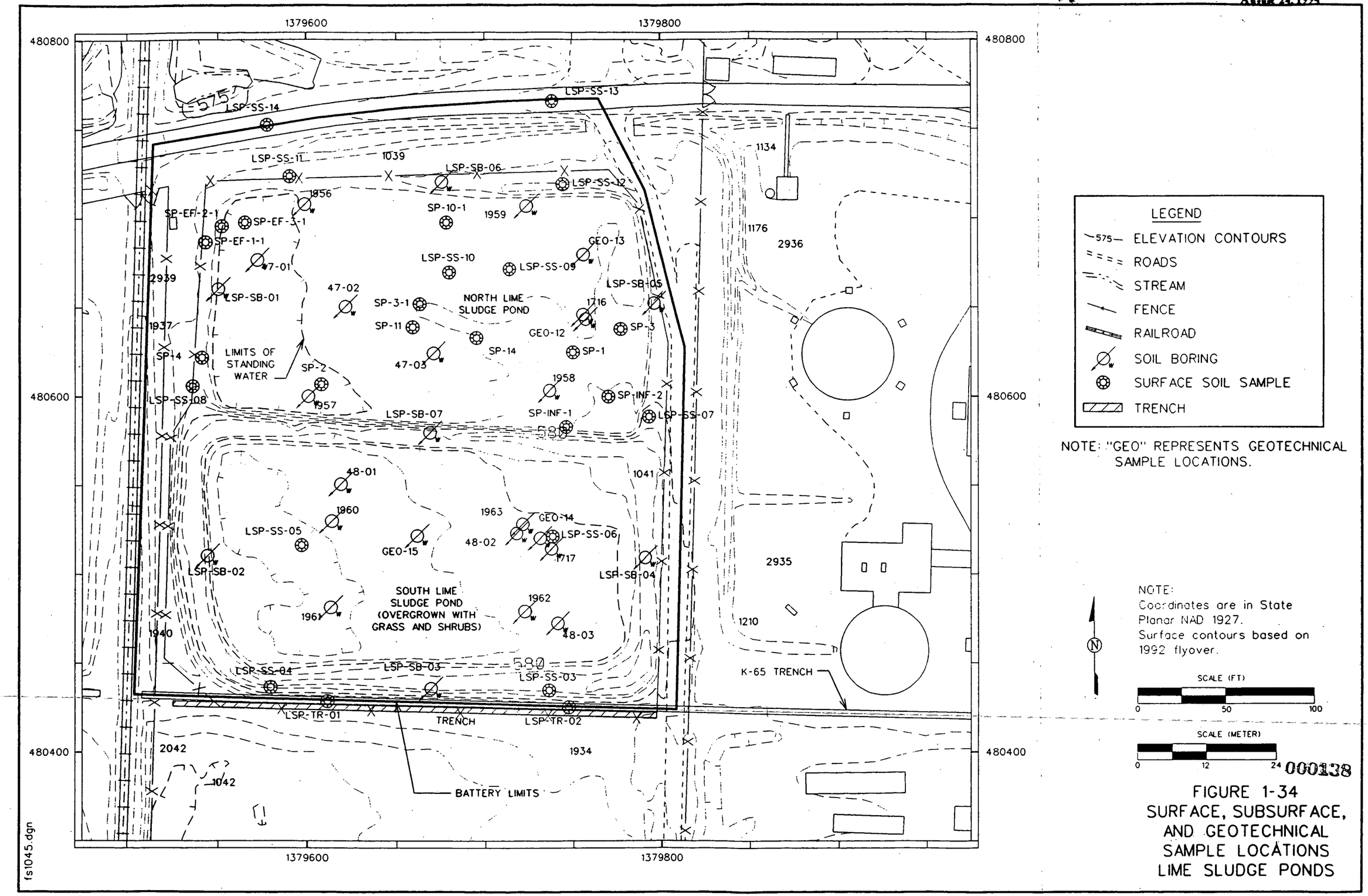

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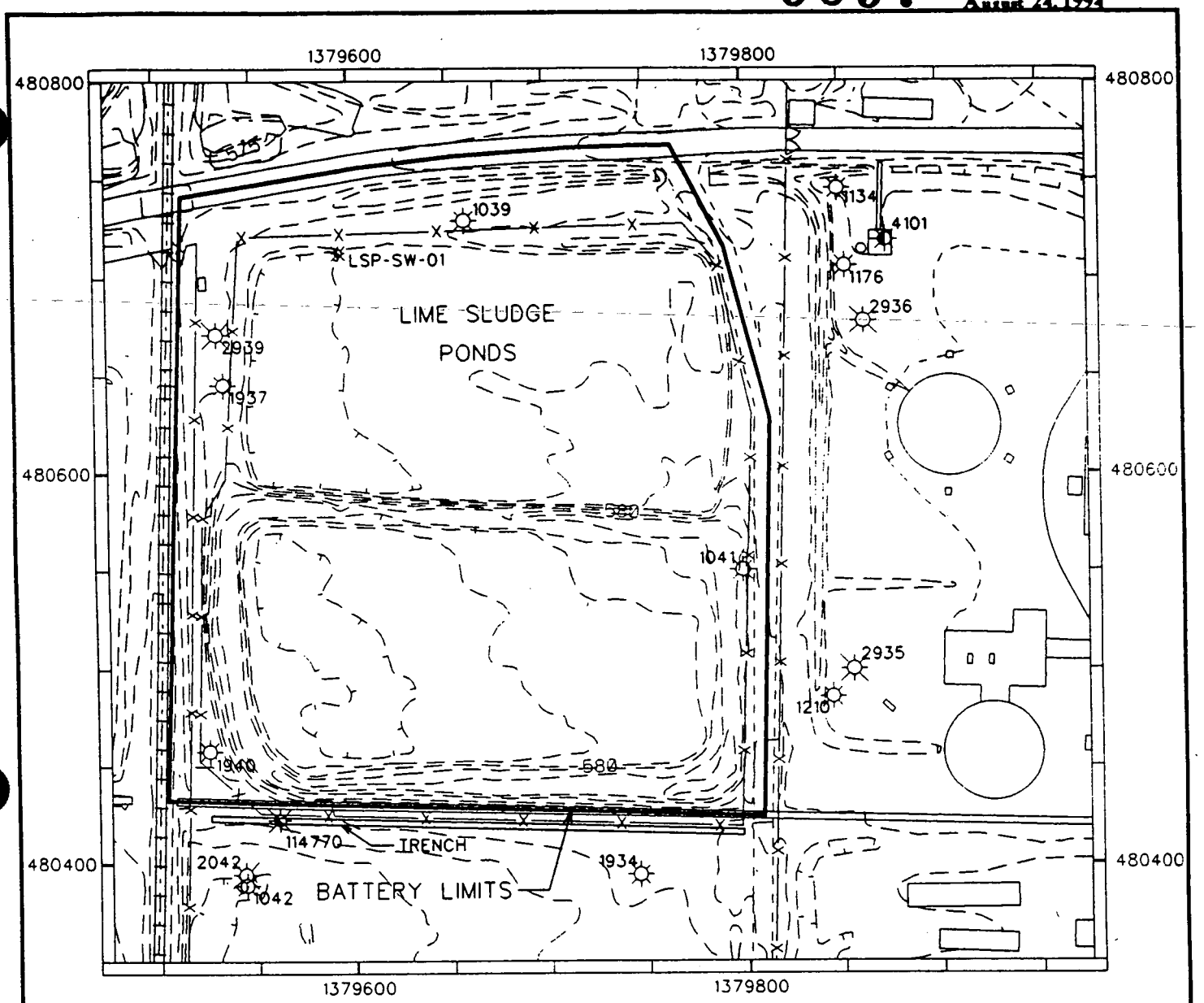
FIGURE 1-34
SURFACE, SUBSURFACE, AND GEOTECHNICAL SAMPLE LOCATIONS LIME SLUDGE PONDS



NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100

SCALE (METER)
0 12 24

LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- 1000 MONITORING WELLS
- 2000 MONITORING WELLS
- 4000 MONITORING WELLS
- SURFACE WATER SAMPLE

FIGURE 1-35
MONITORING WELLS
SURFACE WATER AND
SEDIMENT SAMPLE LOCATIONS
LIME SLUDGE PONDS

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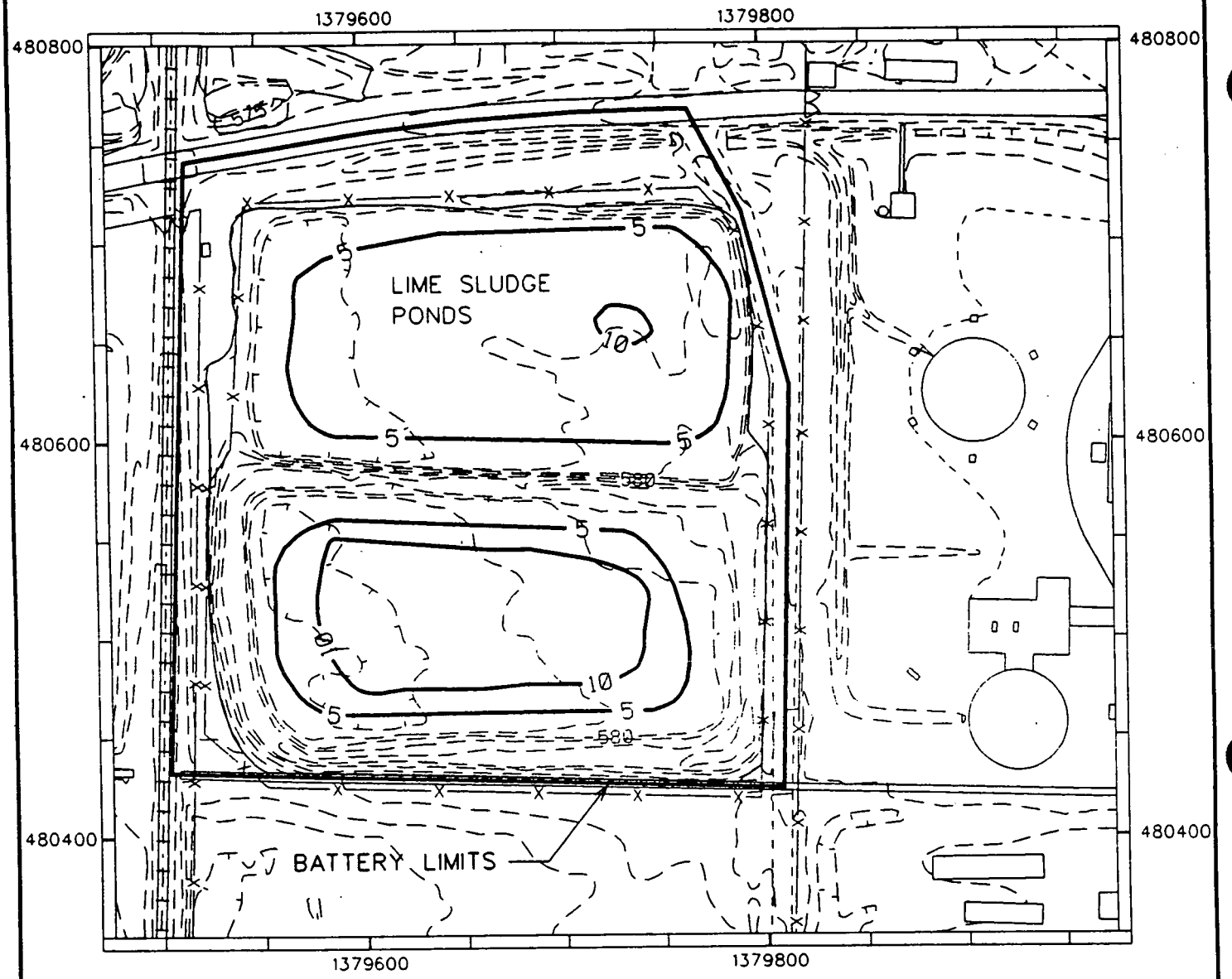

LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- DRAINAGE
- 5 THICKNESS OF FILL MATERIAL (LIME SLUDGE AND BERM) 5 FT CONTOUR
- FENCE
- RAILROAD

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 80 160

SCALE (METER)
0 19.2 38.4

LIME SLUDGE VOLUME	=	12,600 Cu. Meters (16,500 Cu.Yards.)
BERM VOLUME	=	4,300 Cu. Meters (5,600 Cu.Yards.)

FIGURE 1-36
VOLUME OF
LIME SLUDGE AND BERM
LIME SLUDGE PONDS

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A comparison of the concentrations of metals detected in surface samples collected from sludge, berm material, and the service road suggests that these features are composed of separate materials.

Analytical data for radionuclides detected in surface soil indicate that activity of isotopes is highest in the samples collected within the K-65 slurry line trench and in samples from the road surface (LSP-SS-13 and LSP-SS-14). Samples collected adjacent to the K-65 slurry line trench also detected elevated concentrations of uranium and thorium isotopes. These data suggest that the surface soil outside of the ponds has been impacted by the K-65 slurry line trench, possibly during maintenance of the line, and by carry-over from spillage on the roads in the former Production Area.

Maximum concentrations for organic compounds detected in surface samples of the sludge included bis(2-ethylhexyl)phthalate (390 μg/kg) and di-n-butyl phthalate (120 μg/kg). Maximum concentrations for the following compounds were detected in samples from the service road along the north boundary: chrysene (1100 μg/kg), benzo(a)pyrene (1100 μg/kg), Aroclor-1254 (590 μg/kg), and benzo(k)fluoranthene (800 μg/kg). A comparison of the number of organic compounds detected in surface samples and their location suggests that the service road north of the Lime Sludge Ponds may be the source of organic compounds detected in surface soil samples from the unit. Aroclor-1254 is an indicator that the source for organic compounds in LSP-SS-12 (North Pond berm) is the same as for LSP-SS-13 and LSP-SS-14 (the service road). Concentrations of poly-chlorinated biphenyls (PCBs) were higher in samples collected from the service road (590 μg/kg and 90 μg/kg Aroclor-1254) when compared to pond surface samples (one detection of 43 μg/kg Aroclor-1254 at LSP-SS-12).

Twenty-four metals/inorganics, isotopes of eight elements, and 13 organic compounds were detected above background concentrations in 30 subsurface samples collected from the Lime Sludge Ponds during Phase II. The data indicate that soil background concentrations were exceeded in sludge most frequently for antimony (seven of seven samples), copper (three of seven samples), beryllium (three of seven samples), and zinc (two of seven samples). Soil samples collected from beneath the lime sludge exceeded background concentrations most frequently for antimony (nine of nine samples), copper (four of nine samples), beryllium (six of nine samples), zinc (three of nine samples), arsenic (two of nine samples), and lead (two of nine samples). A comparison of sludge data with data from soil underlying the sludge indicates that the underlying soil has higher concentrations than the sludge for antimony, copper, beryllium, and zinc.

Two locations contained concentrations of metals that exceeded background concentrations most frequently. Four of eight metals in Boring No. 1956 sludge and five of eight metals in Boring No. 1959 sludge were detected at concentrations above background. The highest lead, copper, zinc, vanadium, and chromium concentrations were detected in sludge from these two borings, which are adjacent to the north edge of the North Pond.

Radionuclide data presented in Section 4.3 of the Operable Unit 2 RI Report indicate that activities measured in sludge, soil beneath the sludge, and in the berm materials exceed background levels. Berm samples displayed higher activities of uranium-238 when compared to sludge samples. When subsurface sludge, soil, and berm sample data are compared, the following conclusions can be made:

- Thorium was detected more frequently and at higher concentrations in samples of the native soil underlying the lime sludge.
- Concentrations of total uranium were approximately the same or lower in samples collected from the sludge when compared to the underlying soil.
- Samples from the berm were, on average, higher in total uranium than the lime sludge.

The data suggest that the upper one foot of the berms has a supplemental source of radioisotopes when compared to the lime sludge material. Samples of sludge and underlying soil indicated that the sludge contains lower concentrations of the radionuclides than the soil.

Eight semivolatile organics were detected in subsurface samples. All were detected two times or less except for di-n-butyl phthalate and bis(2-ethylhexyl)phthalate.

An investigation trench approximately 84 m (275 ft) long was excavated parallel to and south of the concrete K-65 slurry line (Figure 1-34) in an effort to locate areas of possible leakage from the slurry line. This trench will be fully characterized during the Operable Unit 3 RI. Field radioactivity measurements did not define soil containing elevated radioactivity where historical leakage from the slurry line containment had occurred. Soil samples from the trench were collected from two locations: adjacent to Well No. 1042 and adjacent to Well No. 1934. A comparison of the data from samples collected within the concrete K-65 slurry line and data from soil outside the slurry line indicates that leakage from the trench may be a source of these isotopes in the soil adjacent to the trench.

Figure 1-37 shows the distribution of uranium-238 concentrations for the Lime Sludge Ponds subsurface till samples relative to the estimated fill/till interface. All of the uranium-238 concentrations in the till below the sludge are very near or below the background concentration. This figure demonstrates that the Lime Sludge Ponds have had no significant impact on the underlying till in terms of uranium-238 migration.

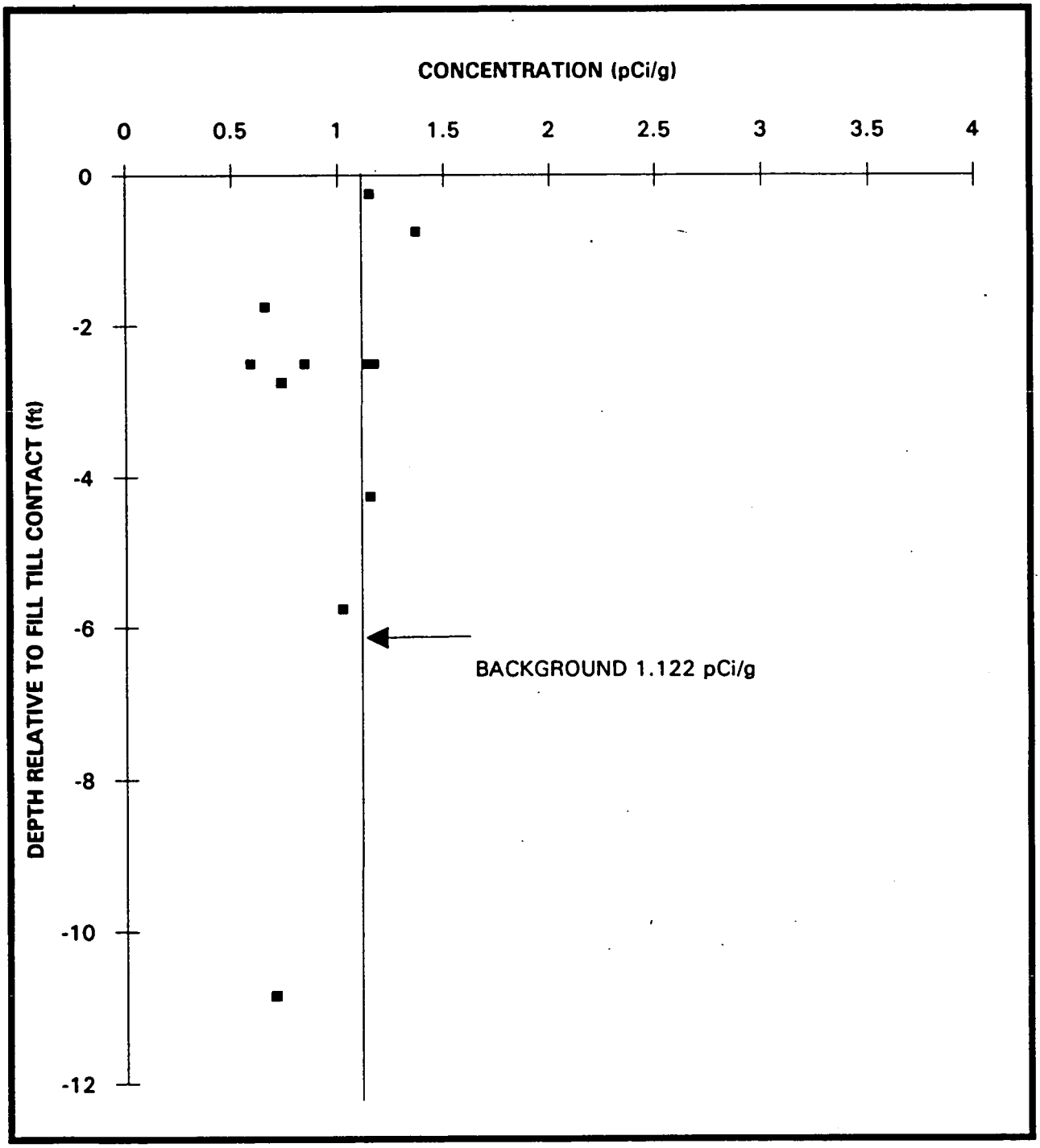
To determine the distribution of COCs in relation to the lithology of the Lime Sludge Ponds, the soil data have been organized into samples in the surface soil, sludge material, other till material, berm material, and unsaturated Great Miami Aquifer soils. This type of analysis assists in the evaluation of technologies and process options for different media with various contaminant concentrations. Till samples consist of those samples taken in the till below the sludge within the subunit battery limits. The unsaturated Great Miami Aquifer soils are located between the bottom of the till and the Great Miami Aquifer water table. Statistical summaries for the COCs within these subsets are given in Tables 1-10 through 1-14. It should be noted that this analysis separates soil into subsets that differ from those presented in the Operable Unit 2 RI Report. As a result, the summary statistics presented here are not directly comparable to those presented in the Operable Unit 2 RI Report, even though the raw data sets are identical.

Composite samples of the lime sludge were collected from 10 borings and tested to determine hazardous waste characteristics by the TCLP method. The results of the TCLP analysis for metals are shown in Table 1-15. Eight samples indicated the presence of barium and chromium in trace concentrations, but none of the detections exceeded the RCRA standard that defines hazardous waste (40 CFR § 261.24). The Lime Sludge Ponds are currently classified as SWMUs. Results from the TCLP analyses confirm that the materials are not characteristically hazardous.

Surface Water and Sediment

There are no perennial sources of running surface water within the battery limits of the Lime Sludge Ponds. A channelized drainage at the north edge of the battery limits is the only drainage identified in the subunit. Flow to this drainage originates from the service road and enters a sewer at the northwest corner of the battery limits. No sediment or surface water samples were collected, because the data would not be representative of impacts from subunit sources. The North Lime Sludge Pond has a free water surface that changes according to inflow from storm water and process discharges. One sample was collected during Phase I, and one was collected during Phase II. Phase I sampling

FIGURE 1-37
U-238 CONCENTRATION VS DEPTH RELATIVE TO FILL/TILL INTERFACE LIME SLUDGE PONDS



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LSP_U238.XLC/4/14/94/10:32 AM/JJB

TABLE 1-10

CONTAMINANTS OF CONCERN, SURFACE SOILS
LIME SLUDGE PONDS

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Uranium-Total	12	12	2.5	244	NA	mg/kg	214.32
Radionuclides							
Cesium-137	12	9	0.06	0.9	0.3[a]	pCi/g	0.7
Radium-226	12	10	0.2	3.5	1.3	pCi/g	2.1
Radium-228	12	8	0.7	2.9	1.2	pCi/g	1.8
Thorium-228	11	10	0.08	2.9	1.1	pCi/g	2.9
Thorium-230	11	11	0.4	44.8	13.8	pCi/g	44.8
Thorium-232	10	9	0.04	2.8	0.9	pCi/g	1.4
Uranium-238	12	12	0.9	84	16.9[a]	pCi/g	71.4

[a]Estimated mean

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TABLE 1-11

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - SLUDGE
LIME SLUDGE PONDS

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Uranium-Total	15	15	2.08	20.5	9.74	mg/kg	12.9
Radionuclides							
Cesium-137	15	4	0.03	0.1	0.1	pCi/g	0.1
Radium-226	15	12	0.2	1.1	0.4	pCi/g	0.6
Radium-228	15	3	0.6	0.8	0.3	pCi/g	0.8
Thorium-228	13	9	0.08	1.5	0.3[a]	pCi/g	0.7
Thorium-230	13	11	0.3	3.1	1.2[a]	pCi/g	2.3
Thorium-232	13	9	0.04	0.5	0.2	pCi/g	0.3
Uranium-238	15	15	0.7	6.7	2.2[a]	pCi/g	3.1

[a]Estimated Mean

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TABLE 1-12

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - OTHER TILL LIME SLUDGE PONDS

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Uranium-Total	10	10	2.2	14.3	10.3	mg/kg	14.3
Radionuclides							
Neptunium-237	8	6	0.05	0.1	0.1	pCi/g	0.1
Radium-226	11	11	0.8	1.4	1.1[a]	pCi/g	1.2
Radium-228	11	10	0.7	1.4	0.9	pCi/g	1.1
Thorium-228	11	11	0.5	1.3	0.8	pCi/g	1.0
Thorium-230	11	10	0.5	4.5	1.6[a]	pCi/g	2.5
Thorium-232	11	11	0.3	1.3	0.8	pCi/g	1.1
Uranium-238	11	11	0.6	1.4	1.0	pCi/g	1.1

[a]Estimated Mean

000147

TABLE 1-13

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - BERM LIME SLUDGE PONDS

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Uranium-Total	20	20	11.2	51.6	24.8	mg/kg	29.4
Radionuclides							
Neptunium-237	21	20	0.03	0.5	0.2[a]	pCi/g	0.3
Radium-226	21	21	1.0	3.5	1.5	pCi/g	3.2
Radium-228	21	21	0.7	2	1.3[a]	pCi/g	1.4
Thorium-228	19	19	0.9	1.8	1.1[a]	pCi/g	1.2
Thorium-230	20	20	1.2	44.8	6.9[a]	pCi/g	12.3
Thorium-232	19	19	0.7	1.5	1.0	pCi/g	1.1
Uranium-238	21	21	2.8	20.4	6.8[a]	pCi/g	8.4

[a]Estimated Mean

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TABLE 1-14

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - GREAT MIAMI AQUIFER LIME SLUDGE PONDS

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Radionuclides							
Radium-226	1	1	0.4	0.4	0.4	pCi/g	0.4
Technetium-99	1	0	NA[a]	NA	0.5	pCi/g	NA
Thorium-230	1	1	1.3	1.3	1.3	pCi/g	1.3

[a]NA = not applicable.

Note: Soil samples were collected from the unsaturated zone beneath the till in the Great Miami Aquifer.

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TABLE 1-15

LIME SLUDGE PONDS TCLP METALS

Parameters	RCRA Standard (mg/L)	Ohio Exempt Waste Standard (mg/L)	Units	# of Analyses	Number of Detects	Minimuum Detect	Maximum Detect	Average Detect
Arsenic	5.0	1.5	mg/L	10	2	0.38	0.5	0.4
Barium	100.0	30.0	mg/L	10	8	0.26	0.8	0.5
Cadmium	1.0	0.3	mg/L	10	5	0.01	0.04	0.02
Chromium	5.0	1.5	mg/L	10	8	0.01	0.1	0.05
Lead	5.0	1.5	mg/L	10	3	0.05	0.3	0.2
Mercury	0.2	0.06	mg/L	10	0	0	0	0
Selenium	1.0	0.3	mg/L	10	1	0.48	0.5	0.5
Silver	5.0	NA[a]	mg/L	10	3	0.01	0.2	0.1
1,1-Dichloroethene	0.7	NA	mg/L	9	1	0.011	0.011	0.011
1,2-Dichloroethane	0.5	NA	mg/L	10	0	0	0	0
2-Butanone	200.0	NA	mg/L	10	3	0.006	0.031	0.021
Benzene	0.5	NA	mg/L	10	0	0	0	0
Carbon Tetrachloride	0.5	NA	mg/L	10	0	0	0	0
Chlorobenzene	100.0	NA	mg/L	10	0	0	0	0
Chloroform	6.0	NA	mg/L	10	0	0	0	0
Pyridine	5.0	NA	mg/L	8	0	0	0	0
Tetrachloroethene	0.7	NA	mg/L	10	1	0.002	0.002	0.002
Trichloroethene	0.5	NA	mg/L	10	0	0	0	0
Vinyl chloride	0.2	NA	mg/L	10	0	0	0	0
1,4-Dichlorobenzene	7.5	NA	mg/L	8	0	0	0	0
2,4,5-Trichlorophenol	400.0	NA	mg/L	8	0	0	0	0

See footnote at end of table.

TABLE 1-15
(Continued)

Parameters	RCRA Standard (mg/L)	Ohio Exempt Waste Standard (mg/L)	Units	# of Analyses	Number of Detects	Minimuum Detect	Maximum Detect	Average Detect
2,4,6-Trichlorophenol	2.0	NA	mg/L	8	0	0	0	0
2,4-Dinitrotoluene	0.13	NA	mg/L	8	0	0	0	0
Hexachlorobenzene	0.13	NA	mg/L	8	0	0	0	0
Hexachlorobutadiene	0.5	NA	mg/L	8	0	0	0	0
Hexachloroethane	3.0	NA	mg/L	8	0	0	0	0
Nitrobenzene	2.0	NA	mg/L	8	0	0	0	0
Pentachlorophenol	100.0	NA	mg/L	8	0	0	0	0
Total Methylphenol	200.0	NA	mg/L	8	0	0	0	0
2,4,5-TP (Silvex)	1.0	NA	mg/L	10	0	0	0	0
2,4-D	10.0	NA	mg/L	10	0	0	0	0
Chlordane	0.03	NA	mg/L	6	0	0	0	0
Endrin	0.02	NA	mg/L	10	0	0	0	0
Heptachlor	0.008	NA	mg/L	10	0	0	0	0
Heptachlor epoxide	0.008	NA	mg/L	10	0	0	0	0
Methoxychlor	10.0	NA	mg/L	10	0	0	0	0
Toxaphene	0.5	NA	mg/L	10	0	0	0	0
alpha-Chlordane	0.03	NA	mg/L	4	0	0	0	0
gamma-BHC (Lindane)	0.4	NA	mg/L	10	0	0	0	0
gamma-Chlordane	0.03	NA	mg/L	4	0	0	0	0

[a]NA = not applicable.

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detected 20 metals and no volatile, semivolatile, or pesticide/PCB analytes. Phase II sampling detected seven inorganic/metals, 0.21 pCi/L of thorium-230, and one organic compound. Metals that were detected in both Phase I and Phase II were antimony, barium, magnesium, silicon, sodium, potassium, and calcium. Chloride and sulfate were detected at 72 milligrams per liter (mg/L) and 39.3 mg/L, respectively.

Groundwater

Groundwater analytical data from the 1000-series wells were compared to background data from the perched groundwater developed for the site. Chemical and radiological analytical results for constituents detected above background are provided in the Operable Unit 2 RI Report, Appendix D, Table D-2G through Table D-2I. Statistical summaries of the COCs within perched groundwater are given in Table 1-16. A comparison of concentrations in upgradient Well No. 1039 and the downgradient wells indicated the following:

- Inorganics/metals detected in elevated concentrations, both in the sludge and samples of groundwater beneath the ponds (Well No. 1041) and downgradient (Well No. 1934), include chromium, copper, beryllium, and vanadium. These data suggest that these constituents leached from the pond sludge and have impacted perched groundwater.

- Total uranium concentration is increased in downgradient Well No. 1042 (30.4 μg/L) and Well No. 1934 (17.5 μg/L) relative to the upgradient Well No.1039 (less than 1 μg/L). The increase may be due to impacts from the K-65 slurry line trench, which is on the flow path between the ponds and the wells.

- Thorium-230 and radium-226 activities are higher in downgradient Well No. 1934 (6.67 and 1.40 pCi/L, respectively) relative to upgradient Well No. 1039 (0.251 and less than 0.183 pCi/L, respectively) and relative to upgradient Well No. 1041 (1.37 pCi/L and 0.310 pCi/L, respectively). The increase may be due to impacts from the K-65 slurry line trench. Also, neptunium-237, strontium-90, and technetium-99 were detected above background in the perched groundwater.

Phase I sampling of one 2000-series well detected two metals, isotopes of thorium and uranium, and two organic compounds (acetone at 7 μg/L and phenol at 50 μg/L) that exceeded background. Phase II sampling of four wells detected three metals, isotopes of three elements, and one organic compound that exceeded background values. Analytical results of samples from upgradient and downgradient wells were compared. Isotopes of neptunium and plutonium were detected above background in water samples from all of the wells. Isotopes of uranium were detected above background in all three downgradient wells (Nos. 2042, 2935, and 2936). The background value for total uranium was

TABLE 1-16

CONTAMINANTS OF CONCERN, PERCHED GROUNDWATER LIME SLUDGE PONDS

Parameter	Filtered?	# of Samples	# of Hits	Min. Hit	Max. Hit	Min. SQL	Max. SQL	Mean	Units	Conc. Term
Radionuclides										
Neptunium-237	Filtered	1	0	NA[a]	NA	NA	NA	NA	pCi/L	NA
Neptunium-237	Unfiltered	12	1	0.3	0.3	0.2	1.0	0.4	pCi/L	0.3
Strontium-90	Filtered	2	0	NA	NA	NA	NA	NA	pCi/L	NA
Strontium-90	Unfiltered	13	0	NA	NA	NA	NA	NA	pCi/L	NA
Technetium-99	Filtered	2	0	NA	NA	10	10.7	NA	pCi/L	NA
Technetium-99	Unfiltered	13	0	NA	NA	9.1	30	NA	pCi/L	NA
Uranium-234	Filtered	2	2	0.4	2.5	NA	NA	1.4	pCi/L	2.5
Uranium-234	Unfiltered	12	10	0.5	3.3	1.0	1.0	1.9	pCi/L	2.6
Uranium-235/236	Filtered	2	1	0.2	0.2	0.1	0.1	0.3	pCi/L	0.2
Uranium-235/236	Unfiltered	13	5	0.1	0.2	0.3	1.0	2.0	pCi/L	2.7
Uranium-238	Filtered	2	2	0.4	2.7	NA	NA	1.6	pCi/L	2.7
Uranium-238	Unfiltered	13	11	0.3	3.7	1.0	1.0	2.0	pCi/L	2.7
Metals										
Uranium-total	Filtered	2	1	8.3	8.3	1.0	1.0	4.4	μg/L	8.3
Uranium-total	Unfiltered	13	12	1.0	9.0	2.0	2.0	5.2	μg/L	6.9

[a]NA = not applicable.

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exceeded slightly in Well No. 2042 (3.39 μg/L) and Well No. 2935 (2.86 μg/L). These data do not indicate an impact from the waste unit upon the regional groundwater.

1.7.1.3 Inactive Flyash Pile

Analytical results for samples collected from the Inactive Flyash Pile are presented in Section 4.4 and Appendix E of the Operable Unit 2 RI Report. Individual sampling locations are shown on Figures 1-38, 1-39 and 1-40.

Volume and Physical Characteristics of the Waste

The volume of flyash and waste materials for the Inactive Flyash Pile is estimated to be approximately 73,401 cu m (96,000 cu yd). Contours of waste thickness are shown on Figure 1-41.

Aerial photographs and interviews with workers indicate that the flyash was deposited by dump trucks as in-filling of depressions in the till surface. One depression of note was a historic drainage channel, as shown on Figure 1-18. Flyash was dumped off a steep till embankment adjacent to Paddys Run and then worked by bulldozers. Discernable dumping patterns were not observed in aerial photographs. It appears that dumping occurred at different working faces within the northern areas of the South Field and Inactive Flyash Pile during the 1950s; the south end of the Inactive Flyash Pile was active during a short period in 1986.

Analyses of subsurface soils collected during Phase II activities were compared to determine if correlations exist between analytes detected above background. Selected constituents were Aroclor-1254, arsenic, beryllium, benzo(a)anthracene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, radium-228, thorium-228, and uranium-238. Concentrations of radium-228 and thorium-228 correlated well with each other, as did arsenic and beryllium, and benzo(a)anthracene and benzo(a)pyrene. Correlation between these radionuclides, metals, and organic compounds suggests that they were deposited at approximately the same time and place. Poor correlation with other analytes, for example uranium, suggests that the other analytes were deposited over a different time period and in different locations. No other correlations in concentrations for these analytes were noted.

The southern portion of the Inactive Flyash Pile has an approximate 2 m (7 ft) soil/fill cover with a moderate vegetative cover. The northern portion, as indicated by the soil boring logs, does not have a soil cover. However, the northern portion is covered with moderate vegetation and stands of

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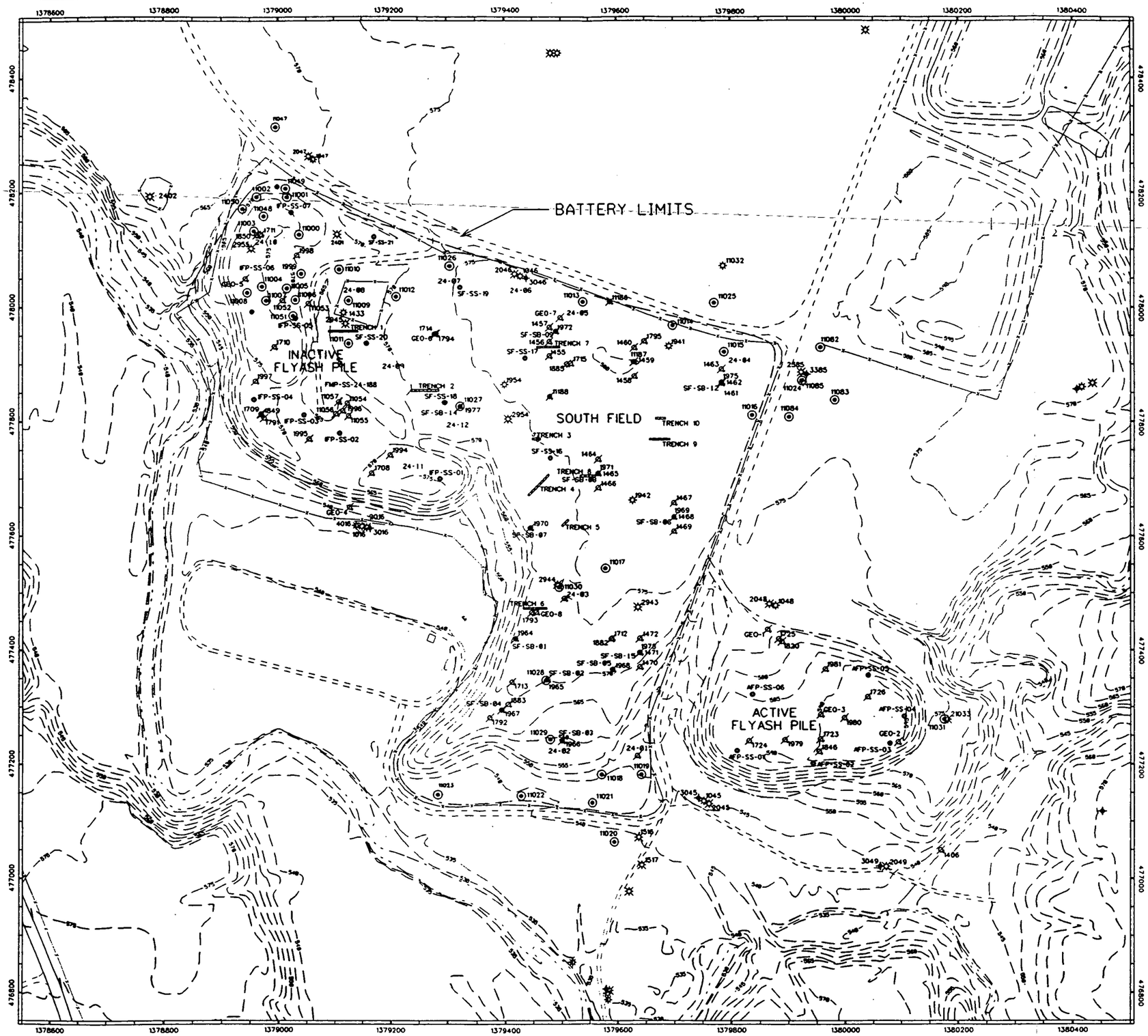

LEGEND
- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- 1000 MONITORING WELLS
- 2000 MONITORING WELLS
- 3000 MONITORING WELLS
- 4000 MONITORING WELLS
- SOIL BORING
- HYDROPUNCH
- SURFACE SAMPLE
- TRENCH

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

N

SCALE (FT)
0 200 400

SCALE (METER)
0 48 38.4

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FIGURE 1-38
SURFACE AND SUBSURFACE
SOIL SAMPLE LOCATIONS
SOUTH FIELD / FLYASH PILES AREA

is0213.m(6340.ws312) po99to4@ws312. Wed Jul 27 07:39:33 EDT 1994

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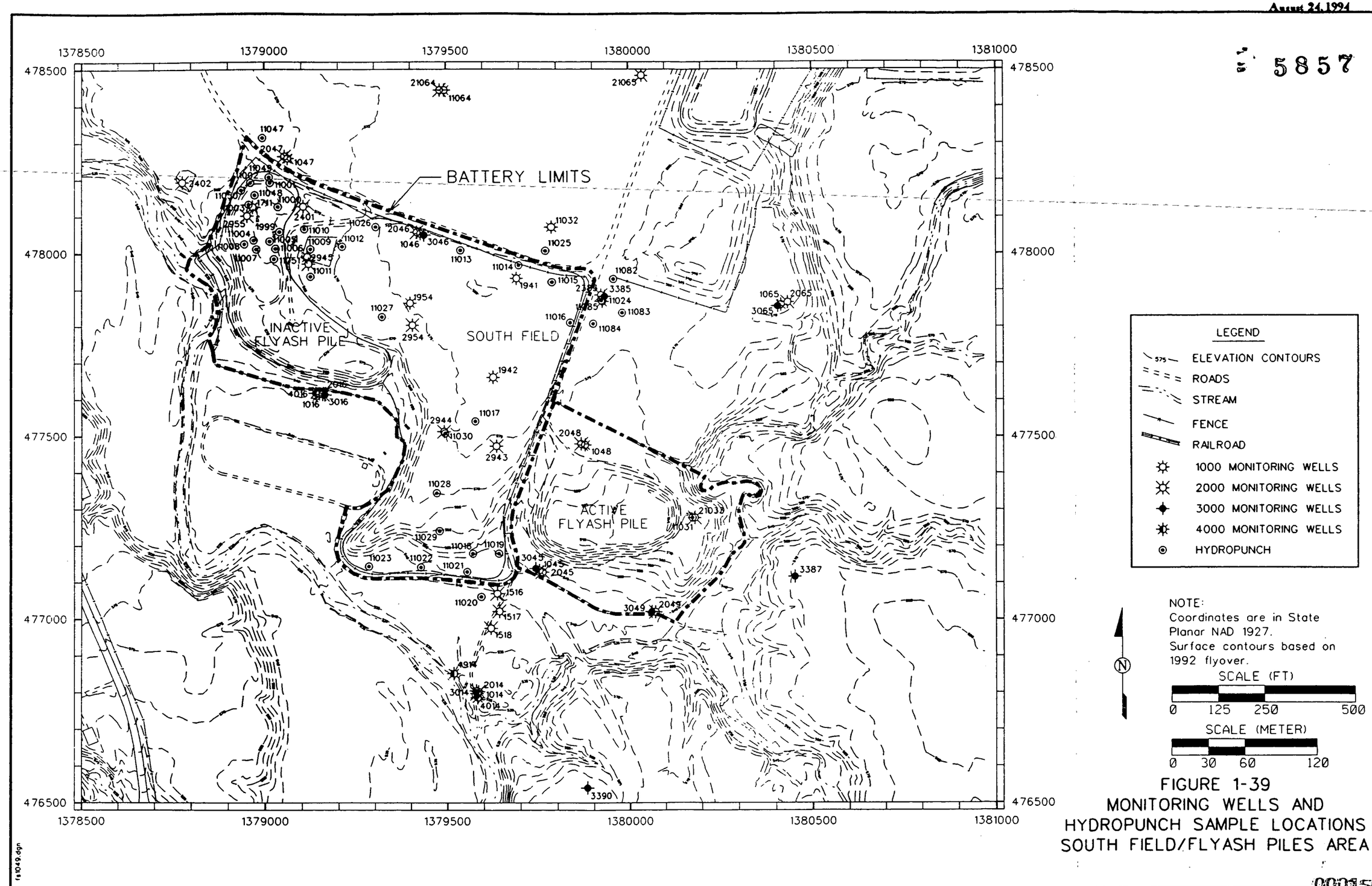

FIGURE 1-39
MONITORING WELLS AND HYDROPUNCH SAMPLE LOCATIONS
SOUTH FIELD/FLYASH PILES AREA

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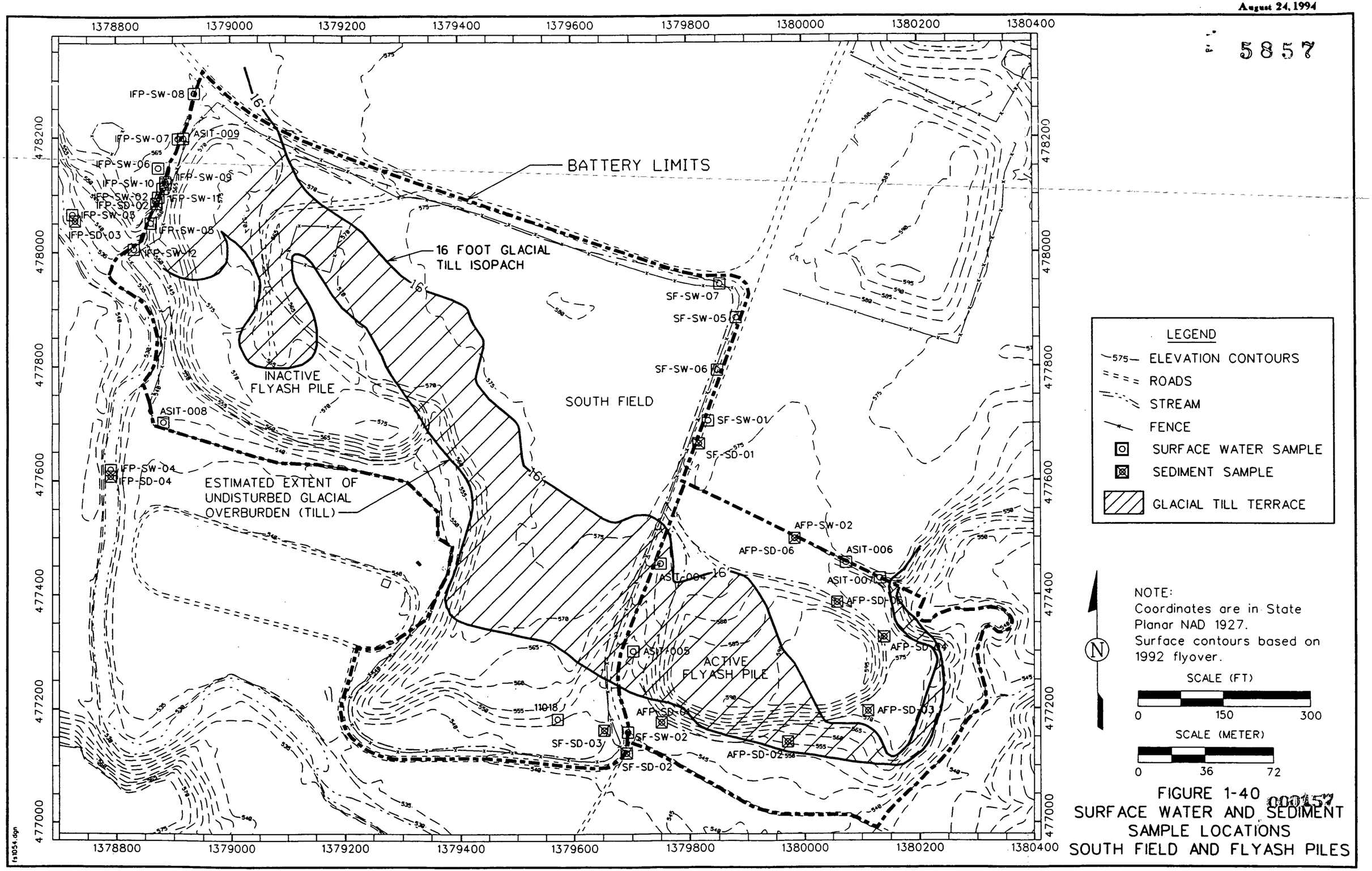

FIGURE 1-40
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
SOUTH FIELD AND FLYASH PILES

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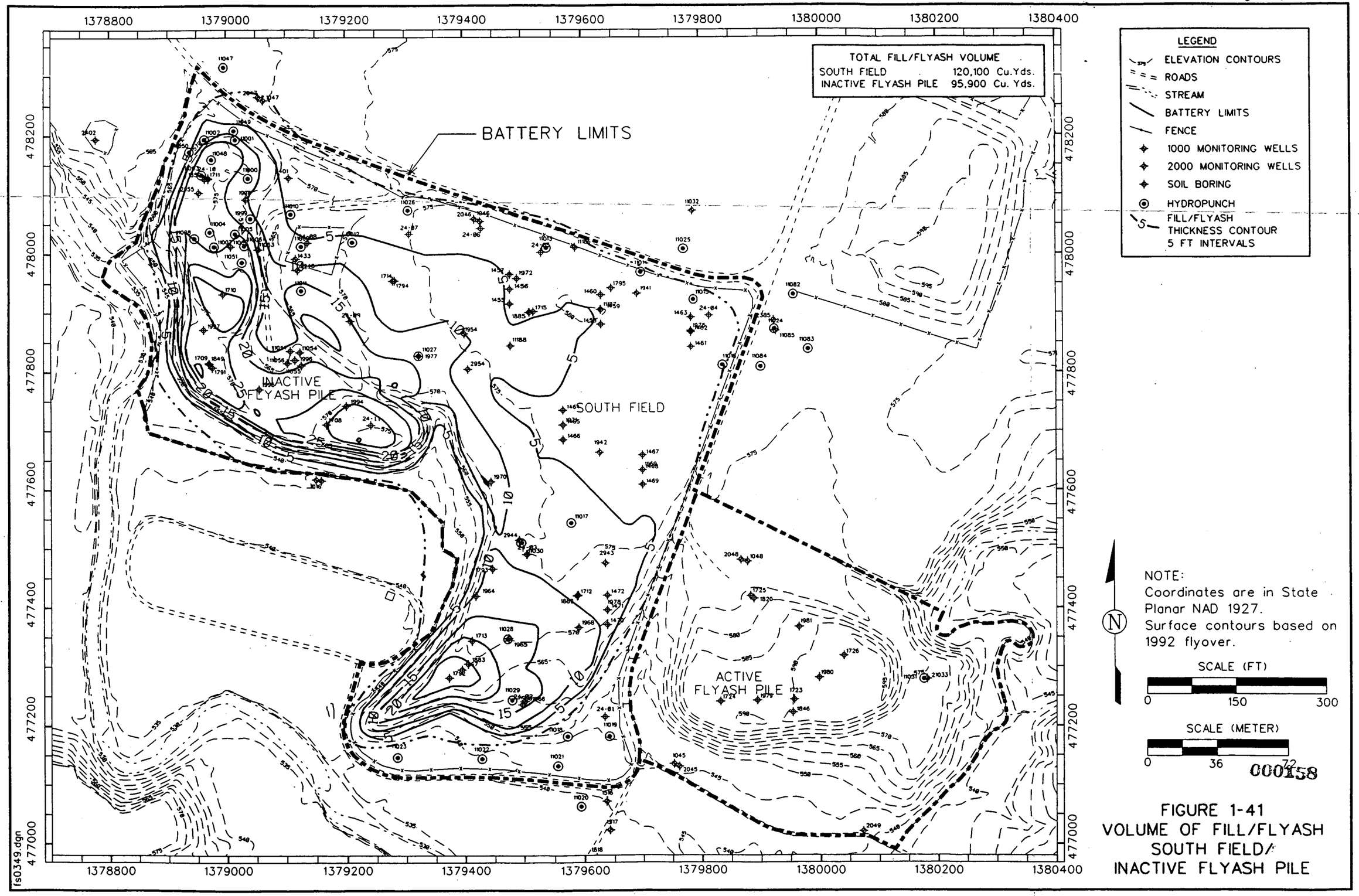

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FIGURE 1-41
VOLUME OF FILL/FLYASH
SOUTH FIELD/
INACTIVE FLYASH PILE

deciduous trees. Standard penetration tests in boreholes at the Inactive Flyash Pile indicate that it contains relatively loose flyash material.

Very moist to wet conditions were detected only at the interface of the Inactive Flyash Pile and the native till surface. The highest beta gamma readings were also detected in samples collected from this interface or from underlying sand layers within the glacial till overburden. Soil samples collected from several soil borings drilled in the flyash displayed solid waste materials of sludge, concrete and construction rubble near the till surface beneath the flyash at Hydropunch™ 11006, 11051, and 11055, and in Boring No. 1996. Flyash was the major material in most of the other subsurface samples collected from the Inactive Flyash Pile. Waste materials identified in samples collected from soil borings in the subunit included sludge, clay tile drain pipe, wood, nails, wire, construction debris, and flyash. All materials except the flyash produced elevated field measured radioactivity by an alpha-beta m. Identifiable waste materials appeared to be resting on or near the interface of flyash and glacial overburden materials near the center of the Inactive Flyash Pile.

Surface and Subsurface Media

Fifteen metals/inorganics, isotopes of six elements, and 12 organic compounds exceeded background concentrations in samples of the surface media collected during the Phase II field program. Total uranium, detected in all surface soils, ranged from 5.01 micrograms per gram (μg/g) to 32.1 μg/g. Strontium-90 was detected in five of seven surface samples and total thorium was detected at 7.74 μg/g and 21.4 μg/g at IFP-SS-05 and IFP-SS-01.

Fifteen metals, isotopes of 10 elements, and 24 organic compounds exceeded background concentrations in 11 subsurface samples collected during the Phase I field program from the Inactive Flyash Pile. Twenty-two metals, isotopes of seven elements, and 34 organic compounds were detected in 30 subsurface samples collected during Phase II.

Metals detected above soil background in 40 percent or more of Phase I samples include antimony, arsenic, barium, beryllium, copper, cyanide, molybdenum, selenium, and silver. Phase II metal samples displayed elevated copper, lead, and mercury concentrations associated with a sludge material found at depths of 5.8 to 7.3 m (19 to 24 ft) beneath the flyash. These data indicate that the metals copper, cyanide, mercury, and thallium are possible indicators of waste-derived metal contamination in the flyash.

Radionuclides detected above background concentrations in Phase I subsurface samples included the fission products cesium-137 (one sample), ruthenium-106 (one sample), strontium-90 (seven samples), and technetium-99 (two samples). This suggests that fission products were not a significant portion of the waste material deposited at the Inactive Flyash Pile.

Uranium, thorium, and radium isotopes are the principal radionuclides detected above background in subsurface samples. Thorium and radium are closely correlated, but do not correlate with uranium concentrations. The highest concentration of uranium was detected in samples from a sludge material detected at depths of 6 to 7.3 m (20 to 24 ft) depths near Hydropunch™ 11006. These depths correspond to the original till surface and may be the surface upon which 1950-era waste material was deposited. Samples from these depths detected elevated total uranium in Boring Nos. 1710 (660 μg/g), 11051 (3580 μg/g), 11052 (294 μg/g), and Hydropunch™ 11006 (1714 μg/g).

Soil boring data indicate that the undisturbed glacial overburden thins and does not extend beneath the far west and southern half of the Inactive Flyash Pile. The inferred extent of the undisturbed glacial overburden, based on soil borings and historical topographic maps, is shown on Figure 1-40. In the area of the South Field, the glacial overburden rapidly thins due to erosion from over six m (20 ft) thick to zero thickness. The 5 m (16 ft) thick contour line is shown for reference. Concentrations of total uranium in samples collected at the interface of the flyash and underlying soil are: 873 μg/g (Boring No. 1791), 68.2 μg/g (Boring No. 1708), and 50.7 μg/g (Boring No. 1994). Sampling depths at these locations varied from 8.2 to 9.2 m (27 to 30 ft). These data indicate that there is a potential source for uranium contamination of the regional aquifer.

The most common volatile organic compound detected in Phase I subsurface samples was TCA, which was detected in 9 of 14 samples throughout the Inactive Flyash Pile and at variable depths. The most common semi-volatile was 2-methylnaphthalene, which was detected in 4 of 16 samples. Phase II samples detected TCA in 10 of 30 samples and also detected acetone (10 samples) and toluene (19 samples). Bis(2-ethylhexyl) phthalate was the most common semivolatile and was detected in 22 of 31 samples, while 2-methylnaphthalene was detected once in 31 samples.

Organic compounds detected in subsurface samples from the Inactive Flyash Pile were predominantly semivolatile compounds detected in samples collected from the till/flyash interface in Borings Nos. 11006 and 11051. These sample locations correlate to the highest uranium concentrations in waste

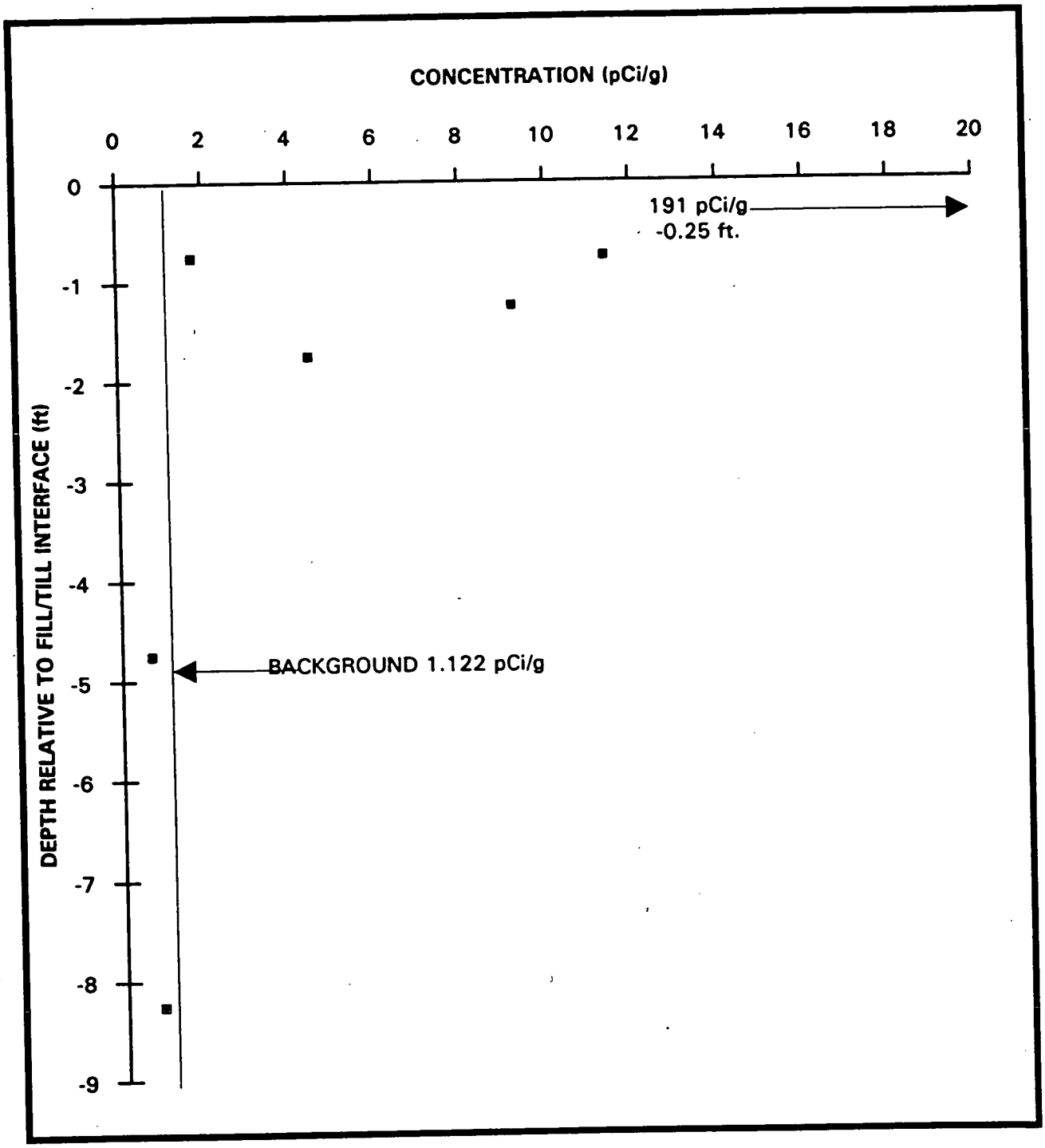
samples found in the Inactive Flyash Pile and are related to the sludge material observed in these borings. The pervasive character of trace organic contamination detected elsewhere suggests that the organics within the flyash originated in a liquid form that was sprayed on the Flyash Pile. Aroclor-1254 was detected in five locations in subsurface samples in the Inactive Flyash Pile: at Boring Nos. 1995 [0.6 m (2 ft deep)], 1710 [8.7 m (28.5 ft deep)], 1711 [5.6 m (18.5 ft deep)], 11006 [6.5 m (22.5 ft deep)], and 11051 [6.7 m (22 ft deep)]. The highest concentrations of Aroclor-1254 and total uranium were found in the area of the buried drainage ditch that existed before the Inactive Flyash Pile was developed (Figure 1-18). Aroclor-1254 was detected in trace concentrations and in combination with other organic compounds, suggesting that it was disposed of in a mixture.

Figure 1-42 shows the distribution of uranium-238 concentrations for the Inactive Flyash Pile subsurface till samples relative to the estimated fill/till interface. All of the uranium-238 concentrations that are more than 0.6 m (2 ft) below the fill/till interface are below the background concentration. This figure demonstrates that the migration of uranium contamination into the till is confined to an impacted till layer that extends about 0.6 m (2 ft) below the fill/till interface.

To determine the distribution of COCs in relation to the lithology of the Inactive Flyash Pile, the soil data have been organized into samples in the surface soil, cover material, source material, other till material, and unsaturated Great Miami Aquifer soils. This type of analysis assists in the evaluation of technologies and process options for different media with various contaminant concentrations. Source material consists of samples from fill material (waste) and the impacted till [within .61 m (2 ft)] of the fill/till interface). The other till samples are those below the impacted till within the battery limits. The unsaturated Great Miami Aquifer soils are located between the bottom of the till and the Great Miami Aquifer water table. Statistical summaries for the COCs within these subsets are given in Tables 1-17 through 1-21. It should be noted that this analysis separated soil into subsets that differ from those presented in the Operable Unit 2 RI Report. As a result, the summary statistics presented here are not directly comparable to those presented in the Operable Unit 2 RI Report, even though the raw data sets are identical.

Thirteen samples were collected to complete waste characteristic determination by TCLP analyses. The results of the TCLP analyses for metals are shown in Table 1-22. No analyses detected concentrations that exceeded the RCRA standard for hazardous waste (40 CFR § 261.24). Likewise,

FIGURE 1-42
U-238 CONCENTRATION VS DEPTH RELATIVE TO TILL/FILL INTERFACE INACTIVE FLYASH PILE



000152

TABLE 1-17

CONTAMINANTS OF CONCERN, SURFACE SOILS
INACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	7	7	1.9	33.2	8.7	mg/kg	33.2
Radionuclides							
Radium-226	7	7	0.5	2.7	1.2[a]	pCi/g	2.0
Radium-228	7	7	0.4	2.6	1.2[a]	pCi/g	2.2
Thorium-228	2	2	0.8	2.7	1.8	pCi/g	2.7
Thorium-232	2	2	0.8	2.3	1.6	pCi/g	2.3
Organics							
Dibenzo(a,h)anthracene	7	1	2200	2200	499.3	μg/kg	2200.0

[a]Estimated Mean

000163

R 5 8 5 2

TABLE 1-18

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - COVER INACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
			Metals				
Arsenic	2	2	1.9	5.1	3.5	mg/kg	5.1
			Radionuclides				
Radium-226	2	2	0.5	1.2	0.9	pCi/g	1.2
Radium-228	2	2	0.4	1.2	0.8	pCi/g	1.2
Thorium-228	ND[a]	ND	ND	ND	ND	pCi/g	ND
Thorium-232	ND	ND	ND	ND	ND	pCi/g	ND
			Metals				
Dibenzo(a,h)anthracene	2	0	-	-	-	μg/kg	-

[a]ND = No data available

TABLE 1-19

CONTAMINANTS OF CONCERN, SOURCE MATERIAL INACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
			Metals				
Arsenic	19	19	1.7	49.7	10.8	mg/kg	49.7
			Radionuclides				
Radium-226	26	26	0.5	42.3	6.4	pCi/g	37.8
Radium-228	26	26	0.4	3.1	1.6[a]	pCi/g	1.9
Thorium-228	21	21	0.6	4.1	1.7[a]	pCi/g	2.0
Thorium-232	21	21	0.6	4	1.5[a]	pCi/g	2.0
			Organics				
Dibenzo(a,h)anthracene	21	2	2	2200	303.7	μg/kg	2.0

[a]Estimated Mean

C001165

W 5 8 5 7

TABLE 1-20

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - OTHER TILL INACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	4	4	3.6	6.9	5.1	mg/kg	6.9
Radionuclides							
Radium-226	2	2	0.8	1.0	0.9	pCi/g	1.0
Radium-228	2	2	0.7	0.7	0.7	pCi/g	0.7
Thorium-228	2	2	0.5	0.8	0.7	pCi/g	0.8
Thorium-232	2	2	0.6	0.7	0.7	pCi/g	0.7
Organics							
Dibenzo(a,h)anthracene	4	0	-	-	-	µg/kg	-

F 5857

TABLE 1-21

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - GREAT MIAMI AQUIFER INACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
			Metals				
Arsenic	3	3	3	5.1	4.3	mg/kg	5.1
			Radionuclides				
Radium-226	3	3	0.6	0.9	0.7	pCi/g	0.9
Radium-228	3	2	0.3	0.5	0.4	pCi/g	0.5
Thorium-228	3	3	0.3	0.4	0.4	pCi/g	0.4
Thorium-232	3	3	0.3	0.4	0.3	pCi/g	0.4
			Metals				
Dibenzo(a,h)anthracene	7	0	-	-	-	μg/kg	-

Note: Soil samples were collected from the unsaturated zone beneath the till in the Great Miami Aquifer.

000187

TABLE 1-22

INACTIVE FLYASH PILE TCLP METALS

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard (mg/L)	Units	Number of Analyses	Number of Detects	Minimum Detects	Maximum Detects	Average Detects
Arsenic	5.0	1.5	mg/L	11	3	0.08	0.1	0.09
Barium	100.0	30.0	mg/L	13	8	0.9	2.2	1.49
Cadmium	1.0	0.3	mg/L	13	3	0.007	0.02	0.01
Chromium	5.0	1.5	mg/L	13	3	0.07	0.09	0.08
Copper	NA[a]	NA	mg/L	5	2	0.002	0.003	0
Iron	NA	NA	mg/L	5	3	0.008	1.2	0.44
Lead	5.0	1.5	mg/L	13	3	0.08	0.1	0.09
Manganese	NA	NA	mg/L	5	5	0.09	0.4	0.17
Mercury	1.2	0.06	mg/L	13	1	0.0006	0.0006	0
Selenium	1.0	0.3	mg/L	11	6	0.08	0.2	0.14
Silver	5.0	NA	mg/L	12	3	0.05	0.08	0.07
Zinc	NA	NA	mg/L	2	0	0	0	0
1,1-Dichloroethene	0.7	NA	mg/L	13	0	0	0	0
1,2-Dichloroethane	0.5	NA	mg/L	13	0	0	0	0
2-Butanone	200.0	NA	mg/L	12	2	0.002	0.004	0.003
Benzene	0.5	NA	mg/L	13	0	0	0	0
Carbon Tetrachloride	0.5	NA	mg/L	13	0	0	0	0
Chlorobenzene	100.0	NA	mg/L	13	0	0	0	0
Chloroform	6.0	NA	mg/L	13	0	0	0	0
Pyridine	5.0	NA	mg/L	11	0	0	0	0
Tetrachloroethene	0.7	NA	mg/L	13	0	0	0	0
Trichloroethene	0.5	NA	mg/L	13	0	0	0	0

See footnote at end of table.

TABLE 1-22
(Continued)

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard (mg/L)	Units	Number of Analyses	Number of Detects	Minimum Detects	Maximum Detects	Average Detects
Vinyl chloride	0.2	NA	mg/L	13	0	0	0	0
1,4-Dichlorobenzene	7.5	NA	mg/L	11	0	0	0	0
2,4,5-Trichlorophenol	400.0	NA	mg/L	11	0	0	0	0
2,4,6-Trichlorophenol	2.0	NA	mg/L	11	0	0	0	0
2,4-Dinitrotoluene	0.13	NA	mg/L	11	0	0	0	0
Hexachlorobenzene	0.13	NA	mg/L	11	0	0	0	0
Hexachlorobutadiene	0.5	NA	mg/L	11	0	0	0	0
Hexachloroethane	3.0	NA	mg/L	11	0	0	0	0
Nitrobenzene	2.0	NA	mg/L	11	0	0	0	0
Pentachlorophenol	100.0	NA	mg/L	11	1	0.008	0.008	0.008
Total Methylphenol	200.0	NA	mg/L	5	0	0	0	0
2,4,5-TP (Silvex)	1.0	NA	mg/L	13	0	0	0	0
2,4-D	10.0	NA	mg/L	13	0	0	0	0
Chlordane	0.03	NA	mg/L	3	0	0	0	0
Endrin	0.02	NA	mg/L	13	0	0	0	0
Heptachlor	0.008	NA	mg/L	13	0	0	0	0
Heptachlor epoxide	0.008	NA	mg/L	13	0	0	0	0
Methoxychlor	10.0	NA	mg/L	13	0	0	0	0
Toxaphene	0.5	NA	mg/L	13	0	0	0	0
alpha-Chlordane	0.03	NA	mg/L	10	0	0	0	0
gamma-BHC (Lindane)	0.4	NA	mg/L	13	0	0	0	0
gamma-Chlordane	0.03	NA	mg/L	10	0	0	0	0

[a]NA = not applicable.

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no detected concentrations exceeded the Ohio Exempt Waste Standard (OEPA Policy 4.07 - Design Criteria: Disposal of Non-toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes).

Waste materials were identified from samples collected from four borings in the Inactive Flyash Pile. The concentration of metals appears elevated in comparison to background soil concentrations, but is similar to the concentrations of metals expected in flyash samples. Therefore, waste material appears to be characterized by elevated radium and uranium isotopes, with slight enrichment in the metals silver and zinc.

A comparison of metals/organics, radionuclides, and organic compounds detected in surface samples and subsurface samples indicates the following:

- Subsurface concentrations of antimony, cyanide, mercury, and silver are consistent with flyash. Above-background concentrations of copper, lead, and mercury were associated with sludge material, which indicates that the analytes, when above flyash background, may be waste derived.
- Concentrations of organic compounds and radionuclides are significantly higher in subsurface samples, suggesting that disposal of contaminated material occurred throughout the Inactive Flyash Pile over the time period the pile was active.
- There does not appear to be a single distribution pattern for analytes that defines a boundary of disposal activity on the surface or subsurface.

Surface Water and Sediment

There are no perennial sources of surface water within the battery limits of the Inactive Flyash Pile. Surface water was not present at several of the proposed drainage sampling locations; therefore, surface water samples were collected on an as-possible basis after rain storms. Drainage within a channel at the west side of the Inactive Flyash Pile was observed to flow for several days after significant rain events, and samples were collected at multiple locations to characterize seeps from the Inactive Flyash Pile.

Locations that were sampled during Phase II field sampling programs are shown on Figure 1-40. One surface water sample was collected during Phase I at an upstream location in the west drainage channel. Sixteen metals (40 μg/L of total uranium) and no organic compounds were detected. Metals included cadmium, chromium, lead, mercury, nickel, silver, and vanadium. These metals were also

detected in soil samples from the Inactive Flyash Pile. Thirteen metals, the isotopes of five elements, and two organic compounds (toluene at 2 μg/L and bis(2-ethylhexyl)phthalate at 1 μg/L) were detected in six surface water samples collected from the Inactive Flyash Pile during Phase II. Metals detected in surface water samples collected from the drainage during Phase II include arsenic, cyanide, selenium, and zinc. Phase II analyses did not detect the following analytes detected during Phase I: chromium, cadmium, lead, mercury, nickel, silver, or vanadium.

Total uranium analyses of surface water in the west drainage were used to define the location of possible springs or seeps contributing to drainage from the Inactive Flyash Pile. One location of observed seepage was sampled (IFP-SW-11) on May 18, 1993, and contained 820 μg/L total uranium; upstream and downstream concentrations were 23 μg/L (IFP-SW-06) and 910 μg/L (IFP-SW-05), respectively, on May 2, 1993. Surface water drainage was traced downstream to where surface water drained into the sandy stream channel. Total uranium in a sample collected on May 18, 1993, slightly upstream of this location was 370 μg/L (IFP-SW-12). Therefore, field observations indicate that recharge to the regional aquifer occurs by surface water from the west drainage. Analytical data indicate that the recharge water has elevated concentrations of uranium.

Two sediment samples collected during Phase I contained five metals/inorganics, total uranium in both samples, and no organic compounds. Three Phase II sediment samples were collected at the same time and location as surface water samples, but at different locations than for Phase I. Four metals/inorganics, the isotopes of four elements, and 21 organic compounds were detected above background in sediment samples. Beryllium was detected at 1.2 mg/kg, and toluene and acetone were detected in samples from Paddys Run. Five semivolatile organic compounds were detected at trace concentrations in the west drainage. These were detected in the downstream sediment sample from Paddys Run. Four compounds detected in the west drainage and in the downstream sediment sample were not detected in the upstream Paddys Run sample. These data suggest that the drainage has contributed sediment contaminated with semivolatile organic compounds to Paddys Run.

Eleven of the semivolatile organic compounds detected in the upstream Paddys Run sediment sample were also detected in the downstream sample. However, an additional nine semivolatile compounds were detected in downstream Paddys Run sediment samples that were not detected at upstream locations. Only two of these [dimethyl phthalate and indeno(1,2,3-cd)pyrene] were not detected in soil samples from the Inactive Flyash Pile. These data indicate that the Inactive Flyash Pile may be

the original source for the nine semivolatile compounds detected in the downstream Paddys Run sediment samples but not detected at upstream locations.

Groundwater

To characterize the perched groundwater system beneath the Inactive Flyash Pile, 12 groundwater samples were collected during Phase II from 17 Hydropunch™ sample locations. On-site analyses were used to define the distribution of uranium in perched groundwater at the subunit. Perched groundwater was encountered beneath the north end of the Inactive Flyash Pile; however, perched groundwater was not encountered during attempted sampling in April to May 1993 at the south end of the Inactive Flyash Pile. The distribution of total uranium in perched groundwater for the Flyash Piles Area and the South Field is shown on Figure 1-43. Hydropunch™ data suggest that perched groundwater is flowing through waste materials containing uranium in the north end and northeast edge of the Inactive Flyash Pile. Analyses of water samples detected elevated concentrations of uranium and indicate that this area may be the source for seeps detected in the west drainage.

Four 2000-series wells were sampled during Phase I: Well No. 21190 at the south edge of the Inactive Flyash Pile, and Well Nos. 2402, 2047, and 2016, which are located on the west, northeast, and southern battery limits of the Inactive Flyash Pile, respectively. Aluminum, calcium, chromium, uranium, and two organic compounds were detected in Well Nos. 21190 and 2016. The nested Well Nos. 3016 and 4016 were also sampled and contained trace lead, manganese, and uranium. The highest concentrations of total uranium in the 21190-2016-3016 well group in 1989 were 9 μg/L, 22 μg/L, and 7 μg/L. These data indicate a possible impact from the waste unit upon groundwater. Well No. 2955 was installed in the Inactive Flyash Pile during Phase II. Phase II sampling detected aluminum and manganese isotopes of four elements, and three organic compounds that exceeded background values in four samples.

To compare upgradient and downgradient regional aquifer groundwater quality, two wells in the South Field are required. A comparison of the concentration of total uranium in upgradient Well No. 2402 (5.62 μg/L) and downgradient Well No. 2954 (2070 μg/L) or downgradient Well No. 2954 (1167 μg/L) indicates that there has been a release of uranium from the subunit to the regional aquifer. Concentrations of uranium in the downgradient wells (see Figure 1-44 for groundwater contaminant contours) are similar to those detected in perched groundwater samples collected from the seep (820 μg/L at IFP-SW-10), from the drainage as it infiltrates into the regional

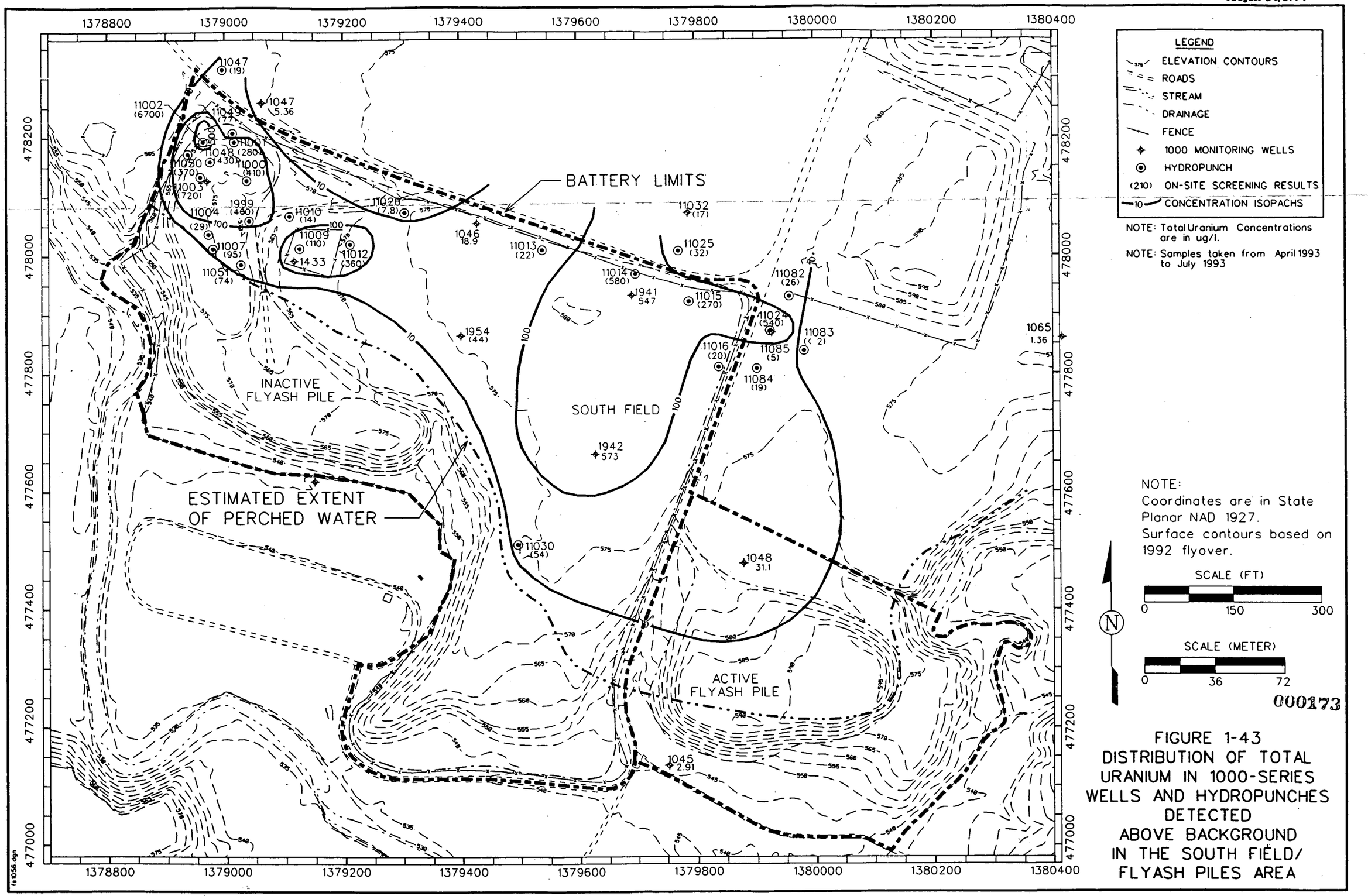
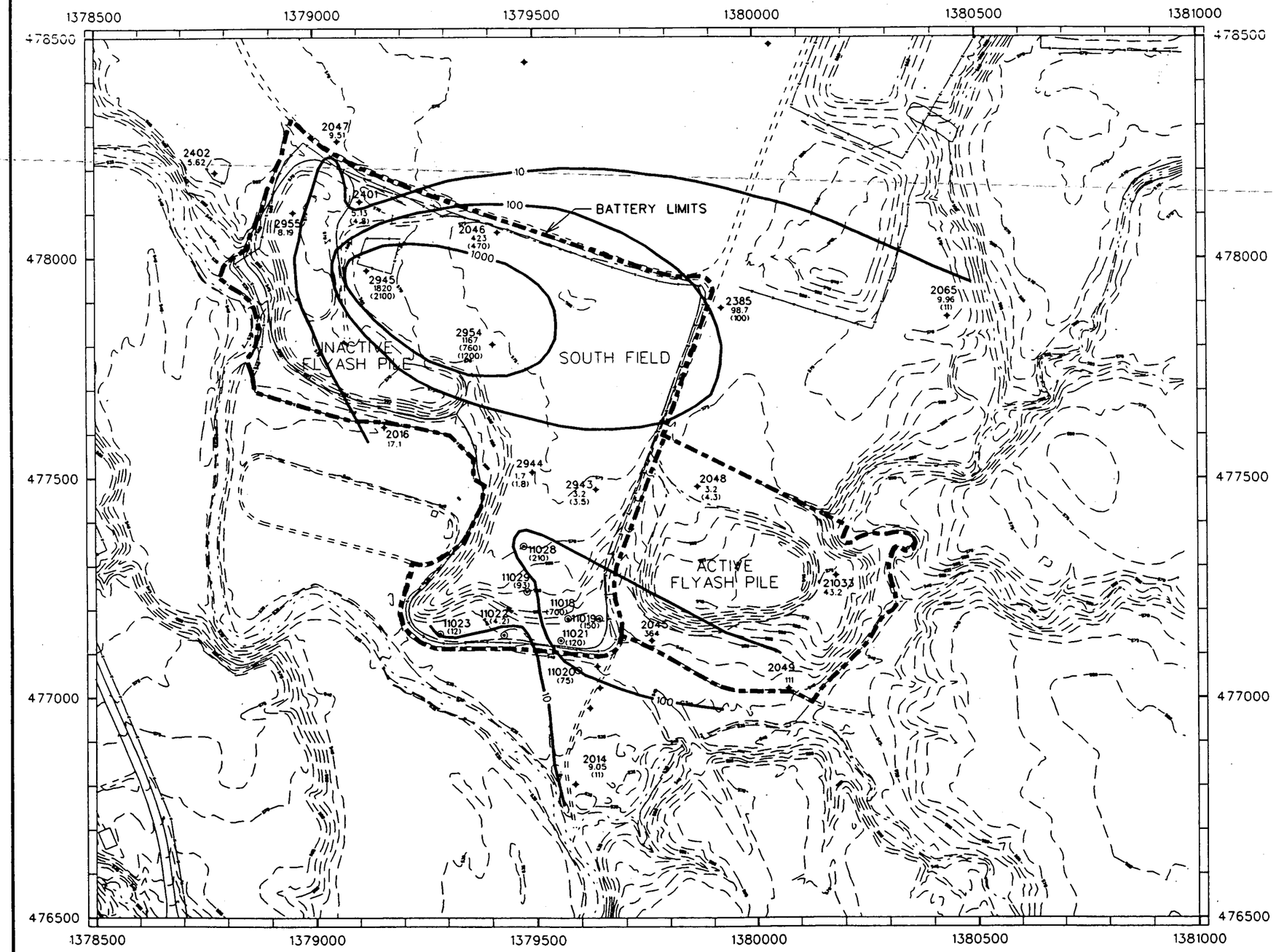


FIGURE 1-43
DISTRIBUTION OF TOTAL URANIUM IN 1000-SERIES WELLS AND HYDROPUNCHES DETECTED ABOVE BACKGROUND IN THE SOUTH FIELD/ FLYASH PILES AREA

000173



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- DRAINAGE
- FENCE
- 2000 MONITORING WELLS
- HYDROPUNCH
- (210) ON-SITE SCREENING RESULTS

NOTE: Total Uranium Concentrations are in ug/l.

NOTE: Data from May 1993.

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 125 250 500

SCALE (METER)
0 30 60 120

N

000174

FIGURE 1-44
DISTRIBUTION OF TOTAL URANIUM IN 2000-SERIES WELLS DETECTED ABOVE BACKGROUND IN THE SOUTH FIELD/ FLYASH PILES AREA

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aquifer (910 μg/L at IFP-SW-05), and from perched groundwater (6700 μg/L from Hydropunch™ 11002).

Total uranium analysis in Well No. 2955 (in the north end of the waste unit) and Well No. 2401 (downgradient of Well No. 2955 in the South Field) detected 5.13 μg/L and 8.19 μg/L, respectively. These data indicate that there has not been a release of uranium from the subunit in this area to the regional aquifer and suggest that the origin of regional aquifer uranium contamination is southeast of these wells, possibly near to Hydropunch™ 11051, where 2,280 μg/g total uranium was detected in a soil sample at 7.3 m (24 ft) deep.

A comparison of the concentration of constituents other than uranium detected in the upgradient and downgradient wells does not identify any constituent that appears to increase in concentration from wells located downgradient of the subunit. This suggests that uranium is the primary waste constituent in water recharging the regional aquifer beneath the Inactive Flyash Pile.

1.7.1.4 South Field

Analytical results for samples collected from the South Field are presented in Section 4.5 and Appendix F of the Operable Unit 2 RI Report. Individual sample locations are shown on Figures 1-38, 1-39 and 1-40.

Volume and Physical Characteristics of Waste

Waste materials detected in boreholes and trenches in the South Field consist of fill materials, construction debris, and radioactive materials mixed with the above waste materials and with the native till. A map showing the estimated thickness of the fill material is presented in Figure 1-41. The estimated volume for the fill and waste materials in the South Field is 92,000 cu m (120,000 cu yd).

Visual observations of the waste materials in trenches excavated to locate and sample typical waste materials buried in the South Field indicate that a wide range of waste materials were buried. Construction debris in the fill materials above the till include concrete, steel pipe and sheet steel, wood, and clay tile. Samples of soil scraped from the objects indicate that soil associated with the waste materials contains elevated amounts of metals, radionuclides, and semivolatile compounds.

Field screening of dry wipe samples from the surfaces of the waste materials indicate that radioactive contamination is located loosely on the surface and can be removed by wipe sampling.

Surface and Subsurface Soils

Firing Range - A firing range was located near the southwestern portion of the South Field and was used approximately 35 years by FMPC personnel. The locations of samples collected for lead analysis at the Firing Range are shown on Figure 1-45. The results are presented on Table 1-23. The highest concentrations were detected in samples from Boring Nos. SP-2 and SP-5, which are aligned with the center of the Firing Range. Lead concentrations rapidly decrease with distance from the center and distance into the soil embankment. The analytical data indicate that shallow samples 0 to .02 m deep (0 to 0.5 ft deep) in the center of the Firing Range have a maximum concentration of 2820 mg/kg, while samples at the edge of the area have a maximum concentration of 665 mg/kg. Moving from the center to the edge at a depth of .61 to .91 m (2 to 3 ft), the lead concentration drops from a maximum of 345 mg/kg to a maximum of 12.8 mg/kg. Only two samples from Boring No. SP-2 contained lead above background concentrations at depths greater than 0.9 m (3 ft.) A horizontal boring, No. SP-7, yielded lead concentrations above background in a composite sample taken from 0 to 1.5 m (0 to 5 ft) beyond the surface of the Firing Range, but below background in samples taken deeper in the boring. These data suggest that lead from bullets was stopped in the soil within 1.5 m (5 ft) of the slope that formed the backdrop of the Firing Range.

The RCRA standard that defines hazardous waste is 5.0 mg/L for lead (40 CFR 261.24). Five of the TCLP results listed in Table 1-23 exceed this standard; therefore, the Firing Range soils are considered to be characteristically hazardous waste. Based on sample recovery, there is an estimated volume of 230 cu m (300 cu yd) of soil that will be considered a RCRA characteristic hazardous waste.

General South Field Area - Nineteen metals, isotopes of eight elements, and 26 organic compounds exceeded background concentrations in 21 analyses of surface samples collected during the Phase II field program at the South Field. Metals that were detected in over 40 percent of the samples included beryllium (15 samples), copper (17 samples), and silver (20 samples). These metals were distributed widely throughout the South Field and were close to the background limits, except for silver, which has a background concentration of 0 mg/kg.

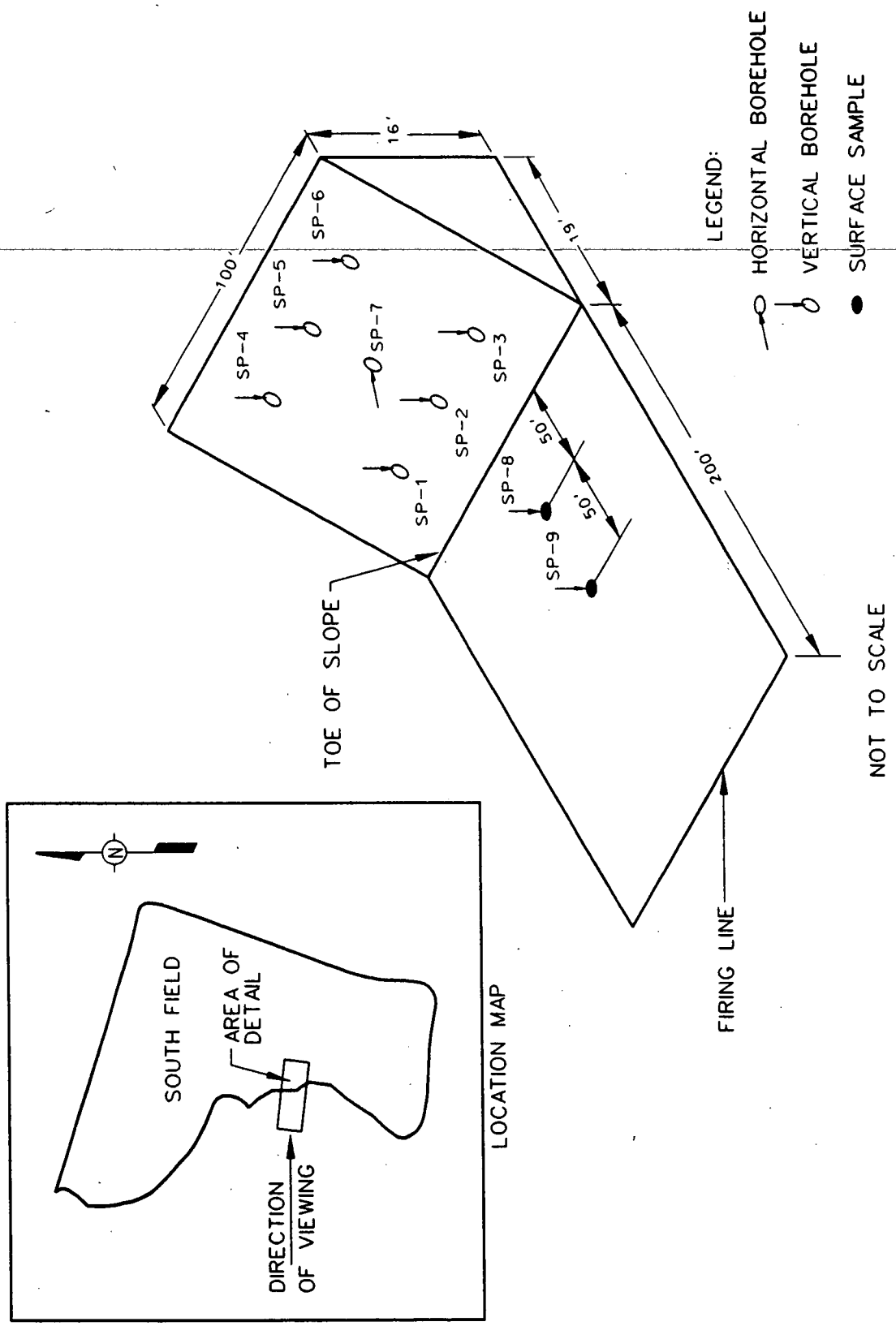

FIGURE 1-45
SUBSURFACE SAMPLING LOCATIONS FOR FIRING RANGE

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TABLE 1-23

LEAD CONCENTRATIONS IN BORINGS AT THE FIRING RANGE

Depth Interval (ft)	Background	Boring Numbers											
		SP-1		SP-2		SP-3		SP-4		SP-5		SP-6	
		Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)	Total (mg/kg)	TCLP (mg/L)
0.0-0.5	29.5	665	6.9	1250	2.0	123	0.4	63.2	NA[a]	2820	101	64.4	NA
0.5-1.0	15.8	154	1.8	2200	4.8	5.6	NA	7.7	NA	2270	21.2	31.3	NA
1.0-2.0	15.8	6.1	NA	2460 1380	8.8 9.3	4.8	NA	11.2 7.0	NA	503	1.3	35.7	NA
2.0-3.0	15.8	6.6	NA	345	1.4	5.1 17.5	NA	12.8	NA	204	2.9	17.6	NA
3.0-4.0	15.8	4.9	NA	57.4	NA	4.0	NA	7.9	NA	2.1	NA	NA	NA
4.0-5.0	15.8	5.6	NA	29.6	NA	1.6	NA	7.5	NA	11.6	NA	NA	NA

[a]NA = not analyzed.
Source: Westinghouse Environmental Management Company of Ohio
Note: Samples sieved with No. 10 sieve to remove lead fragments greater than 2 mm

SP-7 - Horizontal Boring										
Depth (ft)	0-5	5-10	10-15	15-20	20-25	25-30	30-50	35-40	40-45	45-50
Total Lead (mg/kg)	1020	4.8	6.1	4.5	6.9	5.3	4.6	7.2	4.6	5.5

Background = 15.8 mg/kg.
TCLP = 0.27 mg/l at 0-5 feet; not analyzed below 5 feet.

The highest radionuclide activities in surface soil samples were detected at Boring Nos. 11186 and 1972, located near the north boundary of the South Field. These locations correspond to the location of waste piles seen in a 1957 aerial photograph of the site. The surface sample at Boring No. 11186 displayed the highest activity of radium-226 (30.8 pCi/g) of any surface sample collected from the South Field. The data do not indicate a correlation between thorium and uranium and radium. The distribution of radionuclide concentrations suggests multiple surficial hot spots which correlate with surface Field Instrumentation for Detecting Low-Energy Radiation (FIDLER) scans conducted during the Characterization Investigation Study (CIS) sampling program, indicating that surface dumping occurred adjacent to the north boundary road.

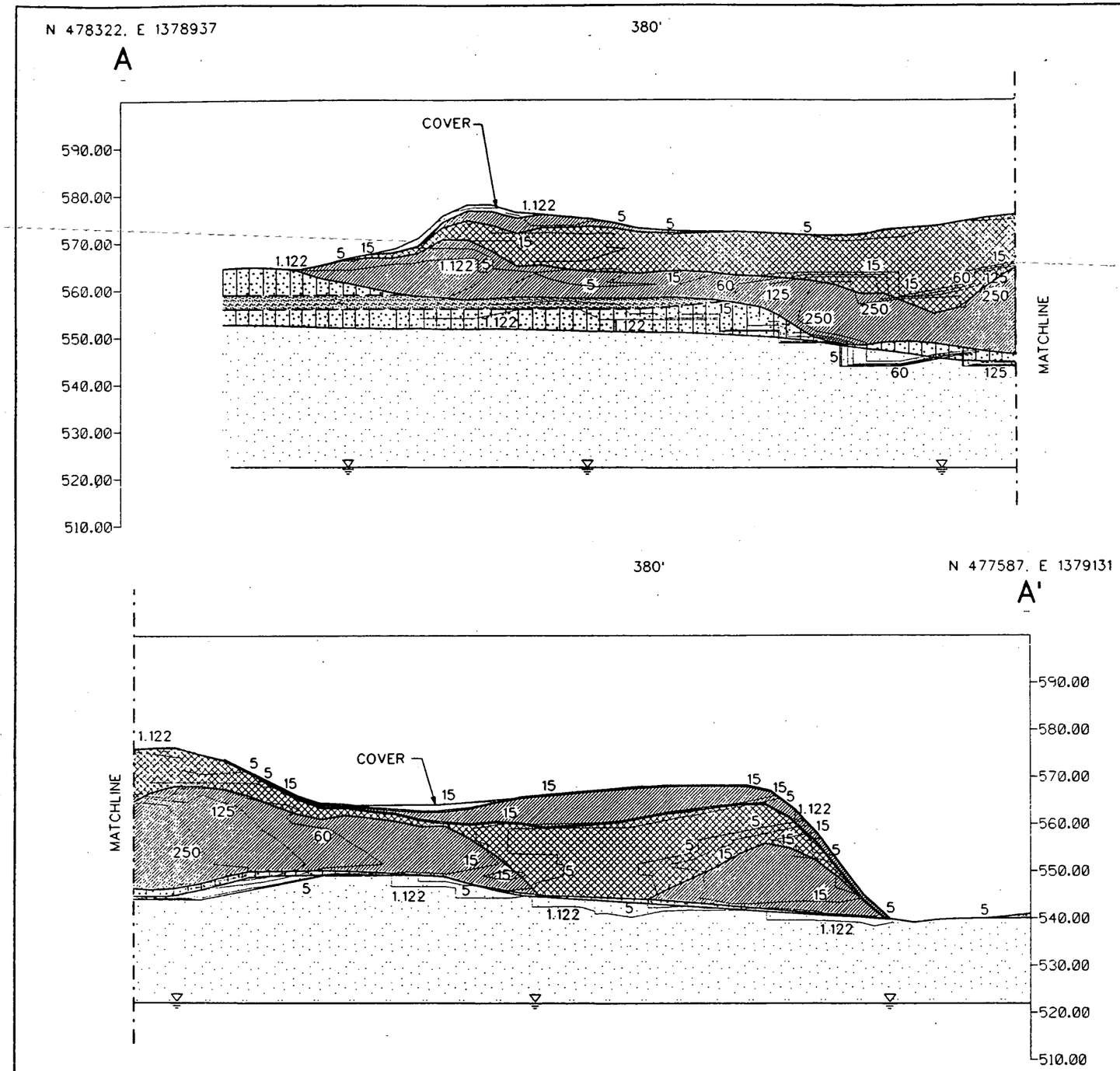
The highest concentrations of organic compounds were detected in samples collected from the northern half of the South Field. Some samples have high concentrations of both radionuclides and organics [SF-SS-17 had 28.4 μg/g total uranium and 36,862 μg/kg total semivolatile organic compounds (SVOCs)], while others had high activities of radionuclides but relatively low concentrations of organic compounds. Boring No. 1965 had 49 μg/g total uranium and 205 μg/kg total organics. This pattern suggests that the contaminants were not consistently co-disposed on the surface of the South Field.

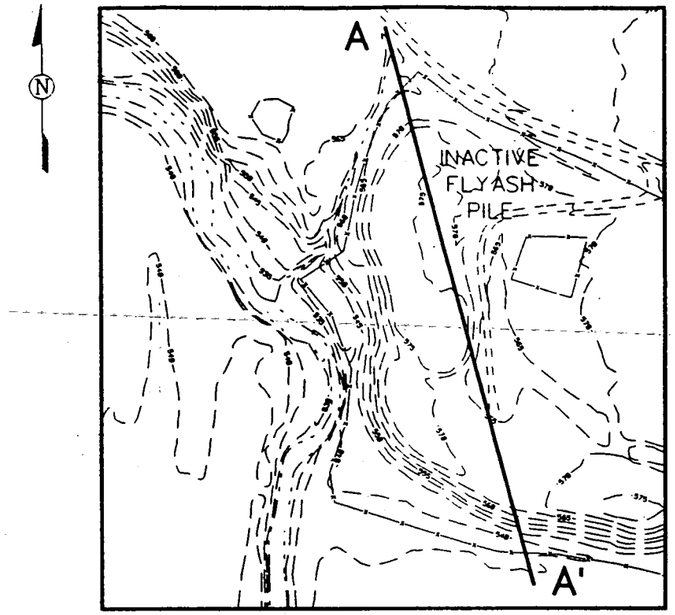
Fifteen metals, isotopes of nine elements, and 25 organic compounds exceeded background concentrations in subsurface samples collected during the Phase I program at the South Field. Metals detected in 40 percent of Phase I subsurface samples included antimony, beryllium, cadmium, chromium, copper, and silver. Most Phase I samples were collected to a maximum depth of 2.3 m (7.5 ft). These metals were also detected above background in surface soil samples, which indicates that metals have been mixed into the upper filled area. Twenty-two metals, isotopes of seven elements, and 30 organic compounds exceeded background concentrations in subsurface samples collected during Phase II. Beryllium, copper, lead, and silver were detected in 20 percent or more of the samples. Lead and copper were detected at up to 20 times background (436 mg/kg for copper and 385 mg/kg for lead) in a sample from Trench 4. Elsewhere, concentrations were detected near background concentrations. The distribution of metal concentrations suggests multiple disposal sites, and the trench sample data suggest lead and copper are waste-derived metals within the subsurface soil.

Six shallow trenches were excavated less than 1.5 m (5 ft) deep during Phase I, from which 18 samples were collected. Elevated concentrations (greater than five times background) of cadmium, lead, and silver were detected in samples that also had elevated concentrations of total uranium. Ten trenches were excavated 3 to 3.7 m (10 to 12 ft) deep during Phase II to investigate anomalous electromagnetic readings. Soil samples were collected from three of these trenches. A sample from 1.8 m (6 ft) deep in Trench 2 (Sample 113724) contained 34 mg/kg total uranium and 3540 mg/kg total thorium. This was the most elevated concentration of total thorium detected in a South Field sample. Concentrations in a sample collected from 0 to 0.9 m (0 to 3 ft) deep in Trench 4 (Sample 113722) included total uranium (1,170 μg/g), total thorium (55.8 μg/g), copper (436 mg/kg), lead (385 mg/kg), vanadium (30.4 μg/g), and zinc (508 μg/g). These data indicate that waste material originated in the former Production Area, and construction debris in these trenches are probably contaminated as a result of process spillage and leakage prior to deposition in the South Field. Wipe samples indicate that radionuclide contamination has transferred to the soil that covers the solid pieces of concrete, wood, and steel. Materials within these trenches are potential sources of radionuclide contamination to percolating water.

The highest concentrations of organic compounds were detected in samples collected from the north border of the South Field and correspond to samples displaying the highest radionuclide concentrations. Semivolatile compounds detected in South Field samples are similar to those detected in samples collected from the Solid Waste Landfill; however, concentrations detected in samples from the Solid Waste Landfill are 100 times greater than those detected in South Field samples. This suggests that mixtures of waste chemical stocks were sent to the Solid Waste Landfill, but that much less chemically contaminated materials were sent to the South Field. The distribution of organic compounds indicates that they are pervasive in the surface, but that the number of compounds is greatly reduced within the upper 4 feet of the soil.

Uranium-238 results from subsurface data were kriged (data mathematically interpreted by a weighted-moving-average interpolation method) and the output processed to provide a model of contaminant distribution in the Inactive Flyash Pile and adjacent areas of the South Field. A conceptual model for contamination located in a geological cross-section of the South Field and Inactive Flyash Pile is presented in Figure 1-46. The cross-section cuts through the highest area of contamination detected in the western portion of the South Field and the Inactive Flyash. Evaluation of the geology in the South Field/Flyash Pile Areas shows that the glacial till is truncated by erosion.





LOCATION KEY (1" = 200')

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

000181

FIGURE 1-46
CONCEPTUAL MODEL FOR SUBSURFACE DISTRIBUTION OF U-238 CONTAMINATION SOUTH FIELD/INACTIVE FLYASH PILE

fs137.dgn

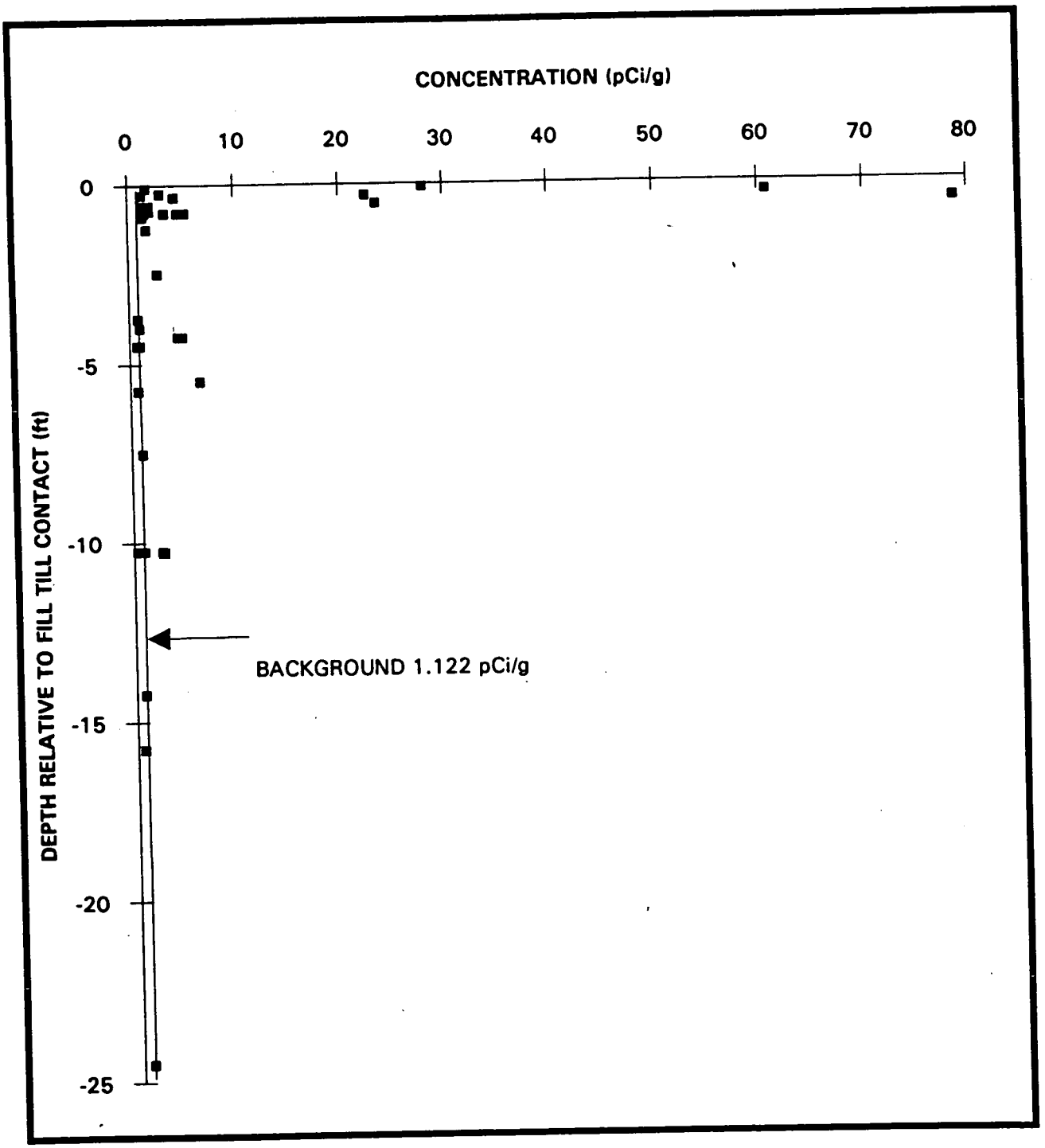
The projected extent of the glacial till is shown in Figure 1-40. In this area, downward infiltration of groundwater is much more rapid than where the glacial overburden is present.

Most soil samples representing the Great Miami Aquifer were collected from Boring Nos. 1518, 1517, and 1518; these borings are located outside the South Field battery limits. Radionuclides were detected above background from the Great Miami Aquifer in only one sample from Monitoring Well No. 3046 at 30.5 to 31 m (100 to 101.7 ft) below ground level. Observed contaminant levels of total uranium (12.7 pCi/g), uranium-234 (4.33 pCi/g), and uranium-238 (4.23 pCi/g) correspond to groundwater sample 004332, in which total uranium at 3.03 pCi/L and uranium-234 at 1.67 pCi/L were detected.

Figure 1-47 shows the distribution of uranium-238 concentrations for the South Field subsurface till samples relative to the estimated fill/till interface. All of the uranium-238 concentrations that are more than 1.3 m (4.25 ft) below the fill/till interface are very near or below the background concentration, with the exception of two samples taken from Boring No. 11186. Samples taken from depths of 1.7 m (5.5 ft) and 3.1 m (10.25 ft) have uranium-238 concentrations of 6.61 pCi/g and 2.73 pCi/g, respectively. There is no fill material at this location; therefore, the till starts at the surface elevation. This particular boring is on the northern border of the South Field and corresponds to a location of high surface activity based on the results of a radiological surface survey. The surface soil sample taken from this location has a uranium-238 concentration of 9.06 pCi/g. The decreasing concentration with increasing depth indicates that the glacial till has an attenuation effect with regard to the vertical migration of uranium. Overall, Figure 1-47 demonstrates that the migration of uranium contamination into the till is largely confined to an impacted till layer that extends approximately 1.3 m (4.25 ft) below the fill/till interface.

To determine the distribution of COCs in relation to the lithology of the South Field, the soil data have been organized into samples in the surface soil, source material, other till material, and unsaturated Great Miami Aquifer soils. This type of analysis assists in the evaluation of technologies and process options for different media with various contaminant concentrations. Source material consists of samples from fill material and the impacted till [within 1.3 m (4.25 ft) of the fill/till interface]. The other till samples are those located below the impacted till within the battery limits. The unsaturated Great Miami Aquifer soils are located between the bottom of the till and the Great Miami Aquifer water table. Statistical summaries for the COCs within these subsets are given in

FIGURE 1-47
U-238 CONCENTRATION VS DEPTH RELATIVE TO TILL/FILL INTERFACE SOUTH FIELD



SF_U238.XLC/4/14/94/10:31 AM/JJB

Tables 1-24 through 1-27 It should be noted that this analysis separates soil into subsets that differ from those presented in the Operable Unit 2 RI report. As a result, the summary statistics presented here are not directly comparable to those presented in the Operable Unit 2 RI Report, even though the raw data sets are identical.

Surface Water and Sediment

There are no perennial sources of surface water in the South Field subunit. Samples were collected after rain events and when flow was available in a drainage. Sample locations are shown on Figure 1-40. No surface water or sediment samples were collected during Phase I in the South Field. Seven metals and uranium were detected in two surface water samples collected during Phase II from the South Field; no organic compounds were detected.

Surface water drainage originating at the northeast corner of the South Field and flowing south along the east boundary was observed for extended periods after rain events. Two seeps were identified upstream of location SF-SW-01. Total uranium in the drainage is therefore believed to be representative of shallow interflow and potential perched groundwater discharge. Concentrations of uranium in drainage water ranged from 110 μg/L at the upstream location (SF-SW-07) to 540 μg/L collected from standing water at the farthest downstream location at the southeast corner of the South Field. These values are in approximate agreement with groundwater samples collected from the glacial till at Monitoring Well No. 1941 (540 μg/L) and Well No. 1942 (320 μg/L) completed at the east side of the South Field. This indicates that the observed drainage is representative of perched groundwater at the east side of the subunit and that the South Field has an impact upon drainage water.

Sediment samples were collected from the drainages during Phase II. Twenty-two metals, isotopes of six elements, and 15 organic compounds exceeded the background concentrations for surface soil. A comparison with metals detected in the South Field shows that arsenic, beryllium, copper, lead, silver, and zinc are common to the sediment and soils of the South Field. This indicates that the source of the sediment may be the South Field; however, all of the metal concentrations are close to background concentrations for flyash.

Soluble constituents such as chloride and fluoride were detected in water samples, but not in the sediment. This suggests that the drainage water originated as groundwater, because these constituents

TABLE 1-24

CONTAMINANTS OF CONCERN, SURFACE SOILS
SOUTH FIELD

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	21	21	4.6	9.3	6.7[a]	mg/kg	7.3
Beryllium	21	20	0.5	1.9	0.8[a]	mg/kg	0.9
Uranium-Total	21	21	1.9	50.6	24.9	mg/kg	30.6
Radionuclides							
Cesium-137	21	19	0.09	0.8	0.4	pCi/g	0.5
Neptunium-237	15	13	0.06	0.5	0.2	pCi/g	0.2
Radium-226	21	21	0.9	30.8	3.7	pCi/g	21.6
Radium-228	21	21	0.9	3.9	1.3	pCi/g	1.9
Strontium-90	21	5	0.2	1	0.3	pCi/g	0.9
Technetium-99	21	1	142	142	6.9	pCi/g	142.0
Thorium-228	16	16	0.7	4.4	1.2	pCi/g	4.4
Thorium-230	16	16	0.1	13.8	3.1	pCi/g	13.8
Thorium-232	16	16	0.2	4.0	1.1	pCi/g	4.0
Uranium-234	21	21	2.7	16.3	6.9[a]	pCi/g	8.7
Uranium-235/236	21	21	0.1	0.9	0.3[a]	pCi/g	0.4
Uranium-238	21	21	2.9	16.6	7.5[a]	pCi/g	9.3
Organics							
Aroclor-1254	21	1	89	89	24.8	µg/kg	89.0
Aroclor-1260	21	2	38	52	23.9	µg/kg	38.0
Benzo(a)anthracene	21	12	44	5500	571.9	µg/kg	2500.0
Benzo(a)pyrene	21	12	51	9400	890.0	µg/kg	4700.0
Benzo(b)fluoranthene	21	12	46	6200	687.3	µg/kg	3900.0
Benzo(k)fluoranthene	21	13	49	7300	706.7	µg/kg	3300.0
Dibenzo(a,h)anthracene	21	7	43	1900	317.0	µg/kg	1100.0
Dieldrin	21	1	9.7	9.7	2.5	µg/kg	9.7
Indeno(1,2,3-cd)pyrene	21	10	45	6000	628.0	µg/kg	3000.0

[a]Estimated Mean

TABLE 1-25

CONTAMINANTS OF CONCERN, SOURCE MATERIAL
SOUTH FIELD

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	67	67	1.5	14.1	6.4	mg/kg	6.9
Beryllium	67	57	0.5	2.2	0.8	mg/kg	1.5
Uranium-Total	87	85	1.8	1170	60.1	mg/kg	230.0
Radionuclides							
Cesium-137	84	28	0.07	0.8	0.2	pCi/g	0.7
Neptunium-237	74	35	0.03	0.6	0.2	pCi/g	0.4
Radium-226	86	82	0.8	31.2	2.7	pCi/g	9.2
Radium-228	85	84	0.7	675	9.4	pCi/g	3.4
Strontium-90	81	23	0.16	2.4	0.4	pCi/g	1.3
Technetium-99	59	3	0.9	142	2.6	pCi/g	0.9
Thorium-228	82	82	0.7	595	8.9	pCi/g	4.4
Thorium-230	82	82	0.1	57.3	4.2	pCi/g	12.1
Thorium-232	82	81	0.2	600	8.8	pCi/g	3.4
Uranium-234	91	91	0.8	378	16.9	pCi/g	75.7
Uranium-235/236	91	66	0.03	20.6	1.1	pCi/g	3.8
Uranium-238	91	91	0.9	397	18.4	pCi/g	78.8
Organics							
Aroclor-1254	61	18	32	740	87.7	μg/kg	430.0
Aroclor-1260	61	3	38	89	67.1	μg/kg	38.0
Benzo(a)anthracene	55	21	44	5500	334.6	μg/kg	1100.0
Benzo(a)pyrene	54	20	3	9400	479.6	μg/kg	1800.0
Benzo(b)fluoranthene	54	20	42	6200	406.7	μg/kg	1600.0
Benzo(k)fluoranthene	54	18	48	7300	412.6	μg/kg	1600.0
Dibenzo(a,h)anthracene	54	8	43	1900	249.1	μg/kg	440.0
Dieldrin	61	2	9.7	16	6.9	μg/kg	9.7
Indeno(1,2,3-cd)pyrene	54	14	42	6000	358.6	μg/kg	620.0

[a]Estimated Mean

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TABLE 1-26

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - OTHER TILL SOUTH FIELD

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	10	10	4	9.4	6.6[a]	mg/kg	7.6
Beryllium	10	7	0.5	1	0.7[a]	mg/kg	0.8
Uranium-Total	10	9	3.5	17.5	-	mg/kg	16.8
Radionuclides							
Cesium-137	10	0	-	-	-	pCi/g	-
Neptunium-237	10	8	0.03	6.5	0.6[a]	pCi/g	5.7
Radium-226	12	11	0.6	1.3	0.9	pCi/g	1.1
Radium-228	12	11	0.5	1.4	0.8	pCi/g	1.0
Strontium-90	11	8	0.5	1.8	0.7	pCi/g	0.9
Technetium-99	10	0	-	-	-	pCi/g	-
Thorium-228	7	5	0.5	0.9	0.6	pCi/g	0.9
Thorium-230	7	7	0.8	1.1	1.0	pCi/g	1.1
Thorium-232	7	5	0.5	0.8	0.6	pCi/g	0.8
Uranium-234	12	11	0.6	3.5	1.1	pCi/g	3.5
Uranium-235/236	12	10	0.02	0.2	0.1[a]	pCi/g	0.2
Uranium-238	12	11	0.4	4.6	1.3	pCi/g	4.6

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TABLE 1-26
(Continued)

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
			Organics				
Aroclor-1254	9	0	-	-	-	µg/kg	-
Aroclor-1260	9	0	-	-	-	µg/kg	-
Benzo(a)anthracene	10	0	-	-	-	µg/kg	-
Benzo(a)pyrene	10	0	-	-	-	µg/kg	-
Benzo(b)fluoranthene	10	0	-	-	-	µg/kg	-
Benzo(k)fluoranthene	10	0	-	-	-	µg/kg	-
Dibenzo(a,h)anthracene	10	0	-	-	-	µg/kg	-
Dieldrin	9	0	-	-	-	µg/kg	-
Indeno(1,2,3-cd)pyrene	10	0	-	-	-	µg/kg	-

[a]Estimated Mean

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TABLE 1-27

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - GREAT MIAMI AQUIFER SOUTH FIELD

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	2	2	4.1	6.2	5.2	mg/kg	6.2
Beryllium	2	0	-	-	-	mg/kg	-
Uranium-Total	2	2	9.8	10.3	10.1	mg/kg	10.3
Radionuclides							
Cesium	2	0	-	-	-	pCi/g	-
Neptunium	3	0	27	-	-	pCi/g	-
Radium-226	2	2	0.6	0.7	0.6	pCi/g	0.7
Radium-228	2	2	0.4	0.5	0.5	pCi/g	0.5
Strontium-90	3	1	0.7	0.7	0.4	pCi/g	0.7
Technetium-99	3	0	-	-	-	pCi/g	-
Thorium-228	2	1	0.3	0.3	0.3	pCi/g	0.3
Thorium-230	2	2	0.9	1.4	1.1	pCi/g	1.4
Thorium-232	2	1	0.3	0.3	0.3	pCi/g	0.3
Uranium-234	3	2	0.6	0.6	0.5	pCi/g	0.6
Uranium-235/236	3	2	0.02	0.02	0.1	pCi/g	0.02
Uranium-238	3	2	0.6	0.7	0.5	pCi/g	0.7

TABLE 1-27
(Continued)

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
			Organics				
Aroclor-1254	2	0	-	-	-	µg/kg	-
Aroclor-1260	2	0	-	-	-	µg/kg	-
Benzo(a)anthracene	2	0	-	-	-	µg/kg	-
Benzo(a)pyrene	2	0	-	-	-	µg/kg	-
Benzo(b)fluoranthene	2	0	-	-	-	µg/kg	-
Benzo(k)fluoranthene	2	0	-	-	-	µg/kg	-
Dibenzo(a,h)anthracene	2	0	-	-	-	µg/kg	-
Dieldrin	2	0	-	-	-	µg/kg	-
Indeno(1,2,3-cd)pyrene	2	0	-	-	-	µg/kg	-

Note: Soil samples were collected from the unsaturated zone beneath the till in the Great Miami Aquifer.

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require relatively long contact time to leach out of geologic materials. Chloride and fluoride are present in trace amounts in precipitation, indicating a source other than rainfall. These data suggest that drainage water samples containing elevated uranium concentrations are representative of perched groundwater.

Concentrations of organic compounds and metals found in sediment were similar to concentrations found in samples of surface soil at the South Field. Organic compounds were detected in sediment but not in drainage water, indicating that these compounds were not adsorbed to the sediments from the drainage water.

Groundwater

One upgradient well in the perched groundwater (No. 1046) was sampled during Phase I. Other perched zone wells were sampled during Phase I, but these were not within the perched system in the South Field. Three of the wells [Nos. (21191) 1516, (21192) 1517, and (21193) 1518) were mislabeled and actually monitor the regional aquifer. Phase I sampling detected seven metals and isotopes for two elements that exceeded the background concentrations; no organic compounds were detected that exceeded background concentrations. Five additional monitoring wells were installed during Phase II, and 12 Hydropunch™ samples were collected in order to define groundwater conditions in the perched groundwater in the South Field. During Phase II, 22 metals, isotopes of six elements, and four organic compounds exceeded background concentrations.

There were 22 metals detected in the 1000-series wells that exceeded background. Of these, beryllium and chromium were the surface soil COCs detected above background. Generally, the maximum detected concentrations were close to background values, except for antimony and silicon, which have a background concentration of 0.00 mg/L. Comparing these concentrations to the metal concentrations for the subsurface soil indicates a minimal impact, if any, of metals from soil on perched groundwater.

Groundwater in the perched zone is believed to be a continuous unit. Therefore, concentrations of uranium detected in wells located in the perched zone are thought to display a concentration gradient in a downstream direction from higher to lower concentrations. Concentration contours of total uranium concentrations detected in samples collected during Phase II are presented on Figure 1-43. Upgradient Well Nos. 1047 and 1046 detected low concentrations of total uranium, while

downgradient Well Nos. 1954, 1942, and 1048 detected elevated concentrations. The distribution of uranium in perched groundwater is controlled by elevated concentrations of uranium in shallow soil samples, by a sand layer identified in South Field soil borings, and by groundwater flow patterns. Two regions of perched groundwater containing greater than 100 μg/L total uranium are shown on Figure 1-43. One area at the west side of the subunit near Well No. 1433 may originate as leachate from buried waste. Buried waste materials were also encountered while drilling Well No. 1433 during Phase I. The second area of elevated total uranium concentration is in perched groundwater at the northeast corner of the subunit. The source for perched groundwater uranium contamination in this area is believed to be waste materials buried or placed on the surface and corresponds to an area of waste piles identified by historical aerial photographs.

Organic compounds detected above background included acetone (6 μg/L), diethyl phthalate (1 μg/L), and tributyl phosphate (1 μg/L) in Well No. 11032 located north and upgradient of the South Field. Acetone was detected at 6 μg/L in Well No. 1046 located along the north edge, also upgradient of the South Field. These data do not suggest an impact of organic compounds from the South Field soil to perched groundwater.

The 2000-series wells were installed at nine locations surrounding the South Field during Phase I investigations. Phase I sampling detected 12 metals, uranium, radium, thorium, and seven organic compounds that exceeded background. The concentration of uranium in downgradient wells was elevated with respect to some upgradient wells, but the relationship between possible source areas and regional aquifer wells was not clear. To complete the sampling network, four additional 2000-series wells and eight Hydropunch™ wells were completed in the South Field. Phase II sampling detected eight metals, isotopes of four elements, and five organic compounds that exceeded background values. Groundwater samples collected downgradient of the former Firing Range and analyzed for lead do not indicate concentrations of lead above background.

Historical data that indicate concentrations of total uranium detected in Well No. 2045 range from 265 μg/L to 461 μg/L since May 1989. Contours of total uranium concentrations detected in 2000-series wells during Phase II are plotted on Figure 1-44. There are several potential sources for the total uranium observed in 2000-series wells. Elevated concentrations detected in 2000-series wells on the western boundary may be related to recharge that occurs beneath the Inactive Flyash Pile and flows to the east beneath the South Field.

Uranium contamination detected in Hydropunch™ and monitoring well groundwater samples at the southeast part of the South Field (Hydropunch™ 11018, 11019, and 11021, and Well No. 2045) indicates that the Great Miami Aquifer may receive contaminated groundwater recharge from at least two sources: perched groundwater recharge from the area north of Hydropunch™ 11028 and contaminated recharge from surface water at the southeast corner of the subunit. The plume at the southeast corner of the South Field appears to be separated from the plume to the north by a zone of less contaminated groundwater that extends from Well No. 2016 (17 μg/L) to Well No. 2944 (1.5 μg/L) and Well No. 2048 (1.3 μg/L). The southeastern part of the total uranium plume appears to flow past Well No. 2045 (364 μg/L), Well No. 2049 (111 μg/L), and possibly Well No. 21033 (43.2 μg/L).

1.7.1.5 Active Flyash Pile

Analytical results for samples collected from the Active Flyash Pile are presented in Section 4.6 and Appendix G of the Operable Unit 2 RI Report. Individual sampling locations are shown on Figure 1-48.

Volume and Physical Characteristics of Waste Material

The volume of flyash was estimated by means of digitized topographic maps, boring log data, and interpolation by using Intergraph Corporation Microstation PC software, and is calculated to be approximately 49,700 cu m (65,000 cu yd). The estimated fill thickness is shown on Figure 1-49.

Flyash was generated at the boiler plant and was transported by truck to the Active Flyash Pile. Aerial photographs indicate that the flyash was deposited on the original ground surface and then worked into lifts by bulldozers. Samples of flyash collected from borings into the Active Flyash Pile indicate that it contains alternating loose to medium dense layers.

Flyash samples collected from borings displayed dry to moist conditions, but never displayed water saturation. Very moist to wet conditions were detected at the interface of the Active Flyash Pile and the native till surface. Soil samples collected from borings drilled through the flyash contained solid waste materials, such as concrete and construction rubble, in the vicinity of Well No. 1048, which is north of the pile. Flyash was the only material detected in all other subsurface samples collected from the flyash pile.

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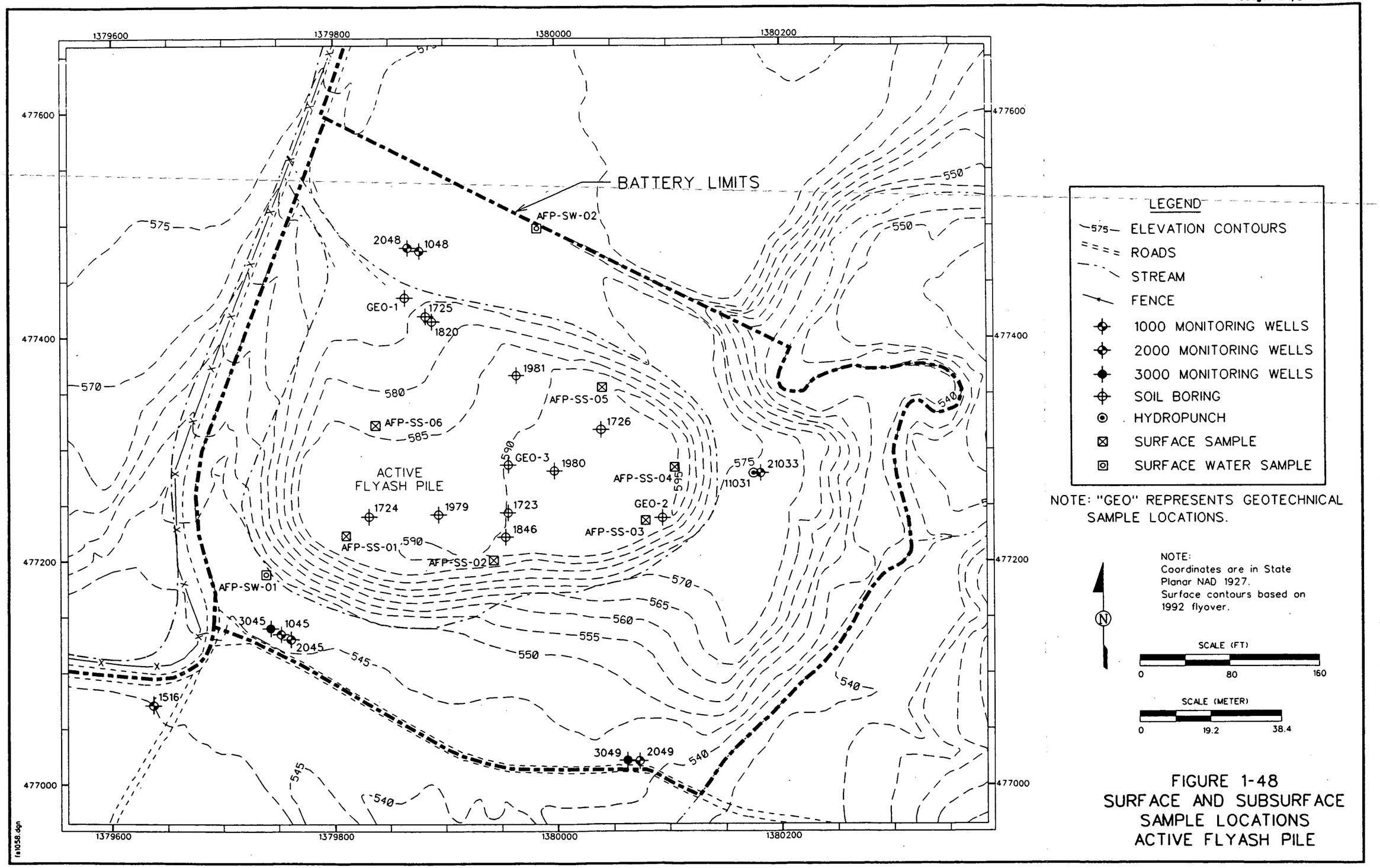

FIGURE 1-48
SURFACE AND SUBSURFACE SAMPLE LOCATIONS
ACTIVE FLYASH PILE

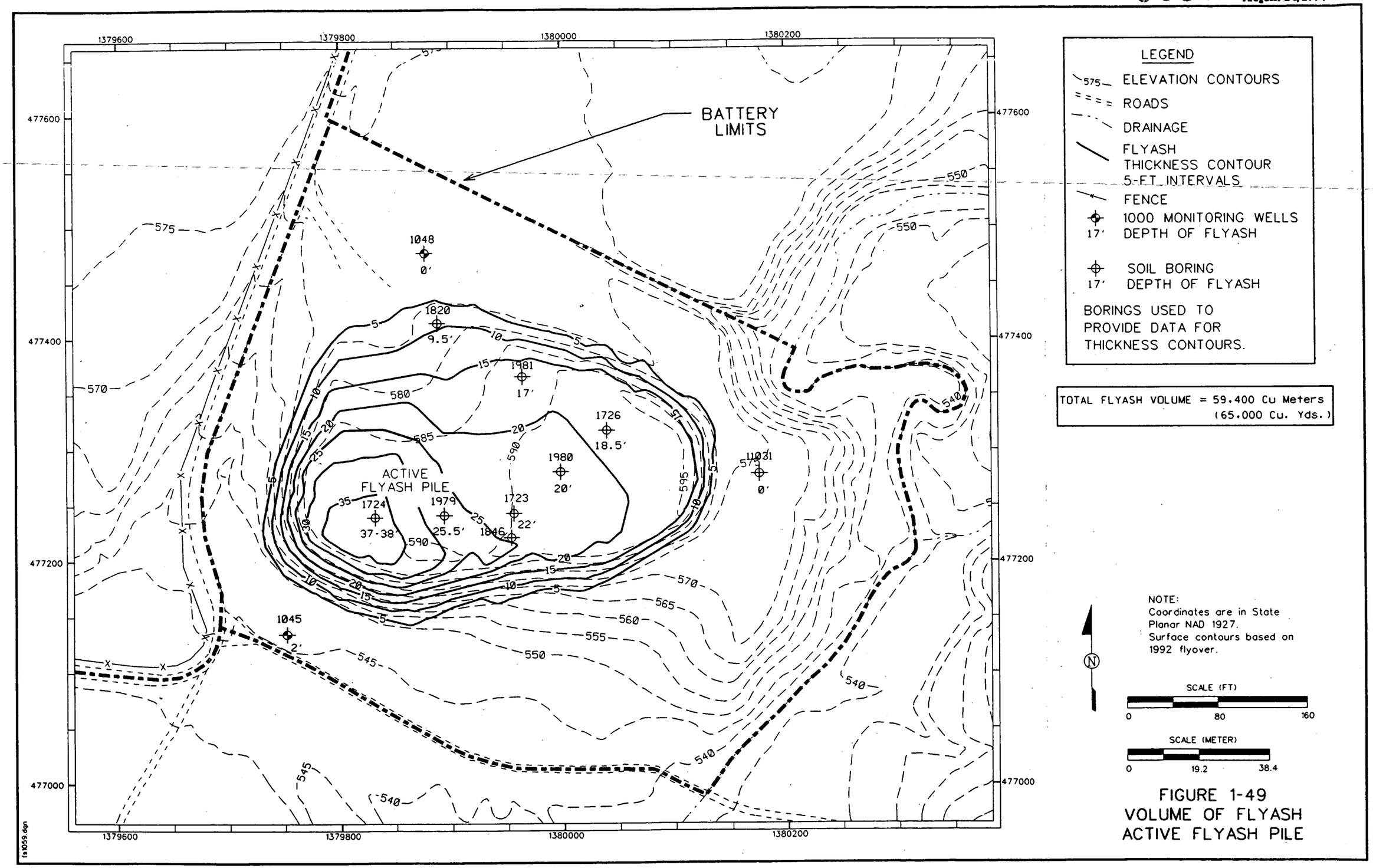

FIGURE 1-49
VOLUME OF FLYASH
ACTIVE FLYASH PILE

Surface and Subsurface Media

During Phase II, surface samples were collected from 14 locations at the Active Flyash Pile. Since these samples were considered by visual observation to be flyash samples, they were compared to background concentrations for flyash material. Arsenic was the only metal detected above background. No radionuclides or organics were detected above ash background concentrations.

Chemical and radiological analytical results for subsurface samples collected from the Active Flyash Pile were compared to expected background values from soil and flyash studies. The number of metals and radionuclides detected above background in subsurface samples depended upon the background values used. The number of metals and radionuclides detections decrease when compared to flyash background data. Regardless of the background values used, radionuclide and organic compounds decrease in samples collected from the soil beneath the flyash. No radionuclides were detected in three soil samples collected from the Great Miami Aquifer.

Concentrations of radionuclides are similar between flyash samples collected within the Active Flyash Pile and are elevated with respect to soil concentrations. A comparison between the concentration of total uranium in flyash and the concentration in native soil does not indicate that uranium from the flyash has leached to the underlying soil. For example, in Boring No. 1726 total uranium in flyash [28.1 μg/g at 5.6 m (18.5 ft)] is greater than the native soil concentration [3.08 μg/g at 6.4 m (21 ft)]. In Boring No. 1979, total uranium in flyash [22.1 μg/g at 6.7 m (22 ft deep)] contrasts with the native soil concentration [4.49 μg/g at 8.4 m (27.5 ft)].

A comparison between surface flyash (source) samples and subsurface flyash and soil samples indicates the following:

- Pyrene, chrysene, benzo (anthracene, pyrene, fluoranthene), and fluoranthene were common to surface samples but were not detected in subsurface samples.
- Benzoic acid, toluene, naphthalene, 1,1,1-trichloroethane, and bis(2-ethylhexyl)phthalate were detected in both surface and subsurface samples.
- 1,1-dichloroethane, chloro-phenols, and xylene were detected in subsurface samples but not in surface samples.
- The concentration of all organics decreases below the flyash/soil interface, from approximately 3 to 5.2 m (10 to 17 ft) deep. Organics appear to be present throughout the flyash from the surface to about 3 m (10 ft) deep.

The distribution suggests that the organics were not deposited at a single location with horizontal and vertical migration. A more probable explanation is the deposition of organics in dilute mixtures at several times during construction.

Figure 1-50 shows the distribution of uranium-238 concentrations for the Active Flyash Pile subsurface till samples relative to the estimated fill/till interface. All of the uranium-238 concentrations are near or below the background concentration, with two exceptions. One sample taken from a depth of 0.7 m (2.25 ft) below the fill/till interface in Boring No. 1048 has a uranium-238 concentration of 2.8 pCi/g. The other, taken from a depth of 1.4 m (4.75 ft) below the interface in Boring No. 1724, has a concentration of 2.04 pCi/g. This figure demonstrates that the migration of uranium contamination into the till is largely confined to an impacted till layer that extends approximately 0.8 m (2.5 ft) below the fill/till interface.

To determine the distribution of COCs in relation to the lithology of the South Field, the soil data has been organized into samples in the surface soil, source material, other till material, and unsaturated Great Miami Aquifer soils. This type of analysis assists in the evaluation of technologies and process options for different media with various contaminant concentrations. Source material consists of samples from fill material (ash) and the impacted till [within 0.8 m (2.5 ft) of the fill/till interface]. The other till samples are those below the impacted till within the battery limits. The unsaturated Great Miami Aquifer soils are located between the bottom of the till and the Great Miami Aquifer water table. Statistical summaries for the COCs within these subsets are given in Tables 1-28 through 1-31. It should be noted that this analysis separates soil into subsets that differ from those presented in the Operable Unit 2 RI Report. As a result, the summary statistics presented here are not directly comparable to those presented in the Operable Unit 2 RI Report, even though the raw sets are identical.

Twelve samples were collected for hazardous waste determination by TCLP analyses. The results of the TCLP analysis for metals are shown in Table 1-32. None of the concentrations of detected analytes exceeded the RCRA standard defining hazardous waste (40 CFR § 261.24). Likewise, no detected concentrations exceed the Ohio Exempt Waste Standard (OEPA Policy 4.07 - Design Criteria: Disposal of Non-toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes).

FIGURE 1-50
U-238 CONCENTRATION VS DEPTH RELATIVE TO FILL/TILL INTERFACE ACTIVE FLY ASH PILE

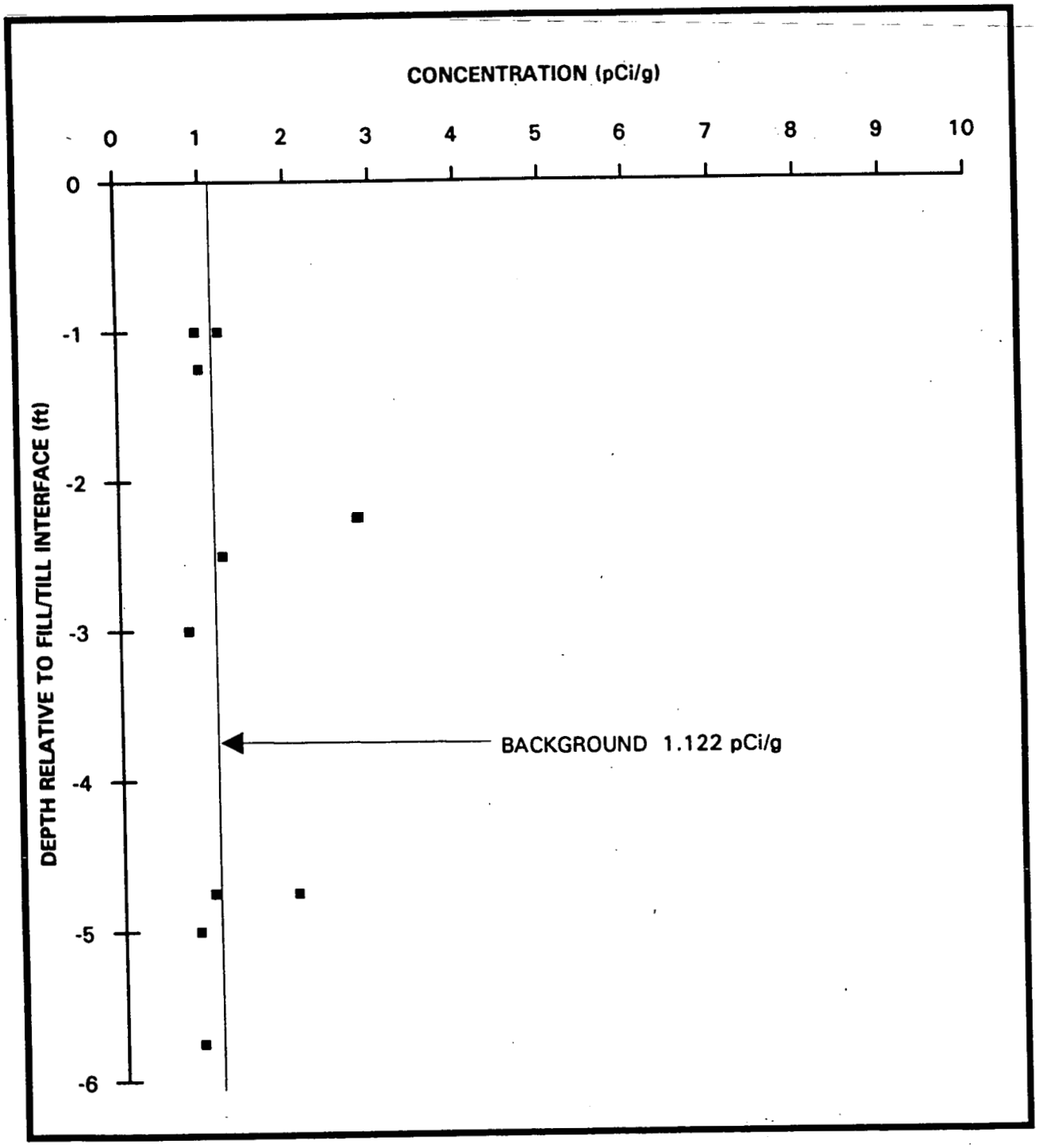

TABLE 1-28

CONTAMINANTS OF CONCERN, SURFACE SOILS
ACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	14	14	10.4	145	70.0	mg/kg	94.2
Beryllium	14	14	1.5	6.4	3.9	mg/kg	4.8
Radionuclides							
Cesium	14	4	0.07	0.9	0.2	pCi/g	0.9
Neptunium-237	6	6	0.06	0.3	0.1	pCi/g	0.3
Radium-226	14	14	1.3	4.6	3.1	pCi/g	4.6
Radium-228	14	14	1.0	3.2	2.5	pCi/g	3.2
Thorium-228	14	14	0.8	3.8	2.2	pCi/g	3.8
Thorium-232	14	4	0.9	3.7	2.2[a]	pCi/g	2.6

[a]Estimated Mean

TABLE 1-29

CONTAMINANTS OF CONCERN, SOURCE MATERIAL ACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	35	35	4.6	145	51.0	mg/kg	63.9
Beryllium	35	35	0.5	6.4	2.9	mg/kg	3.5
Radionuclides							
Cesium	39	5	0.09	0.9	0.1	pCi/g	0.5
Neptunium-237	23	16	0.04	0.4	0.2	pCi/g	0.4
Radium-226	39	39	0.5	6.2	2.9	pCi/g	4.6
Radium-228	39	39	0.7	5.3	2.4	pCi/g	3.9
Thorium-228	39	39	0.8	5.8	2.4	pCi/g	2.8
Thorium-232	39	38	0.5	5.1	2.1	pCi/g	2.4

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TABLE 1-30

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - OTHER TILL
ACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Metals							
Arsenic	3	3	4.1	14	8.8	mg/kg	14.0
Beryllium	3	3	0.6	1.1	0.8	mg/kg	1.1
Radionuclides							
Cesium-137	4	0	-	-	-	pCi/g	-
Neptunium-237	4	2	0.1	0.2	0.2	pCi/g	0.2
Radium-226	4	3	0.8	1.1	0.8	pCi/g	1.1
Radium-228	3	3	0.6	0.9	0.7	pCi/g	0.9
Thorium-228	4	4	0.6	1.8	1.1	pCi/g	1.8
Thorium-232	4	4	0.6	1.2	0.8	pCi/g	1.2

TABLE 1-31

CONTAMINANTS OF CONCERN, SUBSURFACE SOILS - GREAT MIAMI AQUIFER ACTIVE FLYASH PILE

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
Radionuclides							
Radium-226	2	2	0.4	0.6	0.5	pCi/g	0.6
Radium-228	2	1	0.5	0.5	0.4	pCi/g	0.5
Thorium-228	3	1	1.2	1.2	0.6	pCi/g	1.2
Thorium-232	3	2	0.6	1.0	0.6	pCi/g	1.0

Note: Soil samples were collected from the unsaturated zone beneath the till in the Great Miami Aquifer.

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TABLE 1-32
ACTIVE FLYASH PILE TCLP METALS

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard (mg/L)	Units	Number of Analyses	Number of Detects	Minimum Detect	Maximum Detect	Average Detect
Arsenic	5.0	1.5	mg/L	14	4	0.02	0.12	0.07
Barium	100.0	30.0	mg/L	15	12	0.2	1.25	0.5
Cadmium	1.0	0.3	mg/L	15	8	0.003	0.03	0.01
Chromium	5.0	1.5	mg/L	17	11	0.02	0.2	0.07
Copper	NA[a]	NA	mg/L	6	1	0.02	0.02	0.02
Iron	NA	NA	mg/L	6	1	0.01	0.01	0.01
Lead	5.0	1.5	mg/L	14	2	0.06	0.07	0.07
Manganese	NA	NA	mg/L	6	4	0.01	0.3	0.09
Mercury	0.2	0.06	mg/L	12	0	0	0	0
Selenium	1.0	0.3	mg/L	14	5	0.01	0.1	0.08
Silver	5.0	NA	mg/L	14	9	0.02	0.2	0.07
Zinc	NA	NA	mg/L	4	2	0.2	1.3	0.8
1,1-Dichloroethene	0.7	NA	mg/L	14	0	0	0	0
1,2-Dichloroethane	0.5	NA	mg/L	14	0	0	0	0
2-Butanone	200.0	NA	mg/L	14	2	0.003	0.010	0.065
Benzene	0.5	NA	mg/L	14	0	0	0	0
Carbon Tetrachloride	0.5	NA	mg/L	14	0	0	0	0
Chlorobenzene	100.0	NA	mg/L	14	0	0	0	0
Chloroform	6.0	NA	mg/L	14	0	0	0	0
Pyridine	5.0	NA	mg/L	13	0	0	0	0
Tetrachloroethene	0.7	NA	mg/L	14	0	0	0	0
Trichloroethene	0.5	NA	mg/L	14	0	0	0	0

See footnote at end of table.

TABLE 1-32
(Continued)

Parameter	RCRA Standard (mg/L)	Ohio Exempt Waste Standard (mg/L)	Units	Number of Analyses	Number of Detects	Minimum Detect	Maximum Detect	Average Detect
Vinyl chloride	0.2	NA	mg/L	14	0	0	0	0
1,4-Dichlorobenzene	7.5	NA	mg/L	12	0	0	0	0
2,4,5-Trichlorophenol	400.0	NA	mg/L	12	0	0	0	0
2,4,6-Trichlorophenol	2.0	NA	mg/L	13	0	0	0	0
2,4-Dinitrotoluene	0.13	NA	mg/L	13	0	0	0	0
Hexachlorobenzene	0.13	NA	mg/L	13	0	0	0	0
Hexachlorobutadiene	0.5	NA	mg/L	12	0	0	0	0
Hexachloroethane	3.0	NA	mg/L	12	0	0	0	0
Nitrobenzene	2.0	NA	mg/L	12	0	0	0	0
Pentachlorophenol	100.0	NA	mg/L	13	0	0	0	0
Total Methylphenol	200.0	NA	mg/L	4	0	0	0	0
2,4,5-TP (Silvex)	1.0	NA	mg/L	15	0	0	0	0
2,4-D	10.0	NA	mg/L	15	0	0	0	0
Chlordane	0.03	NA	mg/L	4	0	0	0	0
Endrin	0.02	NA	mg/L	15	0	0	0	0
Heptachlor	0.008	NA	mg/L	14	0	0	0	0
Heptachlor epoxide	0.008	NA	mg/L	14	0	0	0	0
Methoxychlor	10.0	NA	mg/L	15	0	0	0	0
Toxaphene	0.5	NA	mg/L	15	0	0	0	0
alpha-Chlordane	0.03	NA	mg/L	11	0	0	0	0
gamma-BHC (Lindane)	0.4	NA	mg/L	15	0	0	0	0
gamma-Chlordane	0.03	NA	mg/L	11	0	0	0	0

[a]NA = not applicable.

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Surface Water and Sediment

There are no perennial sources of surface water within the battery limits of the Active Flyash Pile; therefore, sampling was completed on an as-possible basis when flow was observed. The drainage system within the battery limits of the Active Flyash Pile was altered to improve drainage during the interval between the Phase I and Phase II sampling events. Present-day surface water drainage from the Active Flyash Pile is rapid after rain events. There was one surface water sampling location (AFP-SW-02) available during the Phase II field sampling program.

Two surface water sampling locations adjacent to the road at the western edge of the Active Flyash Pile were identified for off-site analyses during Phase I. Total uranium was detected above background in both samples, and concentrations fluctuated widely in multiple samples collected over six months. These data indicate an impact at both the upstream and downstream locations. The origin for the discharge may be the South Field. Concentrations of total uranium are similar in South Field discharge samples from Phase II. The drainage where the Phase I samples were collected has since been filled in, and a rock-lined channel was constructed beside it at the toe of the Active Flyash Pile.

Nine metals and the isotopes of four elements were detected in one Phase II surface water sample; no organic compounds were detected. These data suggest that organic compounds and metals detected in surface media and sediments are not present in surface water draining the subunit. Surface water data from Phase I and Phase II were not compared because samples were collected from different drainages.

Two sediment samples were collected during Phase I from the same locations as the surface water samples collected nine months earlier. Sample ASIT-004 contained 38.9 mg/kg total uranium, and sample ASIT-005 contained 51.8 mg/kg total uranium at the downstream location. Sediment samples collected from the South Field drainage detected concentrations ranging from 100 μg/g to 500 μg/g total uranium in Phase II samples.

During the Phase II field activities, six sediment locations were designated to be sampled. After sampling of the six locations occurred, only one location (AFP-SD-06) was considered a sediment sample. The remaining five locations appeared to be surface soil samples and were combined with Phase II surface soil data. The five sediment locations were changed to surface soil locations because

field observations of the topography determined that the soils were not deposited as a result of surface water movement around the Active Flyash Pile. Seven metals, isotopes of three elements, and four semivolatile organic compounds were detected above background in the sediment sample from Phase II. No volatile organics or pesticides/PCBs were detected. Detections above background in the sediment sample are similar to those for surface and subsurface flyash, indicating that sediments have been impacted by the Active Flyash Pile.

Groundwater

Groundwater in the perched groundwater system is believed to flow within a sand lens in the glacial overburden (Figure 1-27). Soil borings indicate that the sand lens thins out beneath the Active Flyash Pile. Thus, the groundwater flow system is continuous from the South Field to the Active Flyash Pile, but it does not exist at the western edge of the Active Flyash Pile. Phase I sampling detected four metals, three isotopes of uranium, and total thorium that exceeded background concentrations. During Phase II, six metals, isotopes of five elements, and one organic (2-butanone at 1 μg/L) exceeded background concentrations. Groundwater quality near to the Active Flyash Pile appears to be impacted by waste disposal activities in the South Field. Due to the location of the Active Flyash Pile relative to the glacial overburden, a perched groundwater well could not be installed downgradient of the pile, except for where Boring No. 11031 was located, which was as far downgradient as safe accessibility allowed. The borehole was advanced to a depth that should have encountered perched groundwater, but the hole was dry; therefore, a well was not installed. Since the Active Flyash Pile is located over the slope which is the terminal edge of the till (glacial overburden), and no free-flowing groundwater was encountered in Boring No. 11031 (potentially downgradient), it may be assumed that the potential impact to perched groundwater would be minimal.

Groundwater in the regional aquifer flows toward the east from the South Field to the Active Flyash Pile. Upgradient wells are located west of the Active Flyash Pile (Well No. 2943); Well No. 21033 (constructed during Phase II) is located downgradient. Phase I sampling of 2000-series wells detected six metals and isotopes of two elements that exceeded background; no organic compounds were analyzed in Phase I samples. Phase II sampling detected five metals, isotopes of two elements, and two organic compounds that exceeded background values. Available uranium and thorium concentration data from samples collected since 1988 indicate that these constituents have remained within the same concentration ranges in all wells except Well No. 2049. The concentration of total uranium in this well has ranged from 2 μg/L to 175 μg/L in eight samples collected from 1988 to

1993. This suggests that there may be an influence from the storm sewer drainage that flows approximately 15m (50 ft) to the east, which may be a source of recharge water containing low uranium concentrations. Concentrations of total uranium in Well No. 2045 ranged from 265.5 μg/L to 461.0 μg/L in samples collected from 1988 to 1993. These concentrations are believed to be related to recharge originating upgradient at the south east corner of the South Field subunit. Upgradient Wells Nos. 2943 and 2048 contained 1 μg/L and 3 μg/L total uranium, respectively. Downgradient Well No. 21033 contained 4.12 μg/L total uranium, which suggests that there has been an impact from the subunit on groundwater.

1.7.1.6 Uranium Leachability Study

To determine the extent to which uranium leaches from contaminated subsurface soils in the Operable Unit 2 subunits, the TCLP was performed for total uranium on selected subsurface soil samples. This study was performed in conjunction with the Uranium Partition Coefficient Evaluation Study for Operable Unit 2 (K_d Study). The results of the K_d Study are presented in Appendix D.

The results of the leachability study are shown in Table 1-33. The initial soil samples and TCLP extract were analyzed for total uranium. Since the volume of the soil sample (100 grams) and the TCLP extract (2 liters) is known, the soil and extract concentrations were converted to mass. The percentage of extractable uranium was then calculated by dividing the mass of uranium in the leachate by the mass in the soil.

The results of the study indicate that most of the Operable Unit 2 subsurface soil/waste samples have a low percentage of extractable uranium. In general, higher percentages of extractable uranium were observed in samples taken from the Solid Waste Landfill. A general trend is also observed in which the percent of extractable uranium increases as the uranium soil concentration increases.

1.7.2 Summary of Fate and Transport Modeling Results

This section summarizes the results of the Operable Unit 2 RI fate and transport modeling that was used to simulate constituent movement from the Operable Unit 2 subunits to potential human receptors via the surface water, groundwater, and air migration pathways. Conservative assumptions were used to simulate "worst-case" contaminant migration scenarios. The modeled future concentrations were based on the unremediated baseline case for the Operable Unit 2 waste areas.

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TABLE 1-33

URANIUM LEACHABILITY STUDY RESULTS

Subunit	Boring No.	Depth (feet)	Sample No.	Soil Concentration (μg/g)	Extract Concentration (μg/L)	Percent Extractable
AFP	1980	2.0 - 4.0	112130	12.9[a]		<1
			112131		<1.0[b]	
AFP	1981	8.0 - 10.0	112167	15.7[a]		<1
			112168		<1.0[b]	
SWL	1986	2.5 - 5.0	111450	1280.0[a]		16
			111454		10100[b]	
SWL	1987	5.0 - 7.5	115357	28.8[a]		2
			115358		25.9[b]	
SWL	1991	7.5 - 10.0	115319	25.4[a]		10
			115320		133.0[b]	
SWL	1986	0.0 - 3.0	111440[c]	113.0	1310.0	23
LSP	1961	0.5 - 1.0	114751[c]	12.9	16.9	3
LSP	1959	0.5 - 1.0	114839[c]	4.46	3.9	2
IFP	11002	3.5 - 4.0	116161[c]	128.0	166.0	3
IFP	11008	9.0 - 9.5	116135[c]	12.0	6.23	1
IFP	11007	4.5 - 5.0	110652[c]	29.2	1.45	<1
SF	11009	3.0 - 3.5	110529[c]	274.0	N/A[d]	-[e]
SF	11011	4.5 - 5.0	110603[c]	23.3	244.0	21
SF	T4	7.0	113721[c]	2.50	1.13	1

[a]The total uranium analysis was provided from the Operable Unit 2 RI.
[b]The total uranium analysis was perfomed on TCLP leachate samples retrieved from the IT Laboratory, where they had been preserved from previous TCLP tests under the Operable Unit 2 RI.
[c]Sample was retrieved from archived soil boring samples.
[d]Not analyzed
[e]Not available

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Groundwater modeling for the FS has been modified since the RI studies by implementing several improvements to the Sandia Waste Isolation Flow and Transport (SWIFT) model. Other changes have also been made to the input parameters for the one-dimensional analytical solute transport (ODAST) and SWIFT models. These model improvements and parameter changes are discussed further in Appendix D.

1.7.2.1 Modeling Approach

Surface Water Pathway

During a storm event, soil particles are dislodged by the impact of raindrops and the flow of runoff water across the soil surface. Constituents adsorbed to soil particles can be desorbed and transported in the runoff water. A uniform concentration was assigned for surface soil constituents in each subunit. The constituent concentrations used in this assessment are the upper 95 percent confidence level on the means (UCL) of the surface soil concentrations from the remedial investigation.

The Modified Universal Soil Loss Equation (MUSLE) model was used to quantify soil migration. This model employs event-specific runoff volume and flow rate parameters to calculate the soil loss for a single rainfall event and allows evaluation of an event-specific worst-case scenario. The stormwater runoff modeling was based on a single storm event (2.5 in. in 24 hours) (Hershfield 1961) resulting in a flow rate in Paddys Run of 4 cu ft per second (ft^3/sec) (Dames and Moore 1985a). No flow from upgradient runoff was assumed for the Storm Sewer Outfall Ditch. An average flow rate of 3,300 ft^3/sec was used for the Great Miami River, based on previous studies (DOE 1993a).

Constituent concentrations in Paddys Run and the Great Miami River were calculated by diluting the dissolved concentrations in storm water runoff with the flows in the receiving streams. To estimate the worst surface water conditions, it was assumed that all flow and all constituent mass in Paddys Run empties into the Great Miami River. To estimate the worst conditions in groundwater due to surface water as a source, it was assumed that 30 percent of constituent mass and flow in Paddys Run infiltrates to the Great Miami River. As a conservative assumption, 44 percent of constituents of potential concern (CPC) mass reaching the Storm Sewer Outfall Ditch was assumed to reach Paddys Run and all water and dissolved mass reaching the Storm Sewer Outfall Ditch from the Active Flyash Pile was considered to infiltrate to the Great Miami Aquifer.

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Groundwater Pathway

Rainfall and surface water runoff infiltrating the surface of the waste units and percolating through the waste and soil overlying the Great Miami Aquifer was considered the primary groundwater pathway for contaminants to be transported to a human receptor. The perched water systems under the Solid Waste Landfill and Lime Sludge Ponds were considered secondary groundwater pathways by which contaminants released from Operable Unit 2 subunits could be transported to a human receptor.

The migration of water and dissolved constituents from the waste source to the receptor involves flow through both unsaturated (vadose zone) and saturated zones (regional aquifer and perched zones). The following five pathways for migration of CPCs from Operable Unit 2 subunits to the Great Miami Aquifer were identified for the modeling:

- Vadose Zone Pathway - Constituent migration from the waste unit laterally (along the waste and glacial till interface) and/or vertically through the vadose zone to the underlying aquifer (Figure 1-51).

- Surface Water Pathway - Migration of constituents from the surface soil due to stormwater runoff to Paddys Run or the Storm Sewer Outfall Ditch and then through the streambed to the aquifer (Figure 1-51).

- Perched Water Infiltration Pathway - Vertical migration of CPCs from the perched water to the aquifer (Figure 1-51).

- Perched Water Subsurface Seep Pathway - Lateral migration of constituents from the perched water to an area where the sand layer within the glacial till comes in contact with the waste. Constituents then migrate along an interface between glacial till and waste until the constituents arrive at an area where glacial till is not present and the waste is in direct contact with the Great Miami Aquifer. At that point, constituents seep into the Great Miami Aquifer (Figure 1-52).

- Seep Pathway - Migration of constituents in the seeps (as surface water) to an area where glacial overburden is not present. Constituents then migrate vertically through the unsaturated portion of the Great Miami Aquifer to the groundwater.

The vadose zone pathway, applicable to all subunits, was modeled as two layers (Figure 1-53): the glacial overburden underlying the subunits (Layer 1) and the unsaturated portion of the underlying Great Miami Aquifer (Layer 2). Layer 1 soils consist of tills in the glacial overburden. A sequence of fine-grained till deposits interbedded with sand and gravel glaciofluvial stringers forms the glacial overburden at the site. The sand and gravel units within the glacial overburden were not included in the vadose zone pathway modeling because this layer has much higher hydraulic conductivity and low

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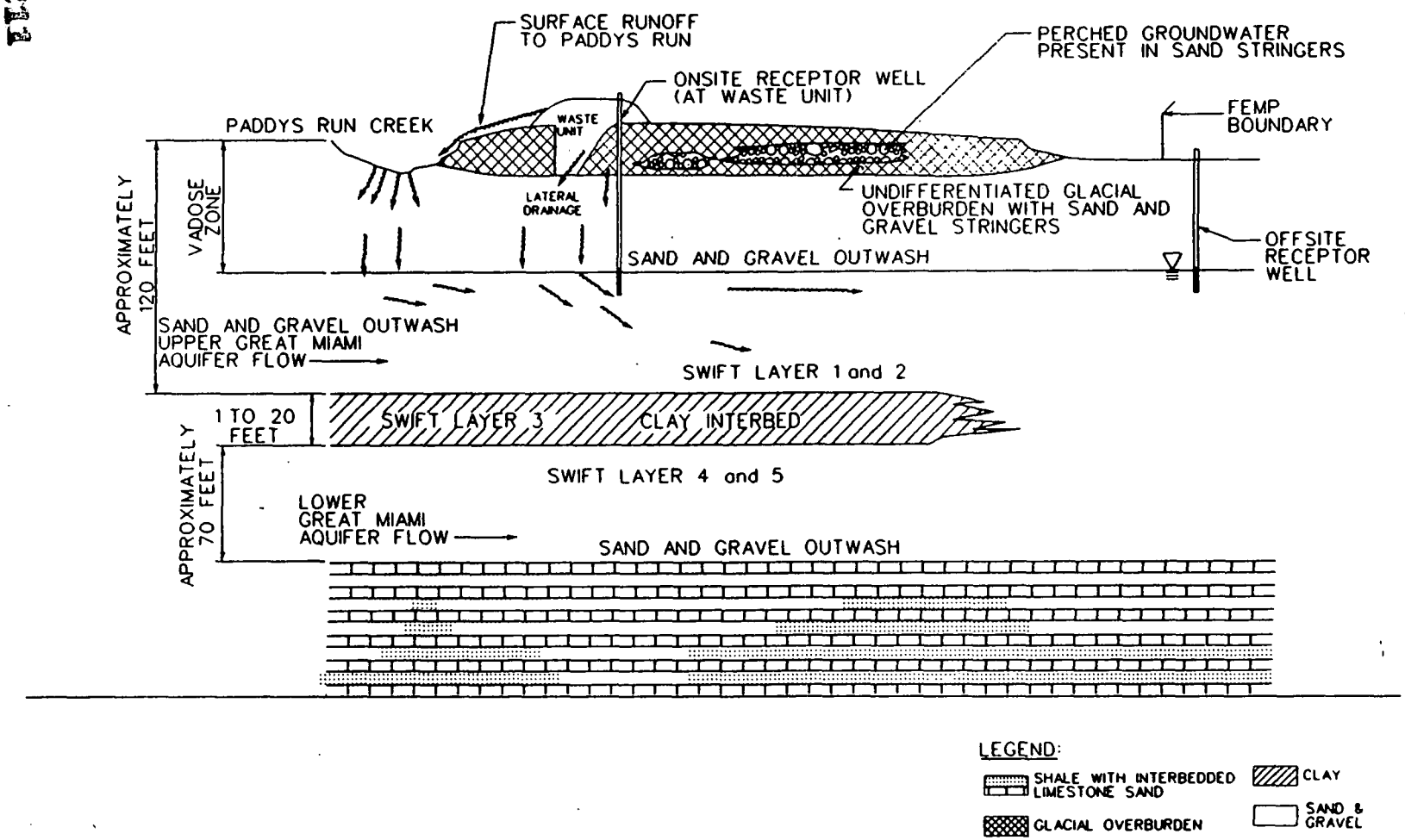

FIGURE 1-51
CONCEPTUAL MODEL OF LOADING TO THE GREAT MIAMI AQUIFER AND CONTAMINANT TRANSPORT BY GROUNDWATER

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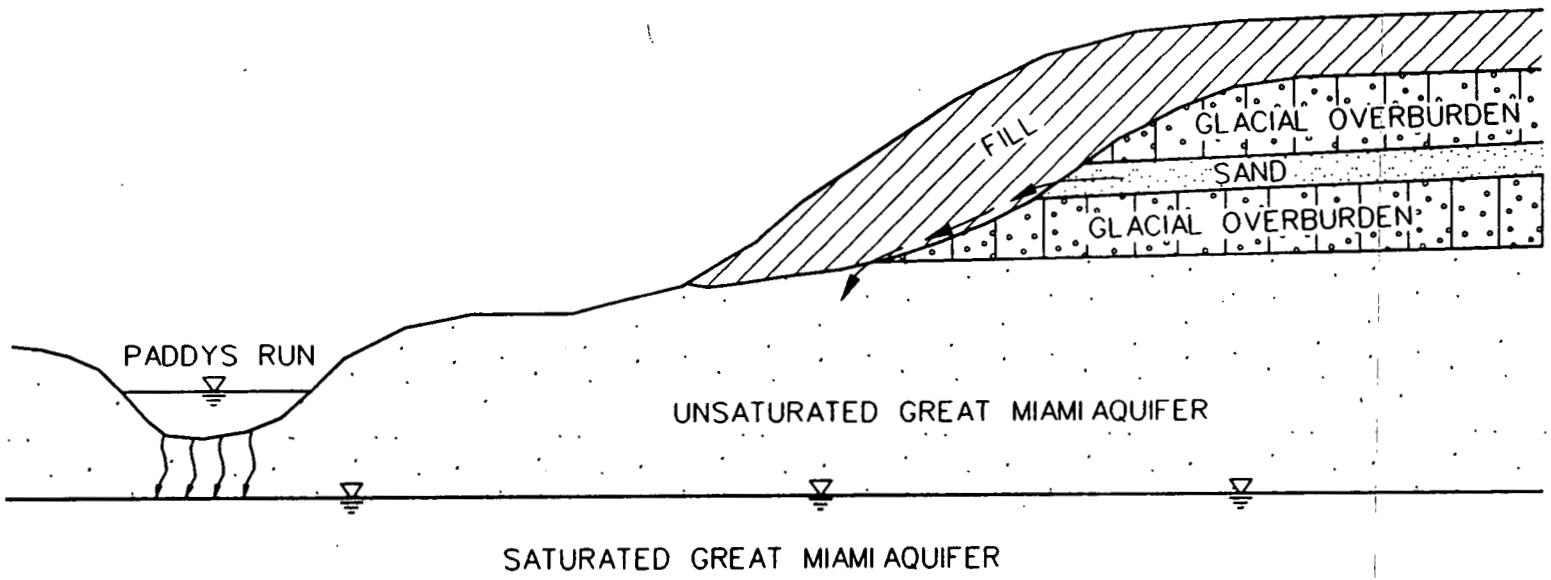

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FIGURE 1-52
CONCEPTUAL MODEL FOR PERCHED WATER SUBSURFACE SEEPS

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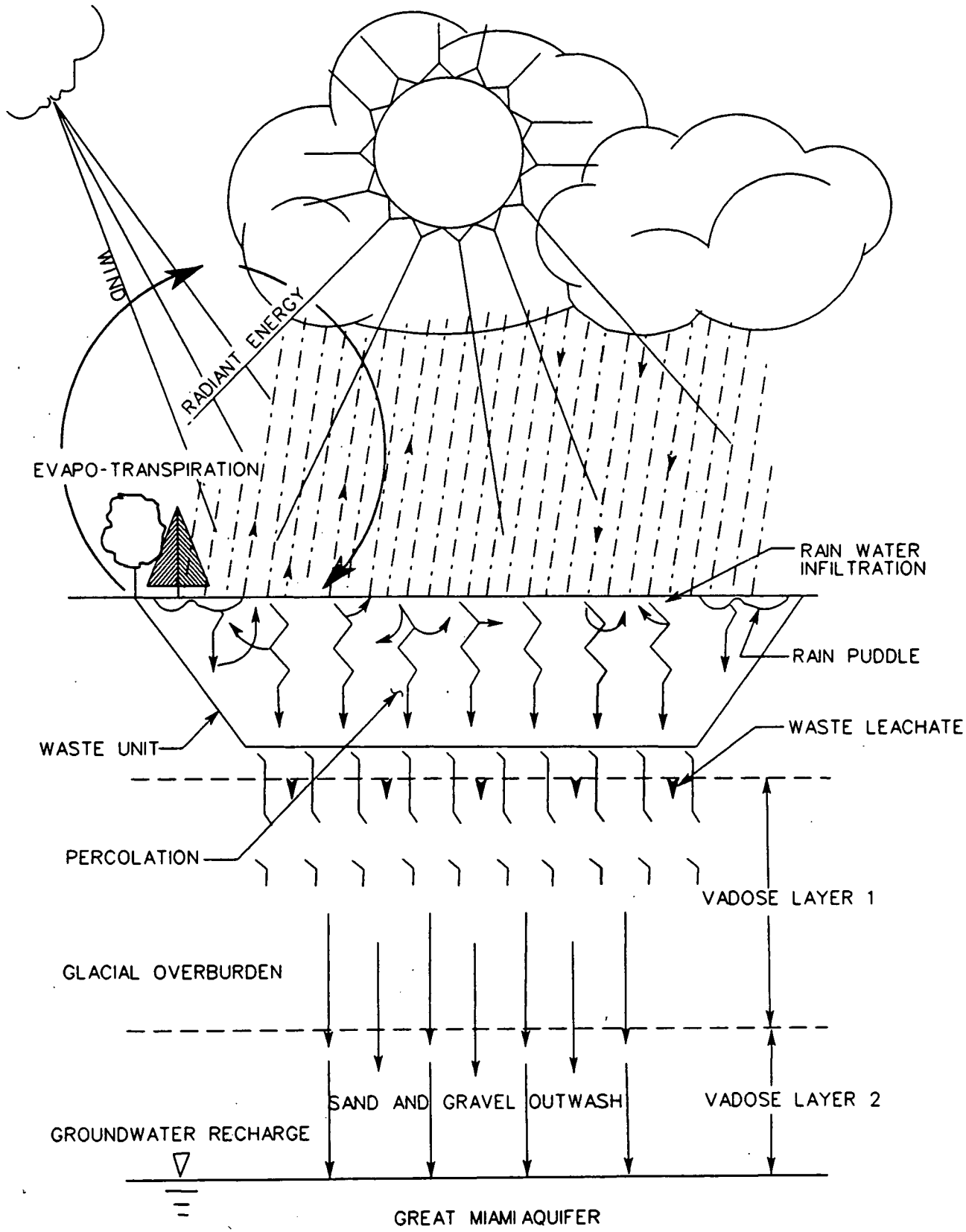

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FIGURE 1-53
CONCEPTUAL VADOSE ZONE MODEL

absorption properties. In addition, the computer model selected to evaluate flow in the vadose zone is limited to two layers. By neglecting the sand and gravel units, the model underpredicts travel time, and is, therefore, conservative. Beneath the till is the unsaturated sand and gravel outwash (Great Miami Aquifer) layer (Layer 2). Figure 1-53 shows the conceptual model for lateral drainage simulation within the vadose zone pathway.

The perched water infiltration pathway was also modeled with two layers. Layer 1 soils consist of till below the perched water zone, and Layer 2 soils consist of the unsaturated portion of the Great Miami Aquifer. Constituent mass in the perched water, as well as adsorbed to the sand layer, was considered in the source term for perched water infiltration.

Figure 1-52 shows the conceptual model for the perched water subsurface seep pathway. This pathway and seep pathway were simulated using a single vadose zone layer consisting of unsaturated Great Miami Aquifer.

Areas overlying each SWIFT III grid block in all subunits were modeled separately with individual stratigraphy, constituent type and concentration, infiltration rate parameters, and applicable pathways. Distribution coefficients (retardation factors) and decay factors were taken from literature studies or site-specific data. UCLs of the waste concentrations (except for uranium-238) from the RI/FS subsurface soil samples for each Operable Unit 2 subunit were used in the groundwater modeling. For uranium-238, the waste concentration in each block was estimated using kriging. This approach was selected because uranium is the largest contributor to risk from groundwater pathways. Also, the use of a geostatistical method, such as kriging, allows for the simulation of uranium hot spots that were identified during the remedial investigation field activities.

All leachate concentrations used for CPCs were constrained by (in order of preference): in situ leachate analyses, TCLP data, or the EPA 70-year rule (EPA 1988a) constrained by the solubility limit. Vadose zone modeling was performed using the leachate concentrations as inputs to the ODAST model to simulate transport through the vadose zone to the Great Miami Aquifer. The Hydrologic Evaluation of Landfill Performance (HELP) model was also used to estimate infiltration rates and lateral drainage.

If the modeling of a possible CPC through the vadose zone to the Great Miami Aquifer revealed that the peak concentration of the constituent at the point of reaching the Great Miami Aquifer was below the screening concentration within 1,000 years, further modeling of the constituent was not considered necessary for the human health risk assessment. The screening concentrations were calculated using EPA Risk Assessment Guidelines for Superfund (RAGs), Part B guidelines.

The CPCs passing the risk-based screening in the vadose zone were modeled using the SWIFT III model to predict future concentrations in the Great Miami Aquifer. Among uranium isotopes, only uranium-238 was modeled in order to reduce computation time. Concentrations of uranium-234 and uranium-235/236 were estimated using site-specific activity ratios between these isotopes and uranium-238. Total uranium was estimated from the site-specific mass ratios between uranium-238 and total uranium.

Air Pathway

Air emissions associated with Operable Unit 2 may involve different types of release mechanisms. During periods of turbulent wind conditions, particles of contaminated surface soil can become suspended in the air and may be subject to inhalation by on- or off-site human receptors. The amount of material that may be suspended depends on wind speed and other site conditions such as soil moisture, particle size, and vegetative cover. Gaseous radon-222 may be emitted from soil and material containing radium-226. Also, if organic compounds are present within the surface soil or exposed waste materials, volatilization of these compounds may occur.

An EPA-approved air dispersion model, Industrial Source Complex Long Term 2 (ISCLT2), was used to account for dispersion and dilution of the contaminants under defined meteorological conditions such as wind speed and direction, atmospheric stability, and mixing height. The radon-222 emissions were calculated using the radon attenuation effectiveness and cover optimization with moisture effects (RAECOM) model algorithms developed for the U.S. Nuclear Regulatory Commission. The RAECOM model converts radium-226 soil concentrations (in pCi/g) to radon-222 emission fluxes picoCuries per second per square m ($pCi/s/m^2$). The primary meteorological parameters used were collected from an on-site meteorological station.

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Two configurations examined were the "current" and "future" emissions source terms. For the current emissions source term, the Operable Unit 2 subunit areas are assumed to have the following physical conditions:

- The Solid Waste Landfill, South Lime Sludge Pond, Inactive Flyash Pile, and South Field are assumed to be 85 percent covered by vegetation.

- The North Lime Sludge Pond is assumed to have 10 percent of the surface area covered with water and 5 percent covered by vegetation. The remaining area of the North Lime Sludge Pond is assumed to be non-vegetated and susceptible to wind erosion; however, much of the surface soil is crusted and thus has a limited erosion potential.

- The Active Flyash Pile is assumed to have no vegetative cover. However, the pile has limited erosion potential because a dust suppressant is used to control wind erosion, and most of the material is composed of large agglomerations of flyash material.

For the future emissions source term, the only changes that occur to the subunit emissions involve the Solid Waste Landfill and the South Field. Both of these subunits are assumed to be used for the farming of crops for human and animal consumption. On an annual basis, these subunits are assumed to have crops for six months of the year to simulate the growing season; for the remaining six months of the year, both subunits are assumed to have no vegetation.

The UCL constituent concentrations in the surface soil and waste area were used in the air dispersion modeling. The principal sources of constituent emissions were assumed to be associated with the wind erosion of surface soil and evolution of radon-222 for radium-226 decay from each Operable Unit 2 subunit. The volatilization of organics from the surface soils and the waste area materials was evaluated as a possible source in both emission scenarios. The volatilization of organics was not found to be significant and was not modeled. (See Section 5.5.2 of the Operable Unit 2 RI Report.) However, particulate transport of organics was modeled.

The technical approach used for estimating particulate emissions due to wind erosion was based on the concept of "threshold friction velocity." Based on the land-use types within a 3 km (1.9 mi) radius of Operable Unit 2, the area was classified as rural for the purpose of dispersion modeling, and rural dispersion coefficients were selected for use in the modeling. All Operable Unit 2 sources were defined as area sources in the model. Because of the large number of constituents that were addressed in this analysis, each subunit area source was modeled using a wind erosion unit emission

rate. All maximum constituent concentrations for on-site and off-site receptors are reported for the worst case annual meteorological period.

The receptor network consisted of a 50 m x 50 m (164 ft x 164 ft) grid on a 4.3 km x 3.0 km (2.7 mi x 1.9 mi) area. A discrete receptor network was also used to calculate annual average concentrations at sensitive locations. The discrete receptor network included four elementary schools, one middle/high school, and one day nursery. All receptors and area emission sources were assumed to be at the same elevation.

1.7.2.2 Solid Waste Landfill

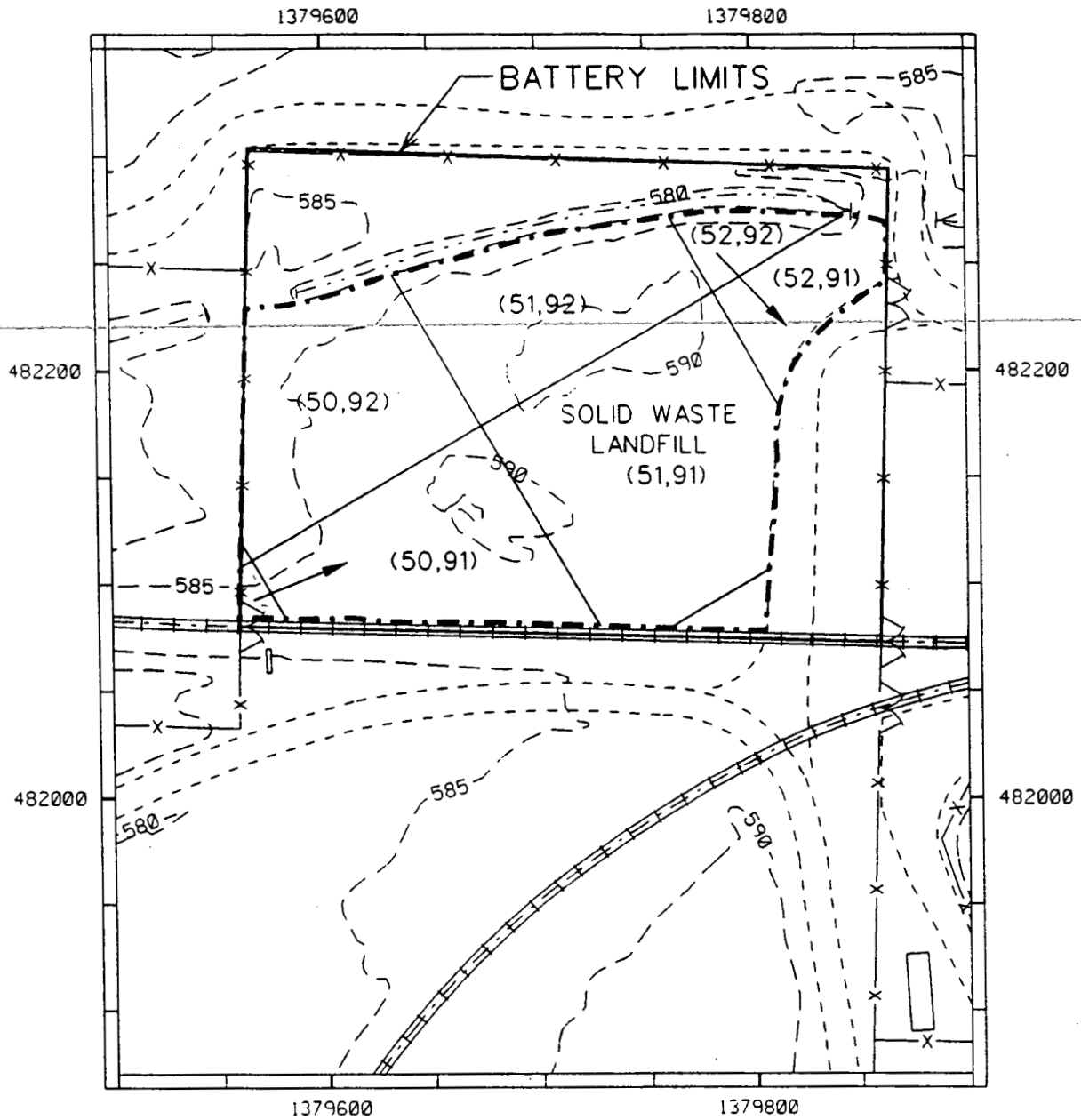
Surface Water

The model results show that the small mass of constituents from the Solid Waste Landfill that partition into the water, combined with a dilution in Paddys Run from a flow of 1.1 m^3/sec (4 ft^3/sec), results in low surface water concentrations. Uranium-238 had the maximum predicted concentrations among all radionuclides in Paddys Run and the Great Miami River. Modeled uranium-238 concentrations were 5.9 x 10^{-2} and 7.1 x 10^{-5} pCi/L for Paddys Run and the Great Miami River, respectively.

Groundwater

None of the constituents from surface water pathways were predicted to be above the screening level in the Great Miami Aquifer. Other constituent migration pathways applicable to the Solid Waste Landfill were the vadose zone and perched groundwater infiltration pathways. Figure 1-54 shows the areal extent of the waste in the Solid Waste Landfill and the SWIFT III grid blocks impacted by the direct loading from the Solid Waste Landfill. Only technetium-99 was found to reach the Great Miami Aquifer above the screening levels.

The groundwater fate and transport modeling results are summarized in Table 1-34 for technetium-99. The table presents the arrival time in the aquifer, the maximum loading concentration, the maximum predicted concentrations in the aquifer within 1,000 years, the time required to reach the maximum value, and the predicted maximum concentration at the FEMP boundary and associated time due to loading from the Solid Waste Landfill. It also presents the screening level for technetium-99. At 1,000 years, concentrations of technetium-99 were predicted to be significantly below the screening concentration.



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- EXTENT OF WASTE
- WASTE FROM CELL IS INCLUDED IN OTHER CELL
- (51,91) SWIFT MODEL CELL (COLUMN, ROW)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

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SCALE (FT)
0 40 80 160

SCALE (METER)
0 9.6 19.2 38.4

FIGURE 1-54
EXTENT OF WASTE
AND MODELED SWIFT GRID CELLS
SOLID WASTE LANDFILL

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TABLE 1-34

SUMMARY OF SWIFT III MODELING RESULTS FOR THE SOLID WASTE LANDFILL

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L)	Time of Maximum Concentration at FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L)	EPA RAGs, Part B Screening Concentration (pCi/L)
Radionuclides							
Technetium-99	28.5	10-20	60	0.61	70	0.054	3.65

In addition to predicting constituent loading to the Great Miami Aquifer, future perched groundwater concentration increases were also predicted using ODAST. Only technetium-99 and carbazole were predicted to reach the perched groundwater zone above the EPA RAGs, Part B screening concentrations. The maximum predicted perched water concentrations for technetium-99 and carbazole were 28.9 pCi/L and 9.6 μg/L, respectively.

Air Quality

For the current emission source term, the constituents with the highest calculated concentrations are radon-222, uranium-238, lead, and benzo(k)fluoranthene. The respective maximum annual average concentrations for these constituents were 1.60 picoCuries per cu m (pCi/m^3), 2.31 x 10^{-4} pCi/m^3, 5.70 x 10^{-8} milligram per cu m (mg/m^3), and 66 x 10^{-9} mg/m^3. The maximum annual average concentration for total uranium was 6.76 x 10^{-7} mg/m^3.

For the future source term, the Solid Waste Landfill is assumed to be used to grow crops. For the future source terms, except for radon-222, maximum calculated concentrations were generally one to two orders of magnitude higher than calculated for the current scenario because of the land-use assumptions. Radon-222 emission rates and concentrations are the same for the current and future cases, because the scenario assumptions do not affect gaseous contaminant emissions. As in the current emissions source term, the constituents with the highest annual average concentrations on site and off site were radon-222, uranium-238, lead, and benzo(k)fluoranthene. Maximum annual average concentrations were 1.60 pCi/g, 7.02 x 10^{-3} pCi/m, 1.73 x 10^{-6} mg/m^3, and 8.05 x 10^{-8} mg/m^3, respectively. The maximum future scenario concentration of total uranium was calculated to be 2.05 x 10^{-5}.

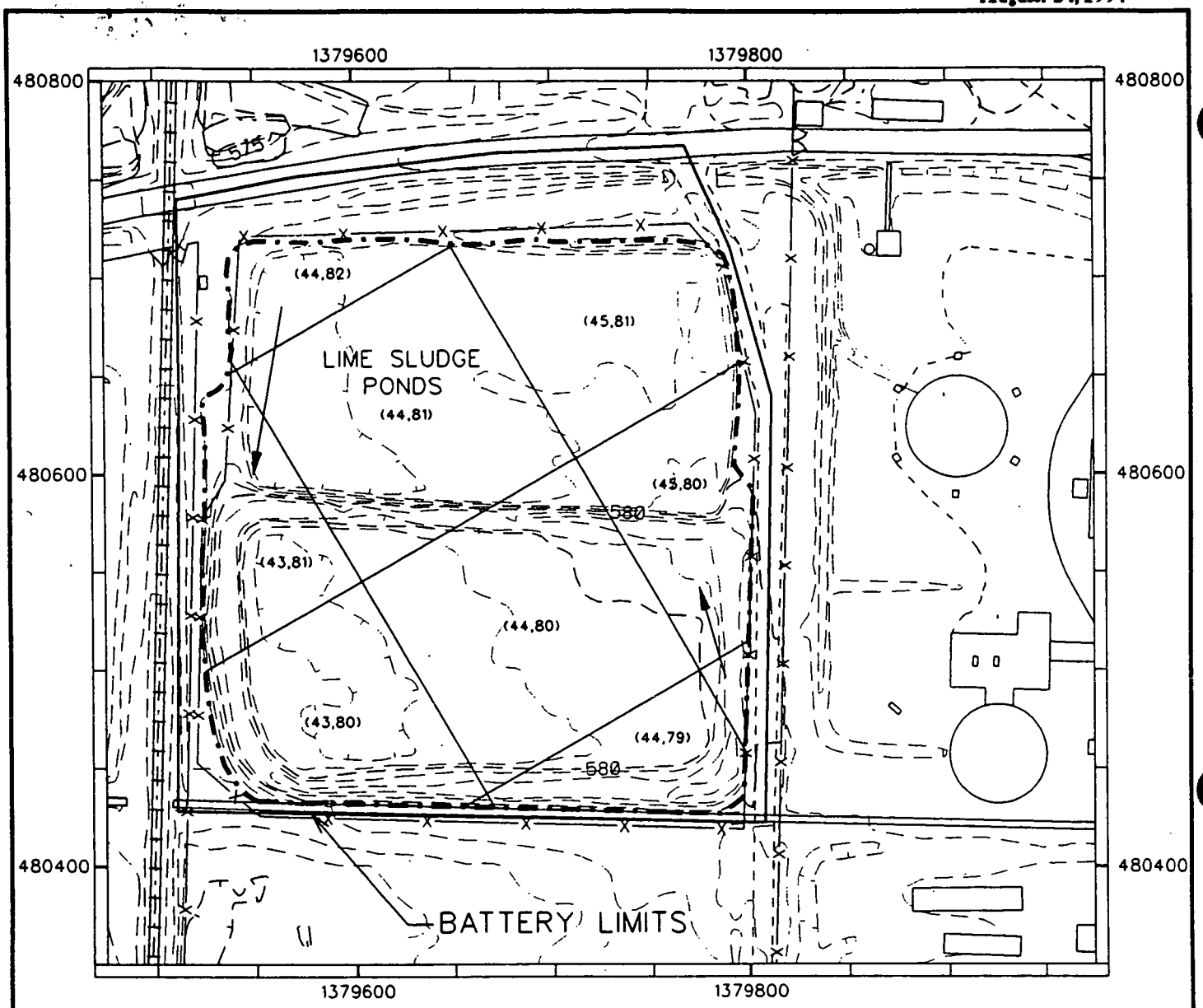
1.7.2.3 Lime Sludge Ponds

Surface Water

The Lime Sludge Ponds are contained within soil berms which isolate them from the surrounding soils; therefore, they were not considered a source of contaminants to the surface waters. No surface water pathway modeling was conducted.

Groundwater

Figure 1-55 shows the aerial extent of the waste in the Lime Sludge Ponds and the SWIFT III grid cells impacted by the direct loading from the Lime Sludge Ponds. Only the vadose zone and perched



LEGEND

- ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- WASTE FROM CELL IS INCLUDED IN OTHER CELL
- EXTENT OF WASTE
- SWIFT MODEL CELL (COLUMN, ROW)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 50 100

SCALE (METER)
0 12 24

FIGURE 1-55
EXTENT OF WASTE AND MODELED SWIFT GRID CELLS, LIME SLUDGE PONDS

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TABLE 1-35

SUMMARY OF SWIFT III MODELING RESULTS FOR THE LIME SLUDGE PONDS

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L)	Time of Maximum Concentration at FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L)	EPA RAGs, Part B Screening Concentrations (pCi/L)
Radionuclides							
Technetium-99	76.4	20-30	40	2.96	40	0.17	3.65

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water infiltration pathways were applicable to vadose zone modeling for the Lime Sludge Ponds. Only technetium-99 was found to reach the Great Miami Aquifer from the Lime Sludge Ponds above the EPA RAGs, Part B screening concentrations.

The groundwater fate and transport modeling results are summarized in Table 1-35 for technetium-99. The table presents the arrival time for technetium-99 in the aquifer, the maximum loading concentration, the maximum predicted in concentrations of technetium-99 in the aquifer within 1,000 years, the time required to reach the maximum value, and the screening level. It shows that the predicted maximum concentration at the FEMP boundary due to loading from the Lime Sludge Ponds is below the screening level (i.e., the off-site impact of Lime Sludge Ponds is negligible). At 1,000 years, concentrations of technetium-99 were predicted to be significantly below the screening level.

In addition to predicting constituent loading to the Great Miami Aquifer, future perched groundwater concentration increases were also predicted using ODAST. Only one layer, consisting of till, above the perched water zone was considered. Neptunium-237, strontium-90, technetium-99, arsenic, and manganese are predicted to reach perched groundwater above the EPA RAGs, Part B screening concentrations. Maximum concentrations were 5.06 pCi/L, 1.9 pCi/L, 82.3 pCi/L, 0.015 μg/L, and 19.4 μg/L, respectively.

Air Quality

Since the conceptual model assumes no alteration in the physical condition or use of the Lime Sludge Ponds, there is no change in the source term for the current and future emission scenarios. The constituents with the highest annual average concentrations for the North and South Lime Sludge Ponds were radon-222, uranium-238, lead, and Aroclor-1254. The respective concentrations calculated for each of these constituents were 3.93×10^{-1} pCi/m^3, 1.86×10^{-3} pCi/m^3, 7.17×10^{-7} mg/m^3, and 1.53×10^{-5} mg/m^3. The maximum annual average concentration for total uranium was calculated to be 5.57×10^{-6} mg/m^3. These maximum concentrations all occurred in the Lime Sludge Ponds subunit.

1.7.2.4 Inactive Flyash Pile

Surface Water

Modeling results show low surface water concentrations in Paddys Run from the Inactive Flyash Pile. For radionuclides, concentrations in the Paddys Run range from a minimum of a 2.37×10^{-4} pCi/L

for plutonium-239/240 to a maximum of 0.67 pCi/L for uranium-238. Concentrations of radionuclides in the Great Miami River range from a low of 2.9 x 10^{-7} pCi/L for plutonium-239/240 to a high of 8.0 x 10^{-4} pCi/L for uranium-238. All inorganics and organics were predicted to remain below 5.29 x 10^{-2} μg/L in Paddys Run and 6.4 x 10^{-5} μg/L in the Great Miami River.

Groundwater

Loading to the Great Miami Aquifer from the Inactive Flyash Pile and the South Field were combined and modeled together because of the close proximity of the Inactive Flyash Pile to the South Field. Results of the groundwater modeling for these two subunits are presented in Section 1.7.2.5.

Air Quality

The conceptual model for the Inactive Flyash Pile assumes that the Inactive Flyash Pile remains in the same condition as specified for the current source term and, therefore, results in no change for the future source term emissions. The maximum annual concentrations from the Inactive Flyash Pile occurred approximately 50 m (164 ft) north-northeast from the center of the Inactive Flyash Pile. This receptor point is situated in the northwestern corner of the South Field subunit. The constituents with the maximum concentrations were uranium-238, radon-222, arsenic, and dibenzo(a,h)anthracene. The respective maximum annual averages for these constituents were calculated to be 4.76 pCi/m^3, 6.21 x 10^{-5} pCi/m^3, 2.32 x 10^{-7} mg/m^3, and 1.54 x 10^{-8} mg/m^3. The maximum annual concentration for total uranium was calculated to be 1.83 x 10^{-7} mg/m^3.

1.7.2.5 South Field

Surface Water

Modeling results showed low surface water concentrations in Paddys Run from the South Field. For radionuclides, concentrations in Paddys Run range from a low of 5.39 x 10^{-4} pCi/L for plutonium-238 to a high of 412 pCi/L for technetium-99. Concentrations of radionuclides in the Great Miami River ranged from 6.63 x 10^{-7} pCi/L for plutonium-238 to 0.51 pCi/L for technetium-99. Modeled uranium-238 concentrations were 3.7 pCi/L and 4.5 x 10^{-3} pCi/L for Paddys Run and the Great Miami River, respectively. All inorganics were predicted to be below 0.3 μg/L in Paddys Run and below 3.7 x 10^{-4} μg/L in the Great Miami River. All organics were predicted to be below 3.75 μg/L and 7.73 x 10^{-4} μg/L in Paddys Run and the Great Miami River, respectively.

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Groundwater

Due to close proximity of the Inactive Flyash Pile and South Field, groundwater modeling for these two units was combined. Figure 1-56 shows the areal extent of the waste in the Inactive Flyash Pile/South Field and the SWIFT III grid cells impacted by direct loading from these subunits. All five pathways were applicable for these two subunits. Many SWIFT III grid blocks received lateral drainage at the interface of waste and glacial overburden. These grid blocks are identified in Figure 1-56. This figure also identifies eight blocks that receive subsurface seep water due to lateral movement of perched groundwater. Furthermore, two seeps have been observed adjacent to or in the area of these subunits. One seep exists on the western boundary of the Inactive Flyash Pile, while another was observed on the eastern side of the South Field. Table 1-36 lists the constituents that survived the various screening processes and were simulated using the SWIFT III model for the Inactive Flyash Pile and South Field.

The Operable Unit 2 SWIFT III model was calibrated for uranium-238. Uranium-238 was selected for calibration because of the high detection frequency, the very sensitive analytic procedure, the projection as main parameter of concern for risk assessment, and for the determination and modeling of hot spots. Through the calibration process, the distribution coefficient in the Great Miami Aquifer (and ODAST) was reduced from 8.4 to 1.48 milliliter per gram (ml/g) to match current uranium-238 concentrations. The value of effective porosity used in the Operable Unit 2 RI SWIFT III model was 25 percent.

The groundwater fate and transport modeling results for the Inactive Flyash Pile and South Field are summarized in Table 1-37 for the CPCs that will reach the Great Miami Aquifer above the screening levels in 1,000 years from the Inactive Flyash Pile and South Field subunits. The table also presents the arrival time for the CPCs to reach the aquifer, the maximum loading concentration, the maximum concentrations of the CPC that would be expected in the aquifer within 1,000 years, and the time required for the CPC to reach the maximum value. It also presents the predicted maximum concentration at the FEMP boundary due to loading from the Inactive Flyash Pile and South Field subunits.

Constituents projected to be above screening levels when they reach the Great Miami Aquifer directly beneath the Inactive Flyash Pile and South Field subunits are the uranium isotopes, neptunium-237, radium-226, strontium-90, technetium-99, antimony, cadmium, lead, manganese, and molybdenum.

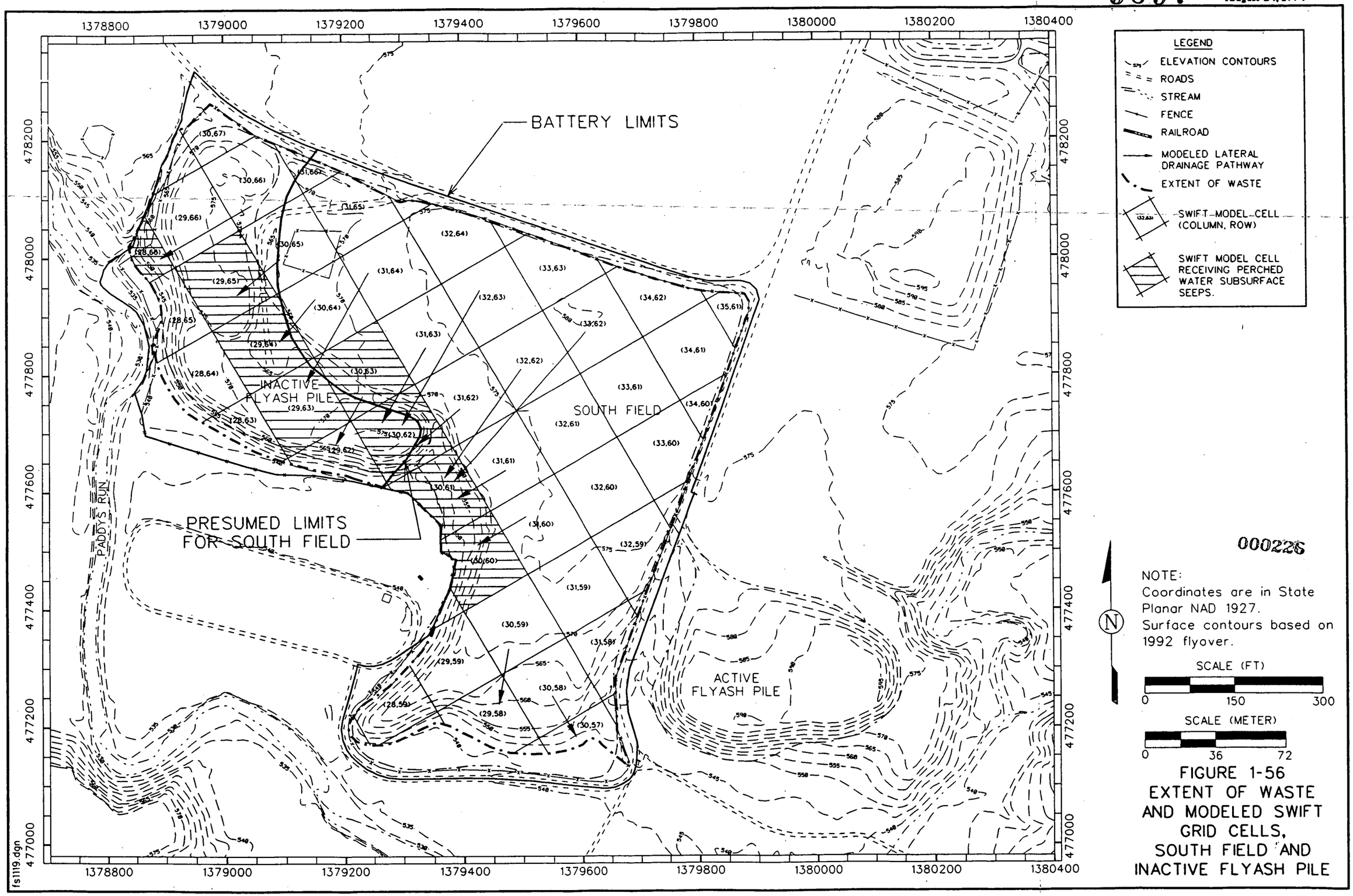

FIGURE 1-56
EXTENT OF WASTE AND MODELED SWIFT GRID CELLS, SOUTH FIELD AND INACTIVE FLYASH PILE

TABLE 1-36

SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN AND SOURCE PATHWAYS FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD

Contaminants of Potential Concern	Source Pathways[a]				
	Inactive Flyash Pile/South Field Waste[b]	Inactive Flyash Pile Seep	South Field Seep	Perched Groundwater Subsurface Seeps in Inactive Flyash Pile/South Field	Paddy's Run Loading from Inactive Flyash Pile/ South Field Runoff
Radionuclides					
Neptunium-237	Yes	Yes	No	Yes	No
Radium-226	Yes	Yes	No	Yes	Yes
Strontium-90	Yes	No	No	No	No
Technetium-99	Yes	No	No	No	Yes
Uranium-234	Yes	Yes	Yes	Yes	Yes
Uranium-235/236	Yes	Yes	Yes	Yes	No
Uranium-238	Yes	Yes	Yes	Yes	Yes
Uranium - Total (non-RAD)	Yes	Yes	Yes	Yes	No
Organics					
2-methylnaphthalene[c]	NA[c]	No	No	No	NA
Benzo(a)pyrene[d]	No	No	No	No	Yes[d]
Benzo(g,h,i)perylene[c]	No	No	No	No	NA
Dieldrin[d]	No	No	No	No	Yes[d]
Phenanthrene[c]	No	No	No	No	NA
Tributyl phosphate[c]	NA	No	No	No	No
Inorganics					
Arsenic	No	Yes	No	No	Yes
Beryllium[d]	No	No	No	No	Yes[d]

See footnotes at end of table.

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TABLE 1-36
(Continued)

Contaminants of Potential Concern	Source Pathways[a]				
	Inactive Flyash Pile/South Field Waste[b]	Inactive Flyash Pile Seep	South Field Seep	Perched Groundwater Subsurface Seeps in Inactive Flyash Pile/South Field	Paddy's Run Loading from Inactive Flyash Pile/ South Field Runoff
INORGANICS (Continued)					
Lead[c]	NA[c]	NA	No	NA	NA

[a]"Yes" indicates that predicted CPC concentration was above screening concentration; "No" indicates that the predicted CPC concentration was below screening concentration.

[b]Includes loading from perched groundwater source leakage through till and unsaturated GMA, if applicable.

[c]NA = no data available to calculate EPA RAGs, Part B screening values for 2-Methylnaphthalene, benzo(g,h,i)perylene, phenanthrene and lead. These CPCs were not considered for further modeling using SWIFT.

[d]Not modeled using SWIFT because diluted GMA concentration without absorption effects is marginaly above the screening concentration. Typical concentration reduction in the GMA is approximately by a factor of 20.

TABLE 1-37

SUMMARY OF SWIFT MODELING RESULTS FOR THE INACTIVE FLYASH PILE AND SOUTH FIELD

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Levels (pCi/L RAD) (μg/L non-RAD)
Radionuclides							
Neptunium-237	$1.06 \times 10^{+2}$	40	360	9.33×10^{-1}	540	8.59×10^{-2}	2.16×10^{-2}
Radium-226	1.58×10^{-1}	760	1,000	8.90×10^{-3}	1,000	1.13×10^{-9}	1.76×10^{-4}
Strontium-90	$1.53 \times 10^{+1}$	60	140	2.07×10^{-1}	200	4.48×10^{-3}	1.32×10^{-1}
Technetium-99	$7.72 \times 10^{+2}$	0	40	$1.03 \times 10^{+1}$	40	2.86×10^{0}	3.65×10^{0}
Uranium-234[a]	-[a, b]	0	160	$4.69 \times 10^{+2}$	220	$2.40 \times 10^{+1}$	2.97×10^{-1}
Uranium-235/236[a]	-[a, b]	0	160	$2.50 \times 10^{+1}$	220	1.28×10^{0}	2.97×10^{-1}
Uranium-238	$5.44 \times 10^{+5}$	0	160	$5.17 \times 10^{+2}$	220	$2.65 \times 10^{+1}$	1.70×10^{-1}
Uranium Total - (non-RAD)[a]	-[a, b]	0	160	$1.84 \times 10^{+3}$	220	$9.45 \times 10^{+1}$	$1.09 \times 10^{+1}$
Organics							
2-Methylnaphthalene[c]	$1.98 \times 10^{+1}$	40	360	1.74×10^{-1}	540	1.61×10^{-2}	NA[d]
Benzo(a)anthracene	-[e]	0	1000	3.84×10^{-3}	-[e]	-[e]	2.82×10^{-3}
Benzo(a)pyrene	-[f]	0	1000	2.75×10^{-3}	-[f]	-[f]	2.82×10^{-4}
Benzo(g,h,i)perylene	-[g]	0	1000	1.32×10^{-2}	-[g]	-[g]	NA
Dibenzo(a,h)anthracene	-[e]	0	1000	6.66×10^{-4}	-[e]	-[e]	2.82×10^{-4}
Dieldrin	-[f]	0	1000	8.47×10^{-4}	-[f]	-[f]	1.12×10^{-4}
Phenanthrene	-[g]	0	1000	4.10×10^{0}	-[g]	-[g]	NA
Tributyl phosphate[h]	$3.95 \times 10^{+1}$	60	660	4.01×10^{-1}	1000	3.72×10^{-2}	NA

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TABLE 1-37
(Continued)

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Screening Levels (pCi/L RAD) (μg/L non-RAD)
Inorganics							
Arsenic[j]	1.29×10^{-5} [i]	0	1000	3.35×10^{-4}	1,000	8.56×10^{-5}	1.46×10^{-4}
Lead	$5.61 \times 10^{+1}$	200	1,000	4.86×10^{0}	1,000	5.94×10^{-3}	NA[c]
Beryllium[j]	-[i]	0	1000	2.61×10^{-5}	1000	6.73×10^{-6}	2.37×10^{-4}

[a]Results for uranium-234, uranium-235/236, and total uranium were established by using appropriate scaling ratios to uranium-238 results.
[b]ODAST results were not used for SWIFT III modeling and therefore not shown in this table.
[c]Results for 2-Methylnaphathalene were estimated based on the results for neptunium-237.
[d]NA = no data available to calculate EPA RAGs, Part B screening value.
[e]Benzo(a)anthracene and dibenzo(a,h)anthracene were not modeled using SWIFT III, because the concentrations in the Great Miami Aquifer fall below the EPA RAGs, Part B screening concentrations after mixing in the SWIFT III grid cell. The maximum predicted concentration based on 30-ft. wide Paddys Run are reported as the maximum on-site concentration.
[f]The predicted maximum concentration after mixing in the full SWIFT III grid cell is marginally above the EPA RAGs, Part B screening concentration. Therefore, SWIFT III modeling was not performed and the maximum predicted concentration based on 30 feet wide Paddys Run is reported as the maximum on-site concentration.
[g]Benzo(g,h,i)perylene and phenanthrene were not modeled using SWIFT III because EPA RAGs, Part B screening concentrations could not be calculated. Maximum predicted concentration based on 30 feet wide Paddys Run are reported as the maximum on-site concentration.
[h]Results for tributyl phosphate are estimated based on results for CPCs with similar adsorption properties.
[i]The main contribution to the Great Miami Aquifer is from the surface water runoff pathway.
[j]The results are scaled from the SWIFT III modeling results for the Active Flyash Pile because of no impact on overall risk, and the main pathway to the Great Miami Aquifer is the surface water runoff pathway.

Only uranium isotopes, neptunium-237, technetium-99, lead, and manganese concentrations are projected to exceed screening levels in the Great Miami Aquifer. Of these CPCs, only uranium isotopes, neptunium-237, and technetium-99 are projected to exceed screening levels at the FEMP boundary.

The maximum on-site uranium-238 concentration occurs at 160 years, while the maximum off-site concentration occurs at 220 years. Figure 1-57 shows the contour plot of projected increase in "incremental" concentrations of uranium-238 at 160 years. Contour plots show projected incremental increases in the uranium-238's concentrations due to the South Field/Inactive Flyash Pile and do not take into account the background concentrations or contributions from other FEMP sources.

As noted earlier, total uranium, uranium-234, and uranium-235/-236 concentrations were estimated from the results of uranium-238 modeling. The following relationships were observed between various uranium forms:

Uranium-234 =	0.91 (Uranium-238)	activity ratio
Uranium-235/236 =	0.048 (Uranium-238)	activity ratio
Uranium-total =	$\frac{\text{uranium-238}}{0.832}$	mass ratio at Inactive Flyash Pile/South Field

Although they were developed from soil samples, these relationships should apply to uranium concentrations in the groundwater because all uranium isotopes have very long half-lives (greater than 10,000 years).

Air Quality

For the current source term, the highest annual average concentrations resulting from the South Field, occurring within the boundary of the South Field subunit, were for radon-222, technetium-99, lead, and benzo(a)pyrene. The respective concentrations for these contaminants were 7.74×10^{1} pCi/m^3, 1.41×10^{-3} pCi/m^3, 2.43×10^{-7} mg/m^3, and 9.31×10^{-8} mg/m^3. The maximum annual concentration for total uranium was 2.93×10^{-7} mg/m^3.

The future source term of the conceptual model assumes that the South Field subunit becomes part of a farm and is used to grow crops for human and animal consumption. As a result, the future source

term for the South Field increases and results in higher exposure concentrations than the current source term results. The impact calculated from the South Field for the future source term also identified radon-222, technetium-99, lead, and benzo(a)pyrene as having the highest annual average concentrations within the subunit boundary. Except for radon-222, the impacts calculated for the future source terms were generally one order of magnitude higher than for the current source terms. Radon-222 emission rates and concentrations are the same for the current and future cases, because the scenario assumptions do not affect gaseous contaminant emissions. The maximum on-subunit concentrations for radon-222, technetium-99, lead, and benzo(a)pyrene were 7.74×10^{1} pCi/m^3, 5.82×10^{-2} pCi/m^3, 1.01×10^{-5} mg/m^3, and 3.85×10^{-6} mg/m^3, respectively. The maximum concentration calculated for total uranium for the future source term was 1.21×10^{-5} mg/m^3.

1.7.2.6 Active Flyash Pile

Surface Water

The predicted concentrations of radionuclides from the Active Flyash Pile into the Storm Sewer Outfall Ditch ranged from 7.79×10^{-2} μg/L for plutonium-239/240 to 51.4 pCi/L for uranium-234. For inorganic parameters, the predicted concentrations in the Storm Sewer Outfall Ditch ranged from 0.44 μg/L for beryllium to 34 μg/L for lead.

The predicted concentrations of radionuclides in Paddys Run range from 9.74×10^{-4} pCi/L for plutonium-239/-240 to 0.64 pCi/L for uranium-234 or uranium-238. Radionuclide concentrations in the Great Miami River were predicted to range from 1.2×10^{-6} pCi/L for plutonium-239/240 to 7.8×10^{-4} pCi/L for uranium-234 or uranium-238. For inorganics and organics, predicted concentrations in Paddys Run ranged from 5.4×10^{-3} μg/L for beryllium to 0.43 μg/L for lead. Concentrations of all inorganics and organics in the Great Miami River were predicted to remain below 5.15×10^{-4} μg/L.

Groundwater

Figure 1-58 shows the areal extent of flyash in the Active Flyash Pile and the SWIFT III grid cells impacted by direct loading from these subunits. Three pathways applicable for this subunit were the vadose zone, perched water infiltration, and surface water pathways. Three SWIFT III grid blocks receiving lateral drainage are identified in Figure 1-58. Table 1-38 lists the constituents that survived the various screening processes and were simulated using the SWIFT III model for the Active Flyash Pile.

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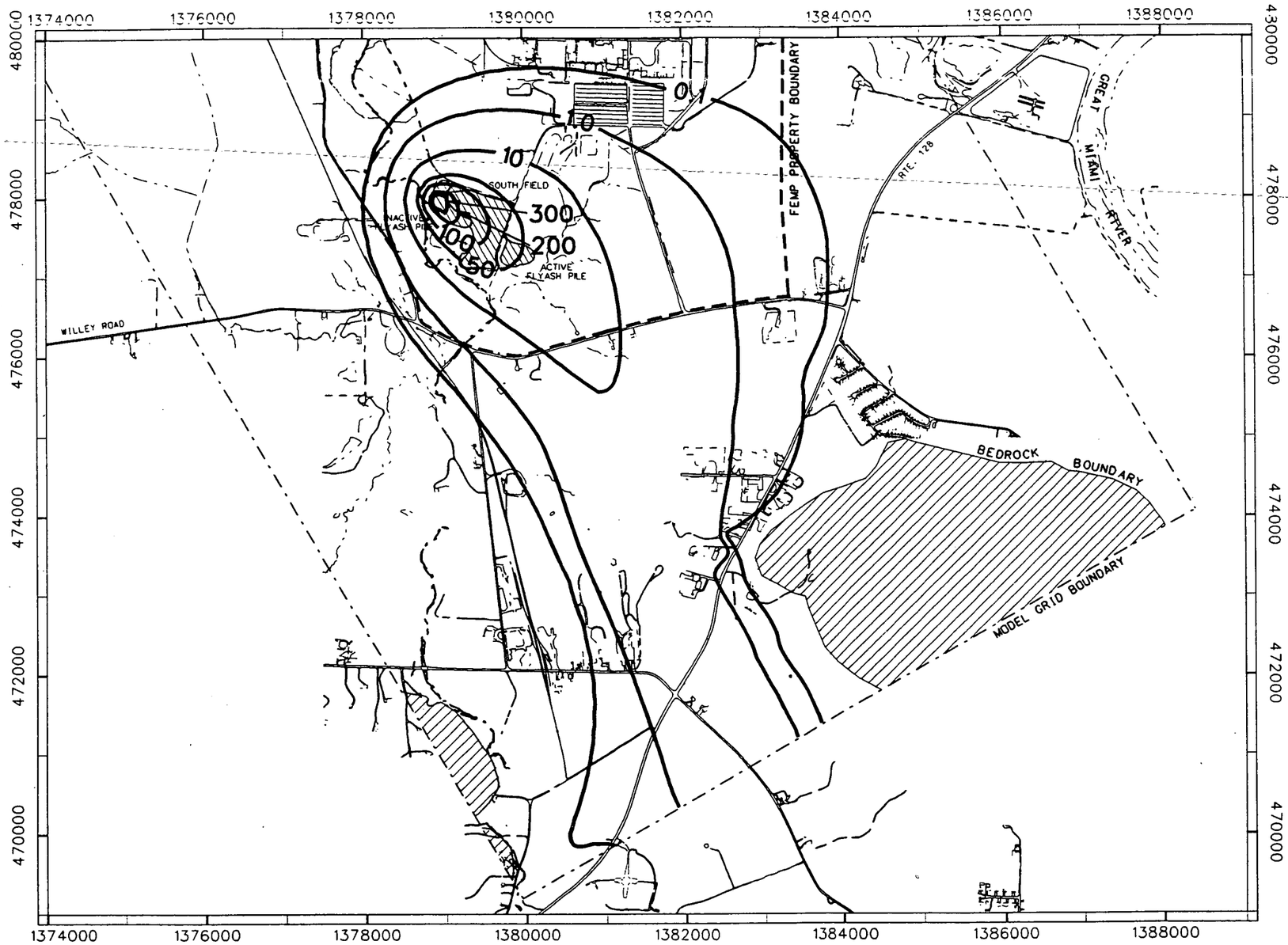

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 1500 3000

SCALE (METER)
0 360 720

N

Other source loadings and background concentration not included.

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MAXIMUM INCREASE IN CONCENTRATION = 517 pCi/L

FIGURE 1-57
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 160 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE AND SOUTH FIELD

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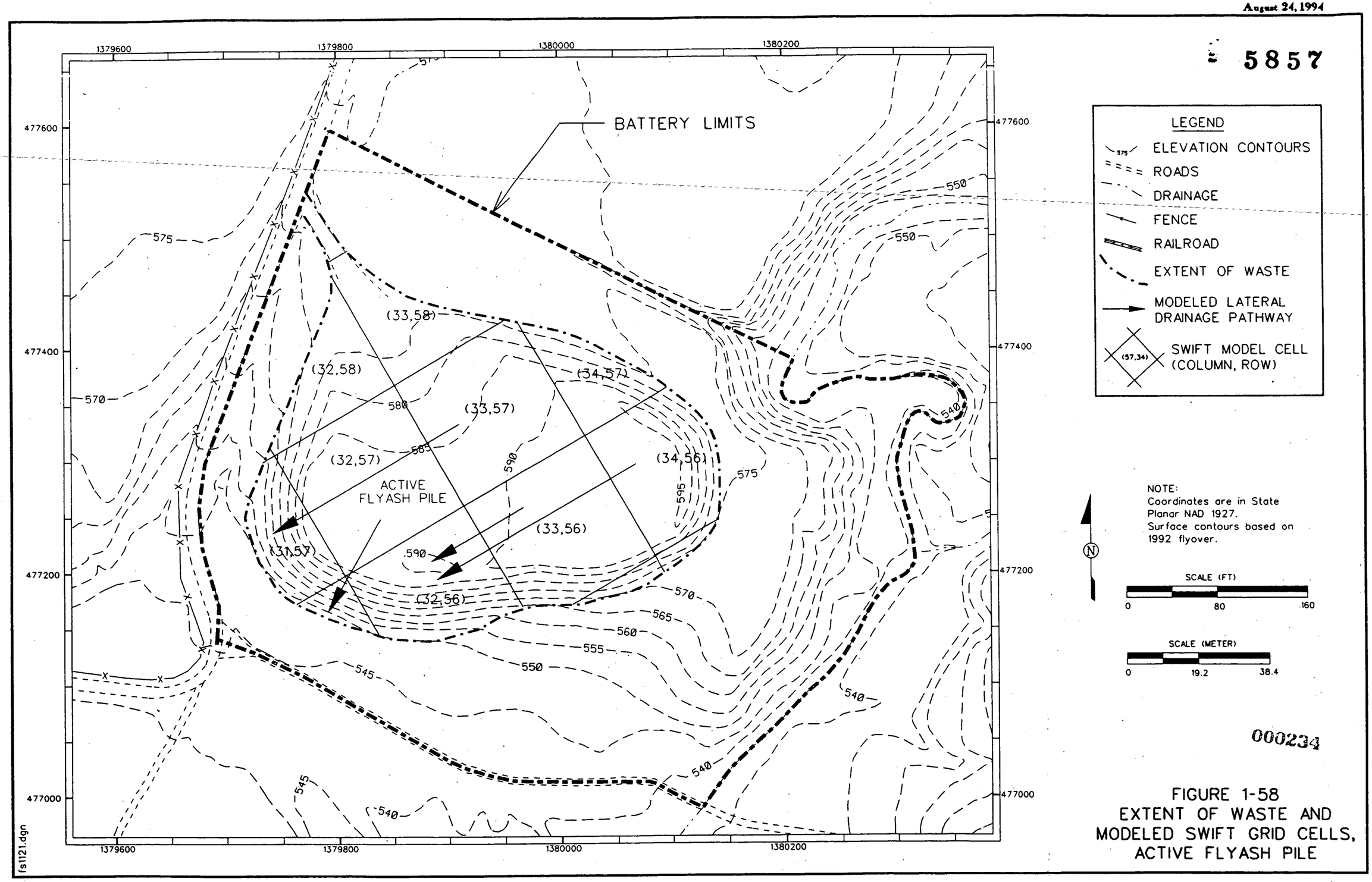

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FIGURE 1-58
EXTENT OF WASTE AND MODELED SWIFT GRID CELLS, ACTIVE FLYASH PILE

TABLE 1-38

SUMMARY OF CONSTITUENTS OF POTENTIAL CONCERN AND SOURCE PATHWAYS FOR THE ACTIVE FLYASH PILE

Contaminants of Potential Concern	Source Pathways[a]	
	Infiltration through Active Flyash Pile[b]	SSOD Loading from Active Flyash Pile Runoff
Radionuclides		
Neptunium-237	Yes	Yes
Strontium-90	Yes	No
Uranium-234	Yes	Yes
Uranium-235/236	Yes	No
Uranium-238	Yes	Yes
Uranium Total	Yes	No
Organics		
2-Methylnaphthalene	NA[d]	No
Inorganics		
Arsenic	No	Yes
Beryllium	No	Yes
Lead	NA	NA

[a]"Yes" indicates predicted CPC concentration was above screening concentration; "No" indicates that the predicted CPC concentration was below screening concentration.
[b]Includes loading from perched groundwater source leakage through till and unsaturated GMA, if applicable.
[c]Not modeled based on diluted GMA concentration less than EPA RAGs, Part B screening concentration.
[d]NA = no data available to calculate EPA, RAGs, Part B screening value.

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The groundwater fate and transport modeling results are summarized in Table 1-39 for CPCs that will reach the Great Miami Aquifer from the Active Flyash Pile. The table presents the arrival time for CPCs in the aquifer, the maximum loading concentration, the projected maximum increase in the concentration of the CPC in the aquifer within 1,000 years, and the time required for the CPC to reach the maximum value. CPCs projected to be above screening levels as they reach the Great Miami Aquifer directly beneath the Active Flyash Pile were uranium isotopes, total uranium, neptunium-237, plutonium-238, plutonium-239/240, arsenic, and beryllium. Although all CPCs are above screening concentrations, only neptunium-237, uranium isotopes, arsenic, and beryllium are expected to be above screening levels at the FEMP boundary. As noted earlier, total uranium, uranium-234, and uranium-235/236 concentrations were estimated from the results of uranium-238 modeling.

The maximum on-site uranium-238 concentration occurs at 100 years, while the maximum off-site concentration occurs at 120 years. Figure 1-59 shows the contour plot of projected increase in concentrations of uranium-238 at 100 years. Contour plots show projected increases in the uranium-238 concentration due to the Active Flyash Pile and do not take into account the background concentrations or contributions from other FEMP sources.

Air Quality

The conceptual model for Operable Unit 2 assumes that the Active Flyash Pile will remain in its present state for the future source term; therefore, the maximum exposure concentrations are the same for the current and future source terms. The calculated highest annual average concentrations of resuspended radionuclides and inorganics contaminants occur within the subunit boundary of the Active Flyash Pile. The highest concentrations were reported for radon, neptunium, and barium. The respective maximum annual on-subunit concentrations for these constituents were calculated to be 1.81 pCi/m^3, 5.67 x 10^{-5} pCi/m^3 and 2.62 x 10^{-6} μg/m^3. The maximum annual concentration calculated for total uranium is 8.06 x 10^{-7} mg/m^3.

1.7.2.7 Modeling Results of Waste at Background Concentrations

Modeling results presented thus far are based on analytical results from soil samples and perched groundwater samples. This section presents results of vadose zone modeling if the waste and perched groundwater were at background concentrations. Selected block(s) in each Operable Unit 2 subunit were modeled using ODAST to predict loadings to the Great Miami Aquifer. Leachate concentrations

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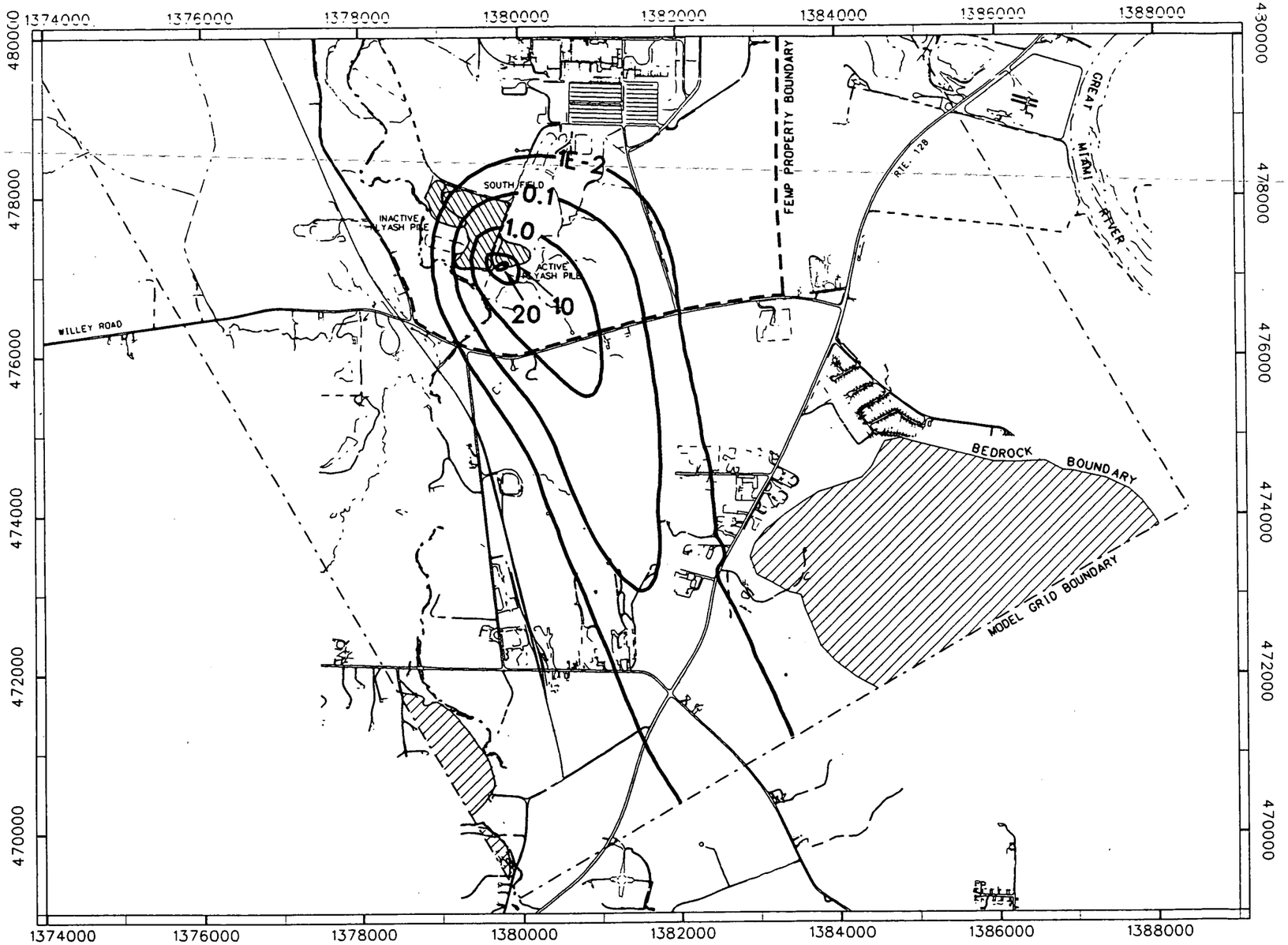

LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 10 — URANIUM-238 CONCENTRATION CONTOUR (pCi/L)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

N

SCALE (FT)
0 1500 3000

SCALE (METER)
0 360 720

Other source loadings and background concentration not included.

000237

MAXIMUM INCREASE IN CONCENTRATION = 21.8 pCi/L

FIGURE 1-59
PROJECTED INCREASE IN URANIUM-238 CONCENTRATION IN GREAT MIAMI AQUIFER AT 100 YEARS DUE TO LOADING FROM THE ACTIVE FLYASH PILE

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TABLE 1-39

SUMMARY OF SWIFT MODELING RESULTS FOR THE ACTIVE FLYASH PILE

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Hazard Index Screening Levels (pCi/L RAD) (μg/L non-RAD)
Radionuclides							
Neptunium-237	$3.28 \times 10^{+1}$	0	160	$1.52 \times 10^{+1}$	280	1.63×10^{-1}	2.16×10^{-2}
Plutonium-238	-[c]	0	1000	5.61×10^{-2}	-[c]	-[c]	2.16×10^{-2}
Plutonium-239/240	-[c]	0	1000	2.57×10^{-2}	-[c]	-[c]	2.07×10^{-2}
Radium-226[c]	-[c]	0	1000	3.37×10^{-1}	-[c]	-[c]	1.76×10^{-4}
Radium-228[c]	-[c]	0	1000	2.34×10^{-1}	-[c]	-[c]	4.75×10^{-2}
Strontium-90	$1.79 \times 10^{+1}$	60	100	1.02×10^{0}	160	8.92×10^{-2}	1.32×10^{-1}
Uranium-234[a]	-[a, b]	0	100	$1.98 \times 10^{+1}$	120	2.58×10^{0}	2.97×10^{-1}
Uranium-235/236[a]	-[a, b]	0	100	1.05×10^{0}	120	1.38×10^{-1}	2.97×10^{-1}
Uranium-238	$4.87 \times 10^{+2}$	0	100	$2.18 \times 10^{+1}$	120	2.85×10^{0}	1.70×10^{-1}
Uranium - Total (non-RAD)[a]	-[a, b]	0	100	$7.76 \times 10^{+1}$	120	$1.02 \times 10^{+1}$	$1.09 \times 10^{+1}$
Organics							
2-Methylnapthalene[e]	-[e]	-[e]	-[e]	$1.95 \times 10^{+0}$	-[e]	$1.95 \times 10^{+0}$	NA[d]

See footnotes at end of table.

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TABLE 1-39
(Continued)

Constituents of Potential Concern	Maximum Loading Concentration from ODAST (pCi/L RAD) (μg/L non-RAD)	Minimum Time of Arrival to the Aquifer (years)	Time of Maximum On-Site Concentration (years)	Maximum On-Site Concentration in the Aquifer (pCi/L RAD) (μg/L non-RAD)	Time of Maximum Concentration at the FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	EPA RAGs, Part B Hazard Index Screening Levels (pCi/L RAD) (μg/L non-RAD)
Inorganics							
Arsenic	NA[f]	0	1,000	7.12×10^{-2}	1,000	1.82×10^{-2}	1.46×10^{-4}
Beryllium	NA	0	1,000	2.75×10^{-3}	1,000	7.08×10^{-4}	2.37×10^{-4}
Lead	$2.87 \times 10^{+1}$	0	1,000	1.64×10^{0}	1,000	3.47×10^{-2}	NA[d]

[a]Uranium-234, uranium-235/236, and total uranium were modeled by applying ratios to uranium-238 results.
[b]ODAST results were not used for SWIFT III modeling and therefore not shown in this table.
[c]Plutonium-238, plutonium-239/240, radium-226, and radium-228, were not modeled using SWIFT III because concentrations in the Great Miami Aquifer falls below the EPA RAGs, Part B screening concentration after mixing in SWIFT III grid cell. The maximum predicted concentration based on the Storm Sewer Outfall Ditch width of 10 feet is reported as the maximum on-site concentration.
[d]NA - No data available to calculate EPA RAGs, Part B screening value for lead and 2-methylnaphthalene
[e]2-Methylnaphthalene was not modeled using ODAST/SWIFT because EPA RAGs, Part B screening value cannot be calculated. Reported concentrations are same as predicted leachate values. If concentrations are needed for risk assessment in future, ODAST/SWIFT model or equivalent should be used to calculate the concentration in the Great Miami Aquifer.
[f]NA = Not applicable because arsenic and beryllium did not have loading from the vadose zone pathway. The only loading for arsenic and beryllium was from the surface runoff pathway.

were estimated using the EPA 70-year rule (EPA 1988a). Only CPCs present in individual subunits and with non-zero background concentrations were modeled. Physical parameters, including waste size and infiltration rates, were assumed to remain at current conditions.

Solid Waste Landfill

Modeling results indicated that impact of the Solid Waste Landfill waste at background level is negligible on the Great Miami Aquifer within 1,000 years.

Lime Sludge Ponds

Modeling results indicated that the impact of the Lime Sludge Ponds waste at background level is negligible on the Great Miami Aquifer within 1,000 years. Only strontium-90, mercury, and cyanide are predicted to reach the Great Miami Aquifer within 1,000 years at non-zero concentrations. However, all are below the 10^{-7} ILCR or 0.1 HI level.

Inactive Flyash Pile and South Field

Modeling results indicated that impact of the waste at background level is negligible on the Great Miami Aquifer within 1,000 years if waste is underlain by glacial till. However, when waste at background concentrations is left in place where glacial till is not present, concentrations of certain CPCs exceed screening concentrations based on 10^{-7} ILCR level or 0.1 HI level. For example, in grid cell (30,61), where lateral drainage was simulated, uranium isotopes, total uranium, and strontium-90 concentrations exceed screening concentrations. In grid cell (29,65), which receives perched groundwater, subsurface seep water, uranium isotopes, total uranium, radium-226, and strontium-90 exceed screening concentrations.

Active Flyash Pile

Modeling indicated that impact of the flyash at background level is negligible on the Great Miami Aquifer within 1,000 years if flyash is underlain by glacial till. However, when flyash at background concentrations is left in place where glacial till is not present, concentrations of uranium isotopes, total uranium, and strontium-90 exceed screening levels. In grid cell (32,56), where lateral drainage was simulated, uranium isotopes, total uranium, strontium-90, barium, and cadmium concentrations exceed screening concentrations.

1.7.3 Summary of the Baseline Risk Assessment

A baseline risk assessment estimates the potential risk to hypothetical receptors exposed to site-related constituents, assuming no further remedial actions are taken to address identified concerns. The baseline risk assessment process uses information developed during the site investigation to:

- Determine the CPCs for Operable Unit 2.
- Assess the potential for constituent transport from Operable Unit 2 subunit-specific sources to potential human exposure points.
- Quantify potential exposures to receptors under current and future land-use scenarios.
- Characterize the nature and magnitude of potential risks, assuming no remedial action.

Operable Unit 2 contains five subunits requiring remedial decisions. In addition, risks were quantified for Operable Unit 2 as a whole. To facilitate remedial decisions for each independent subunit, risk was quantified separately for each. The specific methodology used for each subunit risk assessment was consistent across subunits and is described in detail in Appendix B of the Operable Unit 2 RI Report.

Land-use assumptions and receptors for which risk was quantified were selected to ensure that: 1) they are consistent with the Risk Assessment Work Plan Addendum (DOE 1992b) where still applicable; 2) they allow adequate quantification of risk for every contaminated or potentially contaminated medium within each subunit; and 3) they are consistent with FEMP risk assessment guidelines for exposure scenarios.

Receptors for which risk was quantified included both current and potential future receptors. Current land use receptors include:

- an off-property resident farmer (adult and child)
- a trespassing youth
- a groundskeeper
- current users of meat and milk products if livestock are allowed to graze on the property
- Great Miami River user

Future land use receptors, assuming continued federal ownership, include:

- an expanded trespasser (adult or child trespasser who routinely visits the area and is exposed to contaminants of concern)

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- an off-property resident farmer (adult and child)
- Great Miami River user

Future land use receptors, assuming private ownership, include:

- the reasonable maximum exposure (RME) on-property resident farmer receptor (adult and child)
- the central tendency (CT) on-property resident farmer (adult and child)
- the future homebuilder (for the South Field and Solid Waste Landfill only)
- the perched-groundwater user (for the Solid Waste Landfill and Lime Sludge Ponds)

The risks associated with ingestion of groundwater for the Inactive Flyash Pile, South Field, and the Active Flyash Pile were based on ingestion of Great Miami Aquifer water only. Ingestion of perched groundwater was not evaluated as a drinking water source for these subunits, because a relatively shallow well in these areas will reach the Great Miami Aquifer. It was assumed that a well designed to provide drinking water would not be placed in a perched zone, when a slightly deeper well would reach the Great Miami Aquifer. In addition to these receptors, risks to a potential future recreational user of the Great Miami River are assessed.

The carcinogenic and noncarcinogenic risks associated with each of these receptors via all media contacted are summarized in detail in the Baseline Risk Assessment (Appendix B) of the Operable Unit 2 RI Report. Total carcinogenic risk and noncarcinogenic hazard for each of the receptors is summarized by subunit in Table 1-40.

For the purpose of evaluating alternatives, Remedial Action Objectives (RAOs) focus primarily on the following three future receptors: the expanded trespasser, the off-property resident farmer, and the on-property resident RME farmer. Therefore, risks to these receptors are summarized in the subsections below.

1.7.3.1 Solid Waste Landfill

Table 1-41 summarizes risk and hazard associated with the Solid Waste Landfill for the future expanded trespasser and on- and off-property resident farmers. Total risk exceeded 1.0×10^{-6} for both future farmer receptors. The risk was primarily due to the estimated presence of naturally occurring radionuclides uranium-234 and uranium-238 in soil. Risks exceeded 1.0×10^{-3} for the RME on-property resident farmer exposed to radium-226, thorium-228, and thorium-232 in surface

TABLE 1-40

BASELINE RISK ASSESSMENT SUMMARY
OPERABLE UNIT 2 REMEDIAL INVESTIGATION
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Waste Subunit	Risk Type[a]	Current Land Use						Future Land Use Assuming Federal Ownership		
		Trespassing Youth	On-Property Groundskeeper	Off-Property Resident Farmer	Off-Property Resident Child	User of Meat and Milk	Great Miami River Recreational User	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child
Solid Waste Landfill	Carcinogenic	$1.5x10^{-5}$	$3.4x10^{-5}$	$6.0x10^{-8}$	$2.7x10^{-9}$	$9.0x10^{-9}$	$2.8x10^{-10}$	$2.0x10^{-5}$	$6.7x10^{-8}$	$3.5x10^{-9}$
	Noncarcinogenic	8.6	$4.3x10^{-3}$	$1.8x10^{-6}$	$6.4x10^{-6}$	$5.8x10^{-7}$	$1.1x10^{-7}$	$2.7x10^{-1}$	$1.8x10^{-6}$	$6.4x10^{-6}$
Lime Sludge Ponds	Carcinogenic	$1.1x10^{-5}$	$4.5x10^{-5}$	$1.5x10^{-7}$	$1.4x10^{-8}$	$1.4x10^{-6}$	NA[b]	$2.4x10^{-5}$	$1.7x10^{-7}$	$1.6x10^{-8}$
	Noncarcinogenic	$2.1x10^{-1}$	$1.3x10^{-1}$	$2.0x10^{-5}$	$9.3x10^{-5}$	$4.3x10^{-4}$	NA	$2.2x10^{-1}$	$2.0x10^{-5}$	$9.3x10^{-5}$
Inactive Flyash Pile	Carcinogenic	$1.5x10^{-5}$	$5.0x10^{-5}$	$6.1x10^{-7}$	$7.9x10^{-8}$	$1.1x10^{-7}$	$8.4x10^{-9}$	$3.0x10^{-5}$	$7.5x10^{-5}$	$4.0x10^{-6}$
	Noncarcinogenic	$1.0x10^{-1}$	$2.0x10^{-2}$	$5.5x10^{-5}$	$2.0x10^{-4}$	$1.4x10^{-5}$	$1.9x10^{-6}$	$1.0x10^{-1}$	1.2	2.5
South Field	Carcinogenic	$1.0x10^{-4}$	$2.2x10^{-4}$	$6.4x10^{-7}$	$2.4x10^{-7}$	$4.5x10^{-6}$	$4.2x10^{-6}$	$1.4x10^{-4}$	$8.7x10^{-5}$	$4.2x10^{-6}$
	Noncarcinogenic	$5.3x10^{-1}$	ND[c]	$2.0x10^{-5}$	$7.2x10^{-5}$	$3.0x10^{-5}$	$8.0x10^{-7}$	$8.0x10^{-2}$	1.1	3.1
Active Flyash Pile	Carcinogenic	$2.6x10^{-5}$	$8.0x10^{-5}$	$4.7x10^{-7}$	$6.6x10^{-8}$	$4.7x10^{-7}$	$1.37x10^{-9}$	$4.9x10^{-5}$	$1.1x10^{-5}$	$7.2x10^{-7}$
	Noncarcinogenic	$3.6x10^{-2}$	$5.9x10^{-2}$	$6.2x10^{-4}$	$2.1x10^{-3}$	$3.7x10^{-3}$	$6.1x10^{-6}$	$4.2x10^{-2}$	$1.9x10^{-1}$	$7.9x10^{-1}$

See footnotes at end of table

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TABLE 1-40
(Continued)

Waste Subunit	Risk Type[a]	Future Land Use Assuming Private Ownership							
		On-Property Resident Farmer (RME)[d]	On-Property Resident Farmer (CT)[e]	On-Property Resident Child	Home Builder	Perched Groundwater User	Great Miami River Recreational User	Great Miami River Residential User	Great Miami River Agricultural User
Solid Waste Landfill	Carcinogenic	$2.8x10^{-3}$	$2.0x10^{-4}$	$6.4x10^{-4}$	$9.0x10^{-6}$	$2.8x10^{-3}$	$2.8x10^{-10}$	$4.2x10^{-9}$	$6.5x10^{-7}$
	Noncarcinogenic	$2.9x10^{-1}$	$1.2x10^{-1}$	1.0	$4.8x10^{-1}$	ND	$1.1x10^{-7}$	$2.2x10^{-6}$	$1.1x10^{-4}$
Lime Sludge Ponds	Carcinogenic	$1.3x10^{-5}$	$9.3x10^{-7}$	$1.2x10^{-6}$	NA	$7.7x10^{-5}$	NA	NA	NA
	Noncarcinogenic	$1.7x10^{-3}$	$7.3x10^{-4}$	$7.9x10^{-3}$	NA	$3.1x10^{-3}$	NA	NA	NA
Inactive Flyash Pile	Carcinogenic	$1.5x10^{-3}$	$8.6x10^{-5}$	$7.7x10^{-5}$	NA	NA	$8.4x10^{-9}$	$3.0x10^{-9}$	$5.4x10^{-10}$
	Noncarcinogenic	22	9.8	65	NA	NA	$1.9x10^{-6}$	$4.2x10^{-6}$	$3.6x10^{-5}$
South Field	Carcinogenic	$3.4x10^{-2}$	$2.0x10^{-3}$	$9.2x10^{-3}$	$1.1x10^{-5}$	NA	$4.2x10^{-6}$	$6.3x10^{-8}$	$4.2x10^{-6}$
	Noncarcinogenic	23	11	63	$5.4x10^{-1}$	NA	$2.5x10^{-6}$	$1.4x10^{-4}$	$4.0x10^{-5}$
Active Flyash Pile	Carcinogenic	$8.4x10^{-5}$	$4.8x10^{-6}$	$5.7x10^{-6}$	NA	NA	$1.4x10^{-9}$	$7.7x10^{-9}$	$3.5x10^{-9}$
	Noncarcinogenic	$9.9x10^{-1}$	$4.5x10^{-1}$	2.8	NA	NA	$6.1x10^{-6}$	$1.5x10^{-5}$	$6.7x10^{-6}$

[a]The carcinogenic risk value is the incremental lifetime cancer risk (ILCR) and the noncarcinogenic hazard value is the Hazard Index (HI).

[b]NA = the indicated land use is not applicable to the waste subunit.

[c]ND = not determined because toxicity data are not available.

[d]RME = reasonable maximum exposure.

[e]CT = central tendency.

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TABLE 1-41

SOLID WASTE LANDFILL FUTURE LAND USE
SUMMARY OF COC CARCINOGENIC RISK CONTRIBUTIONS[a,b]

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	Great Miami River User	% Total Receptor Risk
Soil:								
Neptunium-237	-[c]	-	2.3E-05	0.82	1.9E-06	0.95	NA[d]	
Plutonium-238	-	-	-	-	-	-	NA	
Radium-226	3.8E-06	18.96	3.5E-04	12.91	2.9E-05	15.03	NA	
Radium-228	2.2E-06	10.92	2.0E-04	7.41	1.7E-05	8.66	NA	
Thorium-228	41.E-06	20.43	3.8E-04	13.89	3.2E-05	16.40	NA	
Thorium-230	-	-	-	-	-	-	NA	
Thorium-232	5.8E-06	28.74	5.4E-04	19.33	4.5E-05	22.86	NA	
Uranium-234	-	-	1.5E-05	0.53	-	-	NA	
Uranium-235/236	-	-	2.9E-05	1.05	2.4E-06	1.24	NA	
Uranium-238	1.4E-06	6.76	1.7E-04	6.03	1.3E-05	6.76	NA	
Arsenic	-	-	3.0E-05	1.09	-	-	NA	
Benzo(a)anthracene	-	-	-	-	-	-	NA	
Beryllium	-	-	-	-	-	-	NA	
Benzo(b)-fluoranthene	-	-	-	-	-	-	NA	
Dibenzo(a,h)-anthracene	-	-	-	-	-	-	NA	
Indeno(1,2,3-cd)pyrene	-	-	-	-	-	-	NA	
Perched Groundwater:								
Technetium-99	NA		NA		NA		NA	
Carbazole	NA		NA		NA		NA	
Home Grown Produce (Dust Affected):								
Neptunium-237	NA		3.4E-06	0.12	-	-	NA	
Radium-226	NA		2.1E-06	0.08	-	-	NA	
Strontium-90	NA		1.1E-05	0.40	-	-	NA	
Uranium-234	NA		3.5E-06	0.13	-	-	NA	
Uranium-238	NA		1.1E-05	0.40	-	-	NA	

See footnotes at end of table.

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TABLE 1-41
(Continued)

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	Great Miami River User	% Total Receptor Risk
Home Grown Produce (Dust Affected): (continued)								
Arsenic	NA		5.1E-06	1.82	2.8E-06	1.42	NA	
Benzo(a)anthracene	NA		4.0E-06	0.14	-	-	NA	
Benzo(a)pyrene	NA		2.1E-05	0.74	1.1E-06	0.58	NA	
Benzo(b)fluoranthene	NA		4.2E-06	0.15	-	-	NA	
Beryllium	NA		3.3E-06	0.12	-	-	NA	
Dibenzo(a,h)anthracene	NA		4.5E-06	0.17	-	-	NA	
Indeno(1,2,3-cd)pyrene	NA		1.5E-06	0.06	-	-	NA	
Beef/Milk (Dust Affected):								
Radium-226	NA		-	-	-	-	NA	
Strontium-90	NA		5.0E-05	1.80	2.3E-06	1.16	NA	
Uranium-234	NA		-	-	-	-	NA	
Uranium-238	NA		9.6E-06	0.34	-	-	NA	
Arsenic	NA		6.7E-05	2.42	3.8E-06	1.94	NA	
Benzo(a)anthracene	NA		1.1E-05	0.39	-	-	NA	
Benzo(a)pyrene	NA		2.0E-04	7.04	9.9E-06	5.03	NA	
Benzo(b)fluoranthene	NA		4.2E-05	1.51	2.1E-06	1.08	NA	
Beryllium	NA		-	-	-	-	NA	
Dibenzo(a,h)anthracene	NA		4.2E-04	15.17	2.1E-05	10.85	NA	
Indeno(1,2,3-cd)pyrene	NA		6.2E-05	2.24	3.1E-06	1.61	NA	
Ambient Radon	-	-	1.4E-06	0.05	-	-	NA	

See footnotes at end of table.

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TABLE 1-41
(Continued)

Medium/ Parameter	On-Property Resident Child	Total Receptor Risk	Homebuilder	Total Receptor Risk	Perched Groundwater User	% Total Receptor Risk	Perched Groundwater Child	% Total Receptor Risk
Soil:								
Neptunium-237	1.7E-06	0.27	-	-	2.3E-05	0.083	NA	
Plutonium-238	-	-	-	-	-	-	NA	
Radium-226	2.7E-05	4.18	-	-	3.5E-04	12.73	NA	
Radium-228	1.5E-05	2.39	-	-	2.4E-04	7.30	NA	
Thorium-228	2.9E-05	4.48	1.1E-06	12.25	3.8E-04	13.70	NA	
Thorium-230	-	-	-	-	-	-	NA	
Thorium-232	4.0E-05	6.30	1.8E-06	19.83	5.4E-04	19.28	NA	
Uranium-234	-	-	-	-	-	-	NA	
Uranium-235/236	2.2E-06	0.04	-	-	2.9E-05	1.05	NA	
Uranium-238	1.0E-05	1.62	-	-	1.7E-04	6.02	NA	
Arsenic	1.3E-05	2.04	-	-	3.0E-05	1.09	NA	
Benzo(a)anthracene	-	-	-	-	-	-	NA	
Benzo(b)-fluoranthene	-	-	-	-	-		NA	
Beryllium	6.6E-06	1.03	-	-	-	-	NA	
Benzo(a)pyrene	5.4E-06	0.86	2.7E-06	30.05	-	-	NA	
Dibenzo(a,h)-anthracene	3.2E-06	0.50	-	-	-	-	NA	
Indeno(1,2,3-cd)pyrene	-	-	-	-	-	-	NA	
Perched Groundwater:								
Technetium-99	NA		NA		1.8E-06	0.07	NA	
Carbazole	NA		NA		5.3E-03	0.19	NA	
Home Grown Produce (Dust Affected):								
Neptunium-237	-	-	NA		3.4E-06	0.12	NA	
Radium-226	-	-	NA		2.1E-06	0.08	NA	
Strontium-90	-	-	NA		1.1E-05	0.40	NA	
Uranium-234	-	-	NA		3.5E-06	0.13	NA	
Uranium-238	-	-	NA		1.1E-05	0.40	NA	

See footnotes at end of table.

TABLE 1-41
(Continued)

Medium/ Parameter	On-Property Resident Child	Total Receptor Risk	Homebuilder	Total Receptor Risk	Perched Groundwater User	% Total Receptor Risk	Perched Groundwater Child	% Total Receptor Risk
Home Grown Produce (Dust Affected): (continued)								
Arsenic	1.7E-05	2.61	5.1E-05	1.82	NA		NA	
Benzo(a)anthracene	1.7E-06	0.21	4.0E-06	0.14	NA		NA	
Benzo(a)pyrene	1.3E-06	1.06	2.1E-05	0.74	NA		NA	
Benzo(b)fluoranthene	6.8E-06	0.22	4.2E-06	0.15	NA		NA	
Beryllium	1.4E-06	0.17	3.3E-06	0.12	NA		NA	
Dibenzo(a,h)anthracene	1.1E-06	0.23	4.5E-06	0.16	NA		NA	
Indeno(1,2,3-cd)pyrene	-	-	1.5E-06	0.06	NA		NA	
Beef/Milk (Dust Affected):								
Radium-226	-	-	NA		-	-	NA	
Strontium-90	9.3E-06	1.46	NA		5.0E-05	1.79	NA	
Uranium-234	-	-	NA		-	-	NA	
Uranium-238	-	-	NA		9.6E-06	0.34	NA	
Arsenic	1.6E-05	2.48	NA		6.7E-05	2.42	NA	
Benzo(a)anthracene	6.6E-06	0.98	NA		1.1E-05	0.39	NA	
Benzo(a)pyrene	1.1E-04	17.63	NA		2.0E-04	7.02	NA	
Benzo(b)fluoranthene	2.4E-05	3.80	NA		4.2E-05	1.51	NA	
Beryllium	-	-	NA		-	-	NA	
Dibenzo(a,h)anthracene	2.4E-04	3.99	NA		4.2E-04	15.13	NA	
Indeno(1,2,3-cd)pyrene	3.6E-05	5.62	NA		6.2E-05	2.24	NA	
Ambient Radon	-	-	NA		1.4E-06	0.05	NA	

[a]Off-property resident farmer and child receptors did not have any COCs associated with them and, therefore, were not included in this table.
[b]Sediment, groundwater, surface water, home grown produce (groundwater affected), perched groundwater, beef/milk (groundwater and surface water affected) pathways did not have any COCs associated with them and, therefore, were not included in this table.
[c]No risk greater than the threshold level of 1×10^{-6}.
[d]NA signifies that exposure of the receptor to the indicated medium is not applicable.

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soil, and benzo(a)pyrene and dibenzo(a,h)anthracene in dust-affected milk. Risk exceeded the 1.0 x 10^{-4} level for the on-property resident child exposed to the same contaminants as the RME farmer. Total HI levels exceeded 1.0 only for the future on-property resident child, due mostly to arsenic in soil and dust-affected homegrown produce and beef and milk products.

1.7.3.2 Lime Sludge Ponds

Table 1-42 summarizes risks and hazards associated with Lime Sludge Ponds for the future expanded trespasser and the on- and off-property resident farmers. Risks due to groundwater did not exceed 1.0 x 10^{-6}. Risks associated with the expanded trespasser exceeded 1.0 x 10^{-5}, due primarily to direct contact with surface soil containing radium-226, thorium-228, and thorium-232. Risks associated with the RME farmer receptors exceeded 1.0 x 10^{-5}, due mostly to the presence of the same compounds in surface soil. Total HI levels for future receptors were less than 1.0.

1.7.3.3 Inactive Flyash Pile

Table 1-43 summarizes the risks and hazards associated with the Inactive Flyash Pile for the future expanded trespasser and on- and off-property resident farmers.

The largest carcinogenic risk, which slightly exceeded 1.0 x 10^{-3}, was associated with groundwater use by the RME farmer. Total risk for this receptor was 1.5 x 10^{-3} due mostly to the future estimated concentrations of uranium-234 and uranium-238 in groundwater and irrigated produce, beef, and milk. HI levels greater than 1.0 were associated with ingestion of groundwater and homegrown produce contaminated with total uranium by the on-property residents.

1.7.3.4 South Field

Table 1-44 summarizes the risks associated with the South Field for the future expanded trespasser and on- and off-property resident farmers. The greatest risk, which was 3.4 x 10^{-2}, was associated with the RME on-property resident farmer. Risks to the off-property resident farmer via contact with groundwater, beef, milk, and homegrown produce were in the 1.0 x 10^{-5} to 1.0 x 10^{-2} range. A proportion of the risks to farmer receptors for each of these pathways was attributable to the future estimated concentrations of uranium-234 and uranium-238 in groundwater and, consequently, in irrigated produce and beef and milk from livestock watered with contaminated groundwater. The on-property resident farmer had major additional risk from the presence of radium-228, thorium-228, and PAHs in surface soil. Exposures resulting in HI levels greater than 1.0 for on- and off-property

TABLE 1-42

LIME SLUDGE PONDS
FUTURE LAND USE
SUMMARY OF COC TOTAL CARCINOGENIC RISK CONTRIBUTIONS[a,b]

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Soil:						
Cesium-137	-[c]	-	-	-	-	-
Radium-226	5.2E-06	21.66	-	-	-	-
Radium-228	2.1E-06	8.88	-	-	-	-
Thorium-228	7.3E-06	30.44	-	-	-	-
Thorium-230	-	-	-	-	2.3E-06	16.94
Thorium-232	5.0E-06	20.81	-	-	-	-
Uranium-238	1.5E-06	6.37	-	-	6.4E-06	48.39
Perched Groundwater:						
Neptunium-237	-	-	-	-	-	-
Strontium-90	-	-	-	-	-	-
Technetium-99	-	-	-	-	-	-

[a]Perched groundwater user, off-property resident child, and perched groundwater child receptors do not have any COCs and are not included in this table.

[b]Sediment, groundwater, surface water, perched groundwater, home grown produce (dust and groundwater affected), and beef/milk (dust and groundwater affected) pathways do not have any COCs associated with them and, therefore, are not included in this table.

[c]No risk greater than the threshold level of 1×10^{-6}.

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TABLE 1-43

INACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF COC CARCINOGENIC RISK CONTRIBUTIONS[a,b]

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer[e]	% Total Receptor Risk	Great Miami River User	% Total Receptor Risk
Soil:						
Radium-226	5.4E-06	17.88	-[c]	-	NA	
Radium-228	2.9E-06	9.71	-	-	NA	
Thorium-228	6.8E-06	22.65	-	-	NA	
Thorium-232	8.9E-06	29.58	-	-	NA	
Arsenic	2.0E-06	6.52	-	-	NA	
Groundwater:						
Uranium-234	NA[d]		1.9E-05	24.98	NA	
Uranium-235/236	NA		1.0E-06	1.33	NA	
Uranium-238	NA		3.6E-05	48.26	NA	
Homegrown Produce (Groundwater Affected)						
Uranium-234	NA		5.7E-06	7.53	NA	
Uranium-238	NA		1.1E-05	14.54	NA	
Beef/Milk (Dust Affected)						
Dibenzo(a,h)anthracene	NA		-	-	NA	
Beef/Milk (Groundwater Affected):						
Uranium-234	NA		-	-	NA	
Uranium-238	NA		1.1E-06	1.42	NA	
Ambient Radon:	-	-	-	-	NA	

See footnotes at end of table.

TABLE 1-43
(Continued)

Medium/ Parameter	Off-Property Resident Child[f]	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk
Soil:								
Radium-226	-	-	-	-	-	-	-	-
Radium-228	-	-	-	-	-	-	-	-
Thorium-228	-	-	-	-	-	-	-	-
Thorium-232	-	-	-	-	-	-	-	-
Arsenic	-	-	-	-	-	-	-	-
Groundwater:								
Uranium-234	-	-	3.7E-04	25.06	2.2E-05	25.67	1.6E-05	20.34
Uranium-235/236	-	-	2.0E-05	1.34	1.2E-06	1.37	-	-
Uranium-238	1.6E-06	39.01	7.1E-04	48.33	4.3E-05	49.53	3.0E-05	39.23
Homegrown Produce (Groundwater Affected)								
Uranium-234	NA		1.1E-04	7.55	6.1E-06	7.07	7.8E-06	10.09
Uranium-238	NA		2.1E-04	14.57	1.2E-05	13.63	1.5E-05	19.46
Beef/Milk (Dust Affected):								
Dibenzo(a,h)anthracene	-	-	-	-	-	-	1.06E-06	1.29
Beef/Milk (Groundwater Affected):								
Uranium-234	-	-	1.1E-05	0.74	-	-	2.0E-06	2.54
Uranium-238	-	-	2.1E-05	1.42	-	-	3.8E-06	4.90
Ambient Radon	-	-	4.2E-06	5.48	-	-	-	-

[a]Sediment, surface water, home grown produce (dust and groundwater affected), and beef/milk (dust affected) pathways do not have any COCs associated with them and, therefore, were not included in this table.
[b]Great Miami River user (adult) and Great Miami River user (youth) receptors did not have any COCs associated with them and, therefore, were not included in this table.
[c]No risk greater than the threshold level of 1×10^{-6}.
[d]NA signifies that exposure of the receptor to the indicated medium is not applicable.
[e]The off-property resident farmer under both federal ownership and private ownership has the same risk.
[f]The off-property resident child under both federal ownership and private ownership has the same risk.

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TABLE 1-44

SOUTH FIELD
FUTURE LAND USE
SUMMARY OF COC CARCINOGENIC RISK CONTRIBUTIONS[a,b]

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	Off-Property Resident Child	% Total Receptor Risk	Great Miami River Recreational User	% Total Receptor Risk	Great Miami River Agricultural User	% Total Receptor Risk
Soil:										
Radium-226	8.3E-05	59.89	-	-	-	-	NA		NA	
Radium-228	5.0E-06	3.62	-	-	-	-	NA		NA	
Thorium-228	1.1E-05	7.94	1.0E-06	0.97	-	-	NA		NA	
Thorium-230	-	-	1.2E-06	1.13	-	-	NA		NA	
Thorium-232	1.5E-05	10.91	1.3E-06	1.24	-	-	NA		NA	
Arsenic	-	-	-	-	-	-	NA		NA	
Benzo(a)pyrene	3.3E-06	2.36	-	-	-	-	NA		NA	
Sediment:										
Radium-226	1.3E-05	9.51	NA		NA		NA		NA	
Groundwater:										
Uranium-234	-	-	1.9E-05	17.55	-	-	NA		NA	
Uranium-235/236	-	-	1.0E-06	0.94	-	-	NA		NA	
Uranium-238	-	-	3.6E-05	33.91	1.6E-06	10.39	NA		NA	
Surface Water:										
Radium-226	NA		NA		NA		1.3E-06	30.40	NA	
Technetium-99	NA		NA		NA		2.0E-06	46.33	NA	
Uranium-238	NA		NA		NA		4.1E-06	97.31	NA	
Home Grown Produce (Dust Affected):										
Benzo(a)pyrene	NA		1.5E-06	1.42	-	-	NA		NA	

See footnotes at end of table.

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TABLE 1-44
(Continued)

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	Off-Property Resident Child	% Total Receptor Risk	Great Miami River Recreational User	% Total Receptor Risk	Great Miami River Agricultural User	% Total Receptor Risk
Home Grown Produce (Groundwater Affected):										
Uranium-234	NA		5.7E-06	5.29	-	-	NA		NA	
Uranium-238	NA		1.1E-05	10.22	-	-	NA		NA	
Beef/Milk (Dust Affected):										
Aroclor-1260	NA		1.8E-06	1.71	1.1E-06	7.03	NA		NA	
Benzo(a)pyrene	NA		6.1E-06	5.73	3.5E-06	23.57	NA		NA	
Dibenzo(a,h)anthracene	NA		6.8E-06	6.32	3.9E-06	26.00	NA		NA	
Indeno(1,2,3-cd)pyrene	NA		1.2E-06	1.08	-	-	NA		NA	
Beef/Milk (Groundwater Affected):										
Technetium-99	NA		NA		NA		4.3E-06	97.31	4.3E-06	97.31
Uranium-238	NA		1.1E-06	1.00	-	-	NA		-	-
Ambient Radon	1.9E-06	1.39	4.4E-06	5.06						

See footnotes at end of table.

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TABLE 1-44
(Continued)

Medium/ Parameter	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk	Homebuilder	% Total Receptor Risk
Soil:								
Radium-226	7.8E-03	23.18	6.5E-04	31.68	5.9E-04	6.34	2.6E-06	22.44
Radium-228	4.7E-04	1.40	3.9E-05	1.92	3.5E-05	0.38	1.6E-06	13.85
Thorium-228	1.0E-03	3.10	8.7E-05	4.25	7.7E-05	0.84	2.1E-06	18.66
Thorium-232	1.4E-03	4.25	1.2E-04	5.84	1.1E-04	1.15	1.1E-06	9.46
Arsenic	3.3E-05	0.11	1.7E-06	0.08	1.4E-05	0.15	-	-
Beryllium	2.0E-05	0.06	-	-	8.9E-06	0.10	-	-
Chromium	1.3E-05	0.35	-	-	1.1E-06	0.25	-	-
Benzo(a)pyrene	3.4E-04	1.03	1.6E-05	0.80	1.5E-04	1.63		
Dibenzo(a,h)-anthracene	6.9E-05	0.21	3.2E-06	0.16	3.0E-05	0.33		
Sediment:	NA		NA		NA			
Groundwater:								
Uranium-234	3.7E-04	1.09	2.2E-05	1.08	1.6E-05	0.17		
Uranium-235/236	2.0E-05	0.06	1.2E-06	0.06	-	-		
Uranium-238	7.1E-04	2.11	4.3E-05	2.09	3.0E-05	0.33		
Home Grown Produce (Dust Affected):								
Radium-226	4.7E-05	0.14	2.6E-06	0.13	3.3E-06	0.04		
Strontium-90	1.9E-05	0.06	1.0E-06	0.05	1.3E-06	0.01		
Technetium-99	3.6E-04	1.06	2.0E-05	0.96	2.5E-05	0.27		
Arsenic	5.5E-05	0.16	3.0E-06	0.15	1.8E-05	0.20		
Benzo(a)anthracene	6.0E-05	0.18	3.0E-06	0.16	2.0E-05	0.21		
Benzo(a)pyrene	5.7E-04	1.70	3.1E-05	1.53	1.9E-04	2.02		
Benzo(b)fluoranthene	3.7E-05	0.11	2.0E-06	0.10	1.2E-05	0.13		
Dibenzo(a,h)anthracene	4.3E-05	0.13	2.4E-06	0.12	1.4E-05	0.15		
Dieldrin	2.5E-04	0.75	1.4E-05	0.68	8.3E-05	0.90		
Indeno(1,2,3-cd)pyrene	1.9E-05	0.06	1.1E-05	0.05	6.3E-06	0.07		

See footnotes at end of table.

TABLE 1-44
(Continued)

Medium/ Parameter	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk	Homebuilder	% Total Receptor Risk
Home Grown Produce (Groundwater Affected):								
Uranium-234	1.1E-04	0.33	6.1E-06	0.30	7.8E-06	0.08		
Uranium-235/236	5.9E-06	0.02	-	-	-	-		
Uranium-238	2.1E-04	0.64	1.2E-06	0.57	1.5E-05	0.16		
Beef/Milk (Dust Affected):								
Benzo(a)pyrene	1.2E-05	0.31	-	-	6.7E-06	1.50		
Benzo(b)-fluoranthene	3.7E-06	0.10	-	-	2.1E-06	0.47		
Benzo(k)-fluoranthene	3.7E-06	0.10	-	-	2.2E-06	0.48		
Dibenzo(a,h)-anthracene	2.6E-06	0.07	-	-	1.5E-06	0.33		
Indeno(1,2,3-cd)pyrene	9.8E-05	2.60	5.9E-06	1.89	5.6E-05	12.54		
Beef/Milk (Groundwater Affected):								
Uranium-234	6.4E-06	0.17	-	-	1.2E-06	0.26		
Uranium-238	1.2E-05	0.33	-	-	2.3E-06	0.50		

[a]Homebuilder, Great Miami River user (adult), and Great Miami River user (youth) receptors did not have any COCs associated with them and, therefore, were not included in this table.
[b]Surface water pathway did not have any COCs associated with carcinogenic risk and, therefore, were not inlcuded in this table.
[c]No risk greater then the threshold level of 1×10^{-6}.
[d]NA signifies that exposure of the receptor to the indicated medium is not applicable.

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resident farmer receptors were due to the estimated future presence of the total uranium in groundwater.

1.7.3.5 Active Flyash Pile

Table 1-45 summarizes carcinogenic and noncarcinogenic risks and hazards associated with the Active Flyash Pile for the future expanded trespasser and on- and off-property resident farmer receptors. The largest risks are from direct contact with soil or surface flyash material. Total estimated risks to the expanded trespasser slightly exceed 1.0×10^{-3}, due mostly to the estimated presence of radium-226, radium-228, thorium-228, thorium-232, neptunium-237, and arsenic in flyash material.

Total estimated risk to the off-property resident farmer exceeded 1.0×10^{-5}, due mostly to direct exposure to the estimated future concentration of uranium-234 and uranium-238 in groundwater. The estimated presence of strontium-90 in flyash material deposited on homegrown produce also contributed to the total risk to this receptor. Total estimated risk and hazard to the users of the Great Miami River were on the order of 1.0×10^{-9}.

Total estimated risks to future on-property residents were greatest for the RME farmer. Total risk to this receptor was 1.9×10^{-3}, due mostly to the presence of uranium-234 and uranium-238 in groundwater, which accounted for 54.4 percent of the total receptor risk. Contributions to risk of homegrown produce for this receptor are 23.7 percent of the total receptor risk, primarily from arsenic in dust-affected produce, and strontium-90 and radium-226 in groundwater-affected produce.

The only receptor associated with total HI levels greater than 1.0 is the future on-property RME child. Total HI for the future on-property resident child is 2.8, due mostly to the presence of total uranium in groundwater, which accounted for 62.1 percent of the total receptor risk, and total uranium in groundwater-affected produce, which accounted for an additional 29.6 percent of the total receptor risk.

1.7.3.6 Comparison with Natural Background

All subunit-specific risks in the risk assessment are total risks, including the potential contribution from natural background concentrations of CPCs. In many cases, the concentrations of CPCs in soil at Operable Unit 2 waste areas are only slightly above natural background concentrations; however, the ILCRs and HIs for these site-related concentrations are often greater than 1.0×10^{-4} and 1.0,

TABLE 1-45

ACTIVE FLYASH PILE
FUTURE LAND USE
SUMMARY OF COC TOTAL CARCINOGENIC RISK CONTRIBUTIONS[a,b]

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer[c]	% Total Receptor Risk
Soil:				
Neptunium-237	1.1E-06	2.22	-[d]	-
Radium-226	1.2E-05	25.25	-	-
Radium-228	4.1E-06	8.33	-	-
Thorium-228	9.6E-06	19.33	-	-
Thorium-232	1.0E-05	20.60	-	-
Arsenic	5.3E-06	10.75	-	-
Sediment:				
Radium-226	2.0E-06	4.00	NA	
Arsenic	1.0E-06	2.11	NA	
Groundwater:				
Uranium-234	NA[e]		2.0E-06	18.74
Uranium-238	NA		3.9E-06	36.24
Home Grown Produce (Dust Affected):				
Arsenic	NA		-	-
Home Grown Produce (Groundwater Affected):				
Strontium-90	NA		1.6E-06	14.61
Ambient Radon	-		-	

See footnotes at end of table.

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TABLE 1-45
(Continued)

Medium/ Parameter	On-Property Resident Farmer (RME)	% Total Receptor Risk	On-Property Resident Farmer (CT)	% Total Receptor Risk	On-Property Resident Child	% Total Receptor Risk
Soil:	-	-	-	-		
Neptunium-237	-	-	-	-		
Radium-226	-	-	-	-		
Radium-228	-	-	-	-		
Thorium-228	-	-	-	-		
Arsenic	-	-	-	-		
Beryllium	-	-	-	-		
Sediment:						
Neptunium-237	NA	-	-	-	-	-
Radium-228	NA	-	-	-	-	-
Thorium-228	NA	-	-	-	-	-
Groundwater:						
Uranium-234	1.6E-05	18.58	-	-	-	-
Uranium-238	3.0E-05	35.81	1.8E-06	37.25	1.3E-06	22.41
Home Grown Produce (Dust Affected):						
Arsenic	1.2E-06	1.43	-	-	-	-
Home Grown Produce (Groundwater Affected):						
Radium-226	6.5E-06	7.81	-	-	-	-
Strontium-90	1.2E-05	14.49	-	-	-	-
Uranium 235/236	5.2E-06	6.17	-	-	-	-
Beef/Milk (Groundwater Affected):						
Strontium-90	6.0E-06	7.22	-	-	1.1E-06	19.69
Ambient Radon	1.5E-06		-		-	

TABLE 1-45
(Continued)

[a]Surface water, home grown produce (groundwater affected), and beef/milk (dust affected) pathways do not have any COCs associated with them, and, therefore, were not included in this table.

[b]Great Miami River user (adult) and Great Miami River user (youth) receptors did not have any COCs associated with them, and, therefore, were not included in this table.

[c]Off-property resident farmer under private ownership and federal ownership pose the same risk.

[d]No risk greater than the threshold level of 1×10^{-6}.

[e]NA signifies that exposure of the receptor to the indicated medium is not applicable.

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respectively. Background contributions provide a useful point of comparison for subunit-specific risk estimates. Therefore, ILCR and HI levels were calculated for the RME on-property resident farmer using background concentrations in soil and groundwater (modeled from background-equivalent source terms). Exposure assumptions and models used for these background calculations are the same as those used for evaluating subunit-specific risks to the RME on-property resident farmer. The results of these risk calculations are summarized in Section 6.3.7 of the Operable Unit 2 RI Report.

1.8 OPERABLE UNIT 2 CERCLA ACTIONS

Removal Site Evaluations (RSEs) and removal actions are CERCLA actions that are performed before the final remediation is implemented to protect the public health, welfare, or the environment from a release or threat of release of hazardous substances. A RSE is conducted to determine if a removal action is warranted. This section discusses the RSE and removal actions that were conducted at the Operable Unit 2 subunits.

1.8.1 Firing Range Removal Site Evaluation

A RSE was conducted to assess lead contamination at the South Field Firing Range and to determine whether the nature and extent of contamination warranted a removal action. In January and February 1992, vertical and horizontal borings were completed in the western embankment of the South Field, just east of the FEMP running track/firing range. It was determined from the sampling results that a removal action was not necessary.

1.8.2 Active Flyash Control Removal Action (Removal No. 10)

The objective of the Active Flyash Pile Control Removal Action, a time-critical removal action, was to mitigate the wind and water erosion of the Active Flyash Pile. This was accomplished by implementing the following controls: (1) A silt trap made from permeable geotextile fabric was installed around the entire perimeter of the pile at the toe of the slope. (2) A wind barrier made from high-density polyethylene was installed around the top perimeter of the flyash pile. (3) The active working surface was altered to minimize the noncompacted area and to prevent an increase in the maximum height of the existing pile. (4) The outer berm received minor regrading, and the nonworking top surfaces of the flyash pile were compacted. (5) Water, foam, and binding-type dust-control agents were applied on side slopes and top. (6) Periodic inspection and necessary maintenance identified during inspection were performed. Planning and design of the removal action

began in December 1991, and implementation was completed in June 1992. Periodic routine inspections and necessary maintenance are ongoing.

1.8.3 Inactive Flyash Pile/South Field Disposal Area Control Removal Action (Removal No. 8)

The Inactive Flyash Pile/South Field Disposal Area Control Removal Action consisted of installing ropes, fences, and warning signs around the perimeter of these waste areas to control access. During the course of the removal action, walk-over radiation surveys were conducted over the entire area to define locations that should be delineated as regulated areas. Implementation began in September 1991. Phase I of the activities, which included fencing and roping the areas to be controlled, was completed in December 1991. Phase II, which included surveying the area for additional hot spots, was completed on June 30, 1992.

1.8.4 Paddys Run Erosion Control Removal Action

A time-critical removal action was implemented in Paddys Run to stabilize the bank adjacent to the Inactive Flyash Pile. Continued erosion of the bank could have undermined the Inactive Flyash Pile's western slope and resulted in a discharge of contamination into Paddys Run.

During late April and early May 1993, the slope was improved by installing a weighted berm to address the erosion problem. This interim action constituted Phase I of the removal action. Phase II was completed during September 1993, when additional riprap stone was installed at the top and toe of the weighted berm. The additional height was sufficient to cover the exposed soil face adjacent to Paddys Run, and toe protection was added to ensure the long-term stability of the berm.

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2.0

2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

2.1 INTRODUCTION

This section develops Remedial Action Objectives (RAOs) for the Operable Unit 2 FS. RAOs are medium-specific goals that define the objectives of remedial actions to protect human health and the environment and comply with applicable or relevant and appropriate requirements (ARARs). According to the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) (40 CFR §300.430(e)(1)(i)), RAOs should specify the media and contaminants of concern (COCs), potential exposure pathways, and remediation goals. Identifying exposure pathways is important because protectiveness can be achieved by reducing or eliminating exposure routes, as well as by reducing contaminant levels.

General RAOs were identified for Operable Unit 2 in Section 7.0 of the RI Report. The objectives for protection of human health were the most stringent of the following:

- Prevent direct contact with, inhalation of, external radiation from, or ingestion of waste material/contaminated soil in excess of the NCP incremental lifetime cancer risk (ILCR) range of 10^{-4} to 10^{-6}.
- Prevent leaching of waste material/contaminated soil that would result in soil concentrations in excess of the NCP ILCR range of 10^{-4} to 10^{-6}.
- Prevent leaching of waste material/contaminated soil that would result in perched water and groundwater concentrations in excess of the NCP ILCR range of 10^{-4} to 10^{-6}.
- Prevent exposures to waste materials/contaminated soil that could cause an individual to exceed annual dose limits of 25 mrem/yr whole body, 75 mrem/yr to the thyroid, and 25 mrem/yr to any other organ.
- Prevent exposures to waste material/contaminated soil that could cause an individual to exceed a 100 mrem/yr effective dose equivalent, above background, from all exposure routes.

For environmental protection, the RI Report identified the following general RAOs:

- Prevent leaching of waste material that would result in groundwater concentrations in excess of the ARARs.
- Prevent release or leaching of waste material/contaminated soil that would result in surface water concentrations in excess of the ARARs.

Based on the definition of Operable Unit 2 in the 1991 Amended Consent Agreement (ACA), the media that must be addressed by the RAOs are the waste material and contaminated soil contained within the battery limits of the Solid Waste Landfill, Lime Sludge Ponds, Active Flyash Pile, South Field, and Inactive Flyash Pile. Other impacted environmental media (e.g., perched groundwater, Great Miami Aquifer, Paddys Run, and sediment) are defined in the 1991 ACA to be a part of Operable Unit 5.

These general RAOs serve as the framework for the remainder of the Operable Unit 2 FS and are utilized during the evaluation of remedial technologies and process options that will be developed into preliminary remedial alternatives. The development of specific RAOs for Operable Unit 2 is presented in five steps: (1) identification of COCs with respect to media exposure routes (Section 2.2); (2) identification of ARARs that address either the COCs, proposed actions, or the location of the waste (Section 2.3); (3) development of preliminary remediation goals (PRGs) (Section 2.4); (4) an example of PRG/PRL development (Section 2.5); and (5) development of specific RAOs for Operable Unit 2 COCs based on the PRLs (Section 2.6).

2.2 IDENTIFICATION OF CONTAMINANTS OF CONCERN

COCs are contaminants that remain a concern at the end of the baseline risk assessment process. The Baseline Risk Assessment (Section 6.0 and Appendix B of the RI Report) evaluates the risk to future receptors if no remedial action is taken at the Operable Unit 2 subunits.

Table 2-1 lists, by media, the Operable Unit 2 COCs for future land-use scenarios. To facilitate development of remedial alternatives in this FS, the list combines COCs by medium, not by pathway, as presented in the Operable Unit 2 RI Report. COCs are defined as the contaminants that pose greater than 1×10^{-6} ILCR or a hazard index (HI) of 0.2. With the exception of uranium at the Solid Waste Landfill and Lime Sludge Ponds, all of the COCs listed in Table 2-1 were determined in the Baseline Risk Assessment to be COCs for the private ownership scenario (RI Section 6.0). Uranium-234, uranium-235/236, uranium-238, and total uranium were added as groundwater COCs for the Solid Waste Landfill and the Lime Sludge Ponds in the FS due to modifications to site-specific distribution coefficients (K_ds) and other parameters used in the fate and transport models (see Appendix D).

TABLE 2-1

OPERABLE UNIT 2 CONTAMINANTS OF CONCERN

Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
Surface Soil				
Neptunium-237	Cesium-137	Radium-226*	Cesium-137	Cesium-137
Radium-226*	Radium-226*	Radium-228*	Neptunium-237	Neptunium-237*
Radium-228*	Radium-228*	Thorium-228*	Radium-226*	Radium-226*
Strontium-90	Thorium-228*	Thorium-232*	Radium-228*	Radium-228*
Thorium-228*	Thorium-230	Arsenic*	Strontium-90	Thorium-228*
Thorium-230	Thorium-232*	Dibenzo(a,h)anthracene	Technetium-99	Thorium-232*
Thorium-232*	Uranium-238*		Thorium-228*	Arsenic*
Plutonium-238	Uranium-total*		Thorium-230*	Beryllium
Uranium-234			Thorium-232*	
Uranium-235/236			Uranium-234	
Uranium-238*			Uranium-235/236	
Antimony			Uranium-238	
Arsenic			Uranium-total	
Beryllium			Arsenic	
Benzo(a)anthracene			Beryllium	
Benzo(a)pyrene			Aroclor-1254	
Benzo(b)fluoranthene			Aroclor-1260*	
Dibenzo(a,h)anthracene			Benzo(a)anthracene	
Indeno(1,2,3-cd)pyrene			Benzo(a)pyrene*	
			Benzo(b)fluoranthene	
			Benzo(k)fluoranthene	
			Dibenzo(a,h)anthracene*	
			Dieldrin	
			Indeno(1,2,3-cd)pyrene*	
Sediment				
Uranium-total*	No COCs	No COCs	Radium-226*	Radium-226* Arsenic*

See footnotes at end of table.

TABLE 2-1
(Continued)

Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
Groundwater				
Uranium-234 Uranium-235/236 Uranium-238 Uranium-total	Uranium-234 Uranium-235/236 Uranium-238 Uranium-total	Uranium-234* Uranium-235/236* Uranium-238* Uranium-total*	Uranium-234* Uranium-235/236* Uranium-238* Uranium-total*	Radium-226 Strontium-90 Uranium-234* Uranium-235/236* Uranium-238* Uranium-total*
Perched Groundwater				
Technetium-99 Carbazole Uranium-234 Uranium-235/236 Uranium-238 Uranium-total	Neptunium-237 Strontium-90 Technetium-99 Uranium-234 Uranium-235/236 Uranium-238 Uranium-total	No COCs	No COCs	No COCs
Impact on Air (Gaseous Emissions)				
Radon-222	No COCs	Radon-222	Radon-222*	Radon-222
Great Miami River Surface Water				
No COCs	No COCs	No COCs	Radium-226* Technetium-99*	No COCs

*COCs to be considered under both the private ownership and the federal ownership scenarios. COCs not marked with an asterisk are considered for the private ownership scenario only.

Contaminants marked with an asterisk on Table 2-1 are the COCs specific to the federal ownership scenario. Contaminants not marked by an asterisk were not found to be COCs for the federal ownership scenario. The asterisk-marked COCs were determined from the Baseline Risk Assessment for the expanded trespasser and the off-property resident farmer.

2.3 IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CRITERIA

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, (CERCLA) §121(d)(2) directs that for wastes left on site, remedial actions must comply with federal laws and regulations and more stringent state requirements that apply or are relevant and appropriate under the circumstances of the release or potential release. Off-site actions must comply with all requirements that legally apply. This section discusses the ARARs for Operable Unit 2.

ARARs are defined as follows:

- 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.

- To Be Considered (TBC) criteria is a category that includes non-promulgated criteria, advisories, and guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. However, pertinent TBCs will be considered along with the ARARs in determining the necessary level of cleanup or technology requirements.

The sources of Operable Unit 2 ARARs are federal and state laws, regulations and guidance, and DOE Orders that address the site-specific circumstances in Operable Unit 2.

The NCP identifies three categories of ARARs [40 CFR §300.400(g)]:

- 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].

- Action-specific ARARs are usually technology- or activity-based requirements, limitations on actions, or conditions involving special substances.

- Location-specific ARARs restrict actions or contaminant concentrations in certain environmentally sensitive areas. Areas regulated under various federal laws include floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

Under CERCLA §121(d)(4), EPA may select a remedy that does not attain an ARAR if EPA finds that any one of the following conditions apply:

- The remedial action selected is only part of a total remedial action that will attain the ARAR level or standard of control when completed.

- Compliance with the requirements will result in greater risk to human health and the environment than other alternatives.

- Compliance with the requirement is technically impracticable from an engineering perspective.

- The remedial action selected will attain a standard of performance that is equivalent to that required by the ARAR through the use of another method or approach.

- With respect to a state standard, the state has not consistently applied (or demonstrated an intention to consistently apply) the ARAR in similar circumstances at other remedial actions within the state.

- Attainment of the ARAR would not provide a balance between the need for protection of public health or welfare and the environment at this site, and the availability of Superfund monies to respond to other sites that may present a threat to public health or the environment. (Because the FEMP is not being remediated with Superfund monies, this last waiver condition does not directly apply to the project. However, cost is still a criteria for the evaluation of identified alternatives.)

Operable Unit 2 may require one waiver, which is discussed in Section 2.3.3.1.

The initial Operable Unit 2 list of potential ARARs was submitted to EPA and Ohio Environmental Protection Agency (OEPA) on October 12, 1990. On February 7, 1991, EPA acknowledged receipt of the list and indicated that their review would be an iterative process, with final approval to be given at the time of remedy selection.

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During the Operable Unit 2 RI, sufficient data was developed to make initial judgments about the chemicals present in Operable Unit 2 and special characteristics of the subunits' locations that need to be considered. A revised list of chemical- and location-specific ARARs was presented in Section 6.0 of the Operable Unit 2 RI Report (DOE 1994).

The ARARs will be finalized with the selection of the preferred remedial alternative for Operable Unit 2. The Record of Decision (ROD) will contain the final list of ARARs that will govern the remedial design and remedial action for the chosen alternative.

The proposed Operable Unit 2 ARARs are identified in detail in Appendix B. A discussion of major ARARs is presented in this section.

2.3.1 Chemical-Specific ARARs

The Baseline Risk Assessment, presented in the Operable Unit 2 RI Report, identified the COCs for Operable Unit 2. Table 2-1 of this FS presented the COCs for media in Operable Unit 2, including soil, surface water, sediment, groundwater, and air. The groundwater COCs were determined based on cross-media effects—that is, the potential of contaminants to leach from the contaminated material to the groundwater at concentrations that would result in unacceptable risk to a future groundwater user.

The chemical-specific ARARs for Operable Unit 2 COCs are discussed in the sections that follow, as listed below:

- ARARs and TBC criteria for drinking water and groundwater
- ARARs and TBC criteria for surface water and sediment
- ARARs and TBC criteria for air emissions
- ARARS and TBC criteria for radiation
- As low-as-reasonably achievable (ALARA) requirements

2.3.1.1 ARARs and TBC Criteria for Drinking Water and Groundwater

There are no applicable requirements for drinking water or groundwater for Operable Unit 2. The NCP [40 CFR §300.430 (e)(2)(i)(B)-(D)] states that non-zero maximum contaminant level goals (MCLGs) or, if the MCLG is zero, the MCLs, are considered to be relevant and appropriate for any aquifer that is a potential source of drinking water. The Great Miami Aquifer beneath the site is a potential source of drinking water. Therefore, chemical-specific requirements for drinking water and

groundwater are relevant and appropriate for Operable Unit 2 remedial actions. EPA Solid Waste Disposal Regulations (40 CFR §257.3-4) state that a solid waste disposal facility shall not contaminate an underground drinking water source beyond the solid waste boundary. Therefore, MCLs and non-zero MCLGs will be met at the boundary of the subunits and also, for certain alternatives, at the boundary of the disposal facility.

If the background level of the chemical subject to CERCLA authority is higher than the MCLG or MCL, attainment of the MCLG or MCL would not be required. Thus, the drinking water standard would not be relevant and appropriate (EPA 1990a).

The relevant and appropriate (promulgated) or TBC (proposed) MCLG and MCL values for the Operable Unit 2 COCs are provided in Appendix B-1.

2.3.1.2 ARARs and TBC Criteria for Surface Water and Sediment

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 this determination to be based on the designated or potential use of the water, the media affected, the purpose of the criteria, and the current information. The OEPA has designated the following uses of the Great Miami River and its tributaries, including Paddys Run [Ohio Administrative Code (OAC) 3745-1-07]:

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

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

The "agricultural" designation refers to waters that are suitable for irrigation and livestock watering without treatment.

The "industrial" designation refers to waters that are suitable for commercial and industrial uses, with or without treatment.

The "primary contact" designation is a description of recreational-use waters. These are waters that, during the recreational season, are suitable for full-body contact recreation such as, but not limited to, swimming, canoeing, and scuba diving, with minimal threat to public health as a result of water quality.

OEPA has promulgated water quality standards specific to state waters and their 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 soils or for groundwater that has the potential to impact the surface waters. The OEPA standards are provided in Appendix 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.

2.3.1.3 ARARs and TBC Criteria for Air Emissions

EPA regulations for National Emission Standards for Hazardous Air Pollutants (NESHAP) provide an applicable air emission standard for remedial activities in Operable Unit 2 (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/yr. 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 1-year period); or
- increase the annual average concentration of radon-222 in the air or above any location outside the disposal site by more than 0.5 pCi/L.

This requirement is relevant and appropriate because the soil in each of the Operable Unit 2 subunits contains radium-226, an element that decays into radon-222.

The National Ambient Air Quality Standards (NAAQS) apply for remedial alternatives that involve treatment (e.g., stabilization, drying) because airborne pollutants may be released. The remedial treatment units for Operable Unit 2, in addition to FEMP's emissions during remedial action, will be designed to maintain the NAAQS for carbon monoxide, nitrogen dioxide, particulate matter (PM_{10}), ozone, and sulfur oxides. These standards are provided in Table B-1 of Appendix B.

For the same reason that the NAAQS apply, the OEPA Air Toxic Policy will be a TBC for air emissions from treatment units in Operable Unit 2, in addition to the FEMP emissions during remedial action. If a compound is classified by EPA as a Class A, B1, or B2 carcinogen and the amount of pollutant released exceeds the de minimis emission levels established in the policy, a health impact/risk assessment study will be performed for the carcinogen to determine the maximum individual risk (MIR). Calculated MIRs must be less than 1.0×10^{-5} per toxicant.

For compounds that are not carcinogenic, maximum acceptable ground-level concentrations (MAGLCs) will be met to ensure acceptable ground-level ambient concentrations. Based on soil and waste concentrations and the amount of material in Operable Unit 2, it is not expected that the de minimis levels in the OEPA Air Toxics Policy or MAGLCs will be exceeded. Operable Unit 2 emissions, in conjunction with all FEMP emissions, will be verified during remedial design.

2.3.1.4 ARARS and TBC Criteria for Radiation

Atomic Energy Act (AEA) requirements for low-level radioactive waste management are incorporated in DOE Order 5820.2A, which was developed under DOE's AEA authority. The Order is generally consistent with and typically includes equivalent Nuclear Regulatory Commission (NRC) 10 CFR §61 (Licensing Requirements for Land Disposal of Radioactive Waste) requirements. DOE Order 5820.2A requirements are TBC criteria that, when included in a DOE CERCLA ROD, are enforceable cleanup standards under CERCLA.

DOE Orders 5400.5 and 5820.2A provide dose levels for the protection of the general public from releases of radioactivity. The exposure of members of the public to radiation sources shall not cause, in 1 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 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. Both of these dose requirements, in addition

to the NESHAP dose standard of 10 mrem per year which was discussed in the previous section, may be required based on the type of exposure scenario. The requirements of NESHAP and DOE Order 5820.2A would be for the protection of the off-property members of the public or the on-property resident farmer if the area is no longer under federal ownership. DOE Order 5400.5 would also be a TBC criteria if waste is maintained on site and members of the public are allowed access, as represented by the expanded trespasser scenario, where direct radiation could also occur.

The relevant and appropriate EPA regulation is 40 CFR §192.20, which requires remedial actions be conducted to provide reasonable assurance that as a result of residual radioactive materials from any designated processing site, the concentrations of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.

Radium-226 was identified as a COC for each Operable Unit 2 subunit.

2.3.1.5 As Low As Reasonably Achievable (ALARA) Requirements

40 CFR § 192.21(f) and § 192.22(b), considered relevant and appropriate, require that reasonable measures be taken to maintain releases of radioactivity in effluent to the general environment as low as is reasonably achievable. The level of releases shall be based on cost and benefit considerations. DOE Order 5400.5 Chapters I (4) and II (2) adopt this ALARA process in planning and carrying out all DOE activities.

2.3.2 Action-Specific ARARs

The principal action-specific requirements for Operable Unit 2 are based on the regulatory definitions and classifications of the materials in each of the subunits. This section describes the waste classifications and indicates the action-specific requirements associated with each material. These action-specific ARARs are described in detail in Appendix B-2.

2.3.2.1 Regulatory Definition of Wastes

Operable Unit 2 subunits contain a mixture of waste materials and other material that will direct pertinent action-specific ARAR and TBC criteria for in situ containment, on-site disposal, and/or off-site disposal. These materials are classified as follows:

- Low-level radioactive waste/residual radioactive material
- Solid waste
- Infectious waste
- Hazardous waste
- Other material not considered waste
  - Soils below the PRLs
  - Residual radioactive material below PRLs

The waste classifications associated with each Operable Unit 2 subunit are identified in Table 2-2.

TABLE 2-2

OPERABLE UNIT 2 SUBUNIT MATERIAL CLASSIFICATIONS

Material Type	Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
Low-Level Radioactive Wastes/ Residual Radioactive Material above PRLs	X	X	X	X	X
Solid Waste	X	X	X	X	X
Infectious Waste	X	NA[a]	NA	NA	NA
Hazardous Waste	NA	NA	NA	X	NA
Soils and Residual Radioactive Material Below the PRLs	X	X	X	X	X

[a]NA = not applicable.

Remedial actions will be required to meet the most stringent requirements of rules governing each type of waste when different materials are being managed together.

Each classification of Operable Unit 2 materials is discussed in the following subsections. Detailed definitions and the technical requirements for in situ, containment or disposal of each of these wastes are provided in Tables B-2, B-3, and B-4 of Appendix B.

Low-Level Radioactive Waste/Residual Radioactive Material

Low-level radioactive waste is defined broadly as a radioactive material that is not high-level waste, spent nuclear fuel, transuranic waste, or byproduct material [defined in Atomic Energy Act; 42 U.S.C. §2014(e)(2)]. DOE has established a more specific definition for residual radioactive material: 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 low-level radioactive waste) if concentration levels can be shown to be below a level that would adversely affect human health or the environment. In the CERCLA process, the free-release levels are determined by the PRLs. The PRLs for Operable Unit 2 are described in Section 2.5. Residual radioactive materials above the PRL levels can be treated to be below PRLs and free released from federal control or, if they cannot be treated, must be disposed in a facility that would provide the required level of protection.

Management and disposal of low-level radioactive waste/residual radioactive material must comply with 40 CFR §192 and DOE Orders 5400.5, 5820.2A, and 6430.1A. The cap design for low-level radioactive waste containment is based on the duration of protection required by 40 CFR §192. DOE Orders provide performance objectives that must be met in managing low-level radioactive waste/residual radioactive material in addition to technical standards for waste characterization, shipment, and disposal.

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 Atomic Energy Act of 1954 as amended, is not solid waste under the federal definition (40 CFR §257). Disposal of solid waste must comply with 40 CFR §257 and §258.

OEPA's definition of solid waste is any unwanted residual solid or semi-solid material resulting from industrial, commercial, agricultural, and community operations. In addition to the EPA requirements, disposal of solid waste must also comply with the Ohio Solid Waste Disposal Regulations (OAC 3745-27). These regulations establish technical requirements for the construction and operation of a solid waste disposal facility including the type of layers in the liner and cap systems and the closure and post-closure care of the facility.

Infectious Waste

OEPA's infectious-waste regulations (OAC 3745-27-30 through 3745-27-37) state that generators of less than 50 pounds of infectious waste per month who do not hold a certificate of registration may transport and dispose of infectious wastes in the same manner as solid wastes. In 1993, the FEMP, with approximately 3,500 employees and subcontractors, had exceeded the 50-pounds-per-month level for the first time. Since May 1987, the infectious waste generated has been disposed at an approved off-site disposal facility. Because past disposal of infectious wastes in the Solid Waste Landfill is considered to have been less than 50 pounds per month based on the past number of employees (2,900 maximum prior to 1993), any infectious waste encountered can be managed as a solid 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 operational history of the Operable Unit 2 subunits, except the Lime Sludge Ponds and the Active Flyash Pile, are not well documented. The Solid Waste Landfill reportedly was used for the disposal of cafeteria waste, rubbish, and other types of wastes from FMPC nonprocess areas and on-site construction/demolition activities. The waste pits were the designated disposal location for process wastes.

No known EPA-listed wastes were disposed in Operable Unit 2 subunits. TCLP analyses performed in these units showed that the Operable Unit 2 subunits are not characteristically toxic. Therefore, RCRA Subtitle C requirements would not be considered applicable or relevant and appropriate for on-site activities.

One exception would be during the remediation of the Firing Range in the South Field. Although the bullets are not considered waste while they are embedded in the soil, they will be assumed to be a mixed waste (both hazardous and radioactive) when they are actively managed (e.g., excavated and disposed off site). The disposal of Operable Unit 2 mixed waste is subject to 40 CFR §262 (RCRA transportation requirements) and DOE Orders 5400.5, 5820.2A, and 6430.1A.

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The RCRA requirements for off-site disposal are considered to be non-ARAR requirements and are listed in Table B-6 of Appendix B. It is assumed that the firing range material is mixed waste; however, the material will be screened during the remedial action to confirm this assumption. If the material, or a portion of the material, is found to be only hazardous, only radioactive, or neither, it will be managed, respectively, as a hazardous waste, low-level radioactive waste, or solid waste if there are contaminants above the PRLs. If the material is not hazardous and does not contain contaminants above the PRLs, it will be managed, respectively, as a soil or residual radioactive material below the PRLs.

Soils and Residual Radioactive Material Below the PRLs

Soils and residual radioactive materials below PRLs determined through the CERCLA process are protective of human health and the environment and are therefore not considered to be waste material. This is consistent with both EPA and OEPA policies. The RCRA Subtitle C "contained-in" policy does not consider environmental media to be a waste material. Thus, if the waste constituents can be removed, the environmental media is no longer a waste. OEPA applied this contained-in policy to petroleum-contaminated soils (Ohio Division of Solid and Infectious Waste Management Policy PP 01 03 200, March 25, 1991) by stating that the soils containing a petroleum hydrocarbon would not need to be managed as a solid waste if the contaminants were removed. As RCRA Subtitle C regulations are not considered to be an ARAR for Operable Unit 2, the OEPA petroleum-contaminated soils policy will be considered a TBC requirement for Operable Unit 2 environmental material below the PRLs. Based on this TBC requirement, these materials will not be defined or handled as a solid waste.

2.3.3 Location-Specific ARARs

The principal location-specific requirements for Operable Unit 2 are based on the location of the FEMP above a sole-source aquifer and near a floodplain and wetlands. This section describes the location-specific requirements for different disposal alternatives.

2.3.3.1 On-Site Disposal of Operable Unit 2 Wastes

The most significant issue influencing the location-specific ARARs is the determination by EPA Region V [53 Federal Register (FR) 25670] 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 the public

health. The determination was effective July 8, 1988. The Federal Safe Drinking Water Act 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(B)(5)]. 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(B)(9)]. The Great Miami Aquifer qualifies as both a sole-source and a 100-gallon-per-minute-yield aquifer. These requirements are derived from the ORC 3734.02(A) which instructs the 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, if on-site disposal is chosen as the preferred remedial alternative, a waiver pursuant to CERCLA §121(d)(4)(D) from OAC 3745-27-07(B)(5) and (B)(9) 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(A). 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 in order to be considered for the preferred remedial alternative. 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 1×10^{-4} to 1×10^{-6} and compliance with MCLs. The risk assessment and transport modeling processes for Operable Unit 2 will verify that the on-site alternative is protective of human health and the environment, including the Great Miami Aquifer. These results are summarized Section 5.0 and presented in detail in Appendices C and D.

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

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addressed in Section 5.0. If on-site disposal is chosen as the preferred remedial alternative, the specific design of the engineering controls and location of the disposal facility would be finalized during the remedial design process.

2.3.3.2 Consolidation of Wastes Resulting From CERCLA Remedial Actions in the Area of Contamination

EPA guidance states that consolidation of waste material during a CERCLA remedial action does not constitute disposal or new placement of waste. OEPA siting criteria only apply to new placement of waste. Therefore, the consolidation of existing Operable Unit 2 waste materials within the area of contamination would not invoke the OEPA siting criteria.

2.3.3.3 Other Location-Specific ARARs

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. An updated floodplain determination was performed for Paddys Run in October 1993 using the U.S. Army Corps of Engineers (COE) standard HEC2 water surface profile analysis program. The 100-year flood elevations reach the western slope of the Inactive Flyash Pile and the toe of the South Field slope. A site-wide delineation of Fernald wetlands, performed in accordance with the COE Wetland Delineation Manual, was completed in March 1993. A small area of wetlands was identified north of the Solid Waste Landfill. 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 becomes necessary to adversely impact wetlands during remediation, Operable Unit 2 will comply with the substantive permitting requirements for impacts to wetlands under the Clean Water Act (33 CFR §§ 323-330).

2.3.4 Non-ARAR Requirements

There are a number of requirements that are not considered ARARs because both the administrative and substantive requirements are applicable to the remediation. These additional requirements include the Occupational, Safety, and Health Act (OSHA) worker protection requirements; U.S. Department of Transportation (DOT) requirements for transportation of hazardous materials; RCRA requirements for accumulation and transportation of hazardous waste (including compliance with the manifest

requirements); and additional DOE Orders which are contractual obligations for all activities at a DOE facility.

2.4 DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS AND PRELIMINARY REMEDIATION LEVELS

The protection of human health is one of two threshold criteria identified in the NCP to evaluate remedial alternatives. A multi-step process, shown in Figure 2-1, was followed to determine remediation levels that will be protective of human health. This process begins with the development of risk-based PRGs using the COCs developed during the remedial investigation, and is completed by establishing PRLs that will direct the remedial actions in Operable Unit 2.

The PRLs differ from risk-based PRGs because of three modifications applied to exposure pathways: (1) administrative controls (federal ownership), (2) cross-media impacts from soil to other media outside Operable Unit 2 that were shown to be impacted from the waste material and contaminated soil contained within the Operable Unit 2 battery limits, and (3) application of two source controls. Other media to which receptors can be exposed include sediments, surface water (e.g., the Great Miami River), air, and groundwater. The source controls were selected to reduce and/or eliminate contaminant transport from the source areas in Operable Unit 2 to other media. The source controls increased the allowable PRGs and increased the number of remedial alternatives that could be considered. These modifiers and the resulting modified PRGs are presented in detail in this section. Each modifier and corresponding modified PRGs are provided in a stepwise fashion to allow the effectiveness of each modification to be evaluated.

PRLs are calculated from the most restrictive PRGs (modified or risk-based) for a defined scenario according to the following method:

- For radionuclides: PRL = PRG + background
- For nonradionuclides: PRL = PRG if PRG > background, or
  PRL = background if PRG < background

The PRLs that will be used in the Operable Unit 2 FS are presented in Section 2.6.

2.4.1 Risk-Based PRGs

Risk-based PRGs were developed from the Baseline Risk Assessment (Section 6.0 and Appendix B of the RI Report) and are used as a guideline for direct contact with Operable Unit 2 materials.

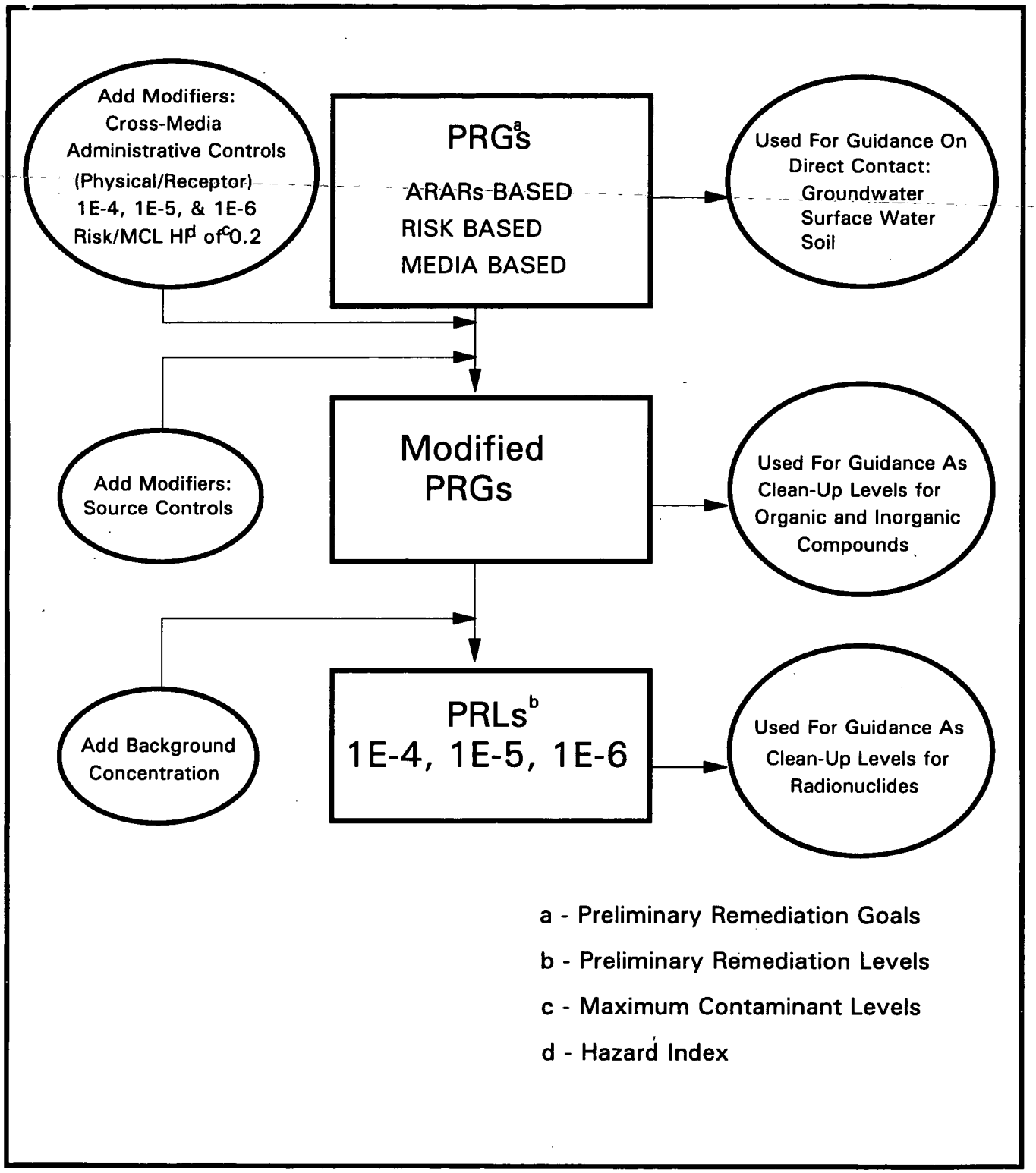

FIGURE 2-1

PROCESS FOR DEVELOPING PRELIMINARY REMEDIATION LEVELS (PRLs)

Risk-based PRGs were based on the following:

- For chemical toxicants, a HI $\geq$ 0.2
- For chemical and radiation carcinogens, an ILCR $\geq$ 1.0×10^{-6}
- Dose limits, ARARs, and TBC requirements

These PRGs are chemical-specific, medium-specific concentration levels necessary to address the contaminants and all direct pathways found to be of concern during the Baseline Risk Assessment. The risk-based PRGs do not consider cross-media impacts to surface water or groundwater. Risk-based PRGs for surface soil and groundwater were calculated in the Baseline Risk Assessment using the on-property [reasonable maximum exposure (RME)] resident farmer exposure scenario, because it is an exposure scenario in which an individual has unlimited access to the operable unit to farm, live, and do other activities. Federal ownership-modified PRGs for surface soil and groundwater were calculated in the Baseline Risk Assessment using the expanded trespasser and off-property resident farmer exposure scenarios.

Risk-based and federal-ownership modified PRGs were calculated from the results of the Baseline Risk Assessment using a linear relationship between concentration of the COC "i" in the source media (either soil, surface water, or groundwater) and the total risk from all direct and indirect exposure pathways resulting from that source media, based on Equation 2-1.

$$PRG_i = \frac{(ILCR)(C_{si})}{\Sigma risk_i} \qquad (2\text{-}1)$$

where:

PRG_i = Preliminary remediation goal for constituent "i" in source media

ILCR = Target risk level 10^{-4} to 10^{-6} for carcinogens; or HI<=0.2 for non-carcinogens

Σ $risk_i$ = Sum of risk from all direct and indirect exposure pathways. Pathways for the expanded trespasser include inhalation, ingestion, dermal contact, and direct radiation from surface soils. Pathways for the on-site and off-site resident farmer include: inhalation, ingestion, dermal contact, and direct radiation of surface soils, ingestion of produce and beef/milk effected by dust, and inhalation, ingestion, and dermal contact with groundwater.

C_{si} = Concentration of COC "i" in source medium

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Note that the concentration of the COC in equation 2-1 is the source medium concentration and not an individual exposure medium pathway concentration, because the risk from a particular source includes exposure to all direct and indirect exposure pathways (i.e., the concentration of particulates in air is not used because it is derived from the surface soil concentration, which is the source medium). Equation 2-1 will be used for determining soil-modified PRGs (e.g., based on impacts to other media with the appropriate pathways included in the $\Sigma risk_i$ term). The only exception is the modified PRGs that involve cross-media impact of soil to groundwater (including perched water), because the modeling for this exposure pathway is not linear. Modeling with the One-dimensional Analytical Solute Transport (ODAST)/Sandia Waste Isolation Fate and Transport (SWIFT) models will be used to determine these modified PRGs based on the risk-based PRGs for groundwater provided in this section.

Table 2-3 presents the minimum risk-based soil PRGs developed for Operable Unit 2 subunits. For comparison, the last column on Table 2-3 presents the 95th percentile of the background concentrations for surface soil.

Certain media associated with Operable Unit 2 (i.e., groundwater, perched water, and surface water) are outside the scope of remedial actions being considered under this FS and will be addressed in the Operable Unit 5 FS. However, risk-based PRGs are provided for groundwater, because groundwater serves as a environmental receptor and cross-media pathway for the uptake of COCs from contaminated material located in Operable Unit 2.

Table 2-4 presents the risk-based groundwater PRGs developed for Operable Unit 2. Perched water as a potential source of drinking water was evaluated for the Lime Sludge Ponds and the Solid Waste Landfill. Perched water was not considered a potential source of drinking water for the Inactive Flyash Pile, South Field, or the Active Flyash Pile subunits due to the low potential for water yield from perched water in these subunits and the close proximity of the Great Miami Aquifer. The Great Miami Aquifer was considered a source of drinking water and a source of water for irrigation for all subunits. COCs were identified for the Solid Waste Landfill and Lime Sludge Ponds for perched groundwater, while COCs were identified for the Great Miami Aquifer for all subunits.

TABLE 2-3

SUMMARY OF CONTAMINANTS OF CONCERN AND RISK-BASED SOIL PRELIMINARY REMEDIATION GOALS (PRGs)[a]

COC	PRIVATE OWNERSHIP On-Property Resident Farmer (RME)[b] PRG (pCi/g or mg/kg)			ARAR/ TBC	Surface Soil Background (pCi/g or mg/kg)
	10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR		
Carcinogenic					
Cesium-137	1.1	1.1E-01	1.1E-02		0.71
Neptunium-237	4.3	4.3E-01	4.3E-02		0.0
Plutonium-238	4.0E+01	4.0	4.0E-01		0.0
Radium-226	3.9E-01	3.9E-02	3.9E-03	5 pCi/g[d]	1.42
Radium-228	8.2E-01	8.2E-02	8.2E-03	5 pCi/g[d]	1.25
Strontium 90	1.6	1.6E-01	1.6E-02		0.0
Technetium 99	1.7	1.7E-01	1.7E-02		0.0
Thorium-228	4.3E-01	4.3E-02	4.3E-03		1.43
Thorium-230	7.7E+01	7.7	7.7E-01	5 pCi/g[e]	1.97
Thorium-232	2.8E-01	2.8E-02	2.8E-03	5 pCi/g[e]	1.36
Uranium-234	7.7E+01	7.7	7.7E-01		1.24
Uranium-235/236	9.0	9.0E-01	9.0E-02		0.15
Uranium-238	2.5E+01	2.5	2.5E-01		1.22
Arsenic	4.5	4.5E-01	4.5E-02		8.20
Beryllium	3.3	3.3E-01	3.3E-02		0.60
Benzo(a)anthracene	2.3	2.3E-01	2.3E-02		0.0
Benzo(a)pyrene	1.5E-01	1.5E-02	1.5E-03		0.0
Benzo(b)fluoranthene	1.4	1.4E-01	1.4E-02		0.0
Benzo(k)fluoranthene	4.7	4.7E-01	4.7E-02		0.0
Dibenzo(a,h)anthracene	4.6E-02	4.6E-03	4.6E-04		0.0
Indeno(1,2,3-cd)pyrene	7.3E-01	7.3E-02	7.3E-03		0.0
Aroclor-1254	1.5E-01	1.5E-02	1.5E-03		0.0
Aroclor-1260	2.3E-02	2.3E-03	2.3E-04		0.0
Dieldrin	4.0E-03	4.0E-04	4.0E-05		0.0

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See footnotes at end of table.

TABLE 2-3
(Continued)

Parameter	PRIVATE OWNERSHIP On-Property Resident Farmer (RME) PRG (pCi/g or mg/kg) HI[f] = 0.1	HI = 0.2	HI = 1.0	ARAR/ TBC	Surface Soil Background (pCi/g or mg/kg)
Noncarcinognic					
Antimony	0.66	1.33	6.6		0.0
Arsenic	4.54	8.97	45.44		8.20
Uranium-Total	17900	37000	1.79E+05		3.7

[a]Risk-based PRGs in this table represent the minimum PRGs for any of the Operable Unit 2 subunits. Specific subunit risk-based PRGs for the on-property resident farmer are presented in Appendix D. Data is taken from Table 7-19 of the RI Report. PRGs were calculated using Equation 2-1.

[b]RME = reasonable maximum exposure.

[c]ILCR = incremental lifetime cancer risk.

[d]First 15 cm (6 in.) depth (40 CFR 192) for radium-226 5 progeny and 15 pCi/g added for each additional 15 cm.

[e]First 15 cm (6 in.) depth [DOE Order 5400.5, Chapter IX (4)(a)(2), (3)] and 15 pCi/g added for each additional 15 cm.

[f]HI = hazard index.

TABLE 2-4

SUMMARY OF RISK-BASED GROUNDWATER PRELIMINARY REMEDIATION GOALS (PRGs)

COC	PRIVATE OWNERSHIP				ARAR/ TBC	Surface Soil Background (mg/kg)
	Off-Property Resident Farmer (RME)[a] PRG (pCi/L)					
	HI[b] = 0.2 ug/L	10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR		
Uranium-234		127	13	1.27		1.24
Uranium-235/236		125	13	1.25		0.15
Uranium-238		73	7.3	0.73		1.22
Uranium-Total	21 ug/L	NA[d]	NA	NA	20 ug/L[e]	

[a]RME = reasonable maximum exposure.

[b]HI = hazard index.

[c]ILCR = incremental lifetime cancer risk.

[d]NA = carcinogenic risk not applicable to this parameter

[e]56 Federal Register 33050 (July 18, 1991) TBC

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2.4.2 Development of Modified Soil PRGs

Risk-based soil PRGs were modified by applying influencing conditions that can include federal ownership, cross-media migration, and source controls. Modified soil PRGs that consider intermedia migration of contamination were developed using fate and transport models to simulate the migration of contaminants from soils into groundwater and other media.

The risk-based PRGs were modified by a review of the future land use, cross-media contamination, exposure assumptions, and source-control assumptions. For purposes of the Operable Unit 2 FS, several modified PRGs have been determined to support the feasibility study process. The following modifiers are evaluated in this report:

- Federal ownership
  - administratively and physically limiting access to potential receptors through continued federal ownership and access control of Operable Unit 2 areas,
- Cross media migration
  - potential for soil to impact surface water, groundwater, perched water, sediment, the Great Miami River and radon/air (Note: Airborne contaminants on particulates were combined with other exposure pathways from the surface soil source.)
- Source-control assumptions
  - lateral control of water movement in perched water within the glacial overburden
  - reduced infiltration and an exposure barrier

Source-control assumptions were added as modifiers to allow additional alternatives to be considered, because cross-media modified soil PRGs were calculated to be below background levels. PRGs that are modified must (1) be protective of human health and (2) comply with ARARs.

Risk-based PRGs may be reduced or increased based on the modifications described above. Therefore, the modified PRGs have been considered in a stepwise fashion to allow the effect of each modification to be evaluated. Figure 2-2 presents the steps and specific sets of PRGs considered for Operable Unit 2. Only the COCs with PRGs that would be affected by the modifications are presented in the modified PRG tables provided in the following sections. Non-modified PRGs remain as defined in Table 2-3.

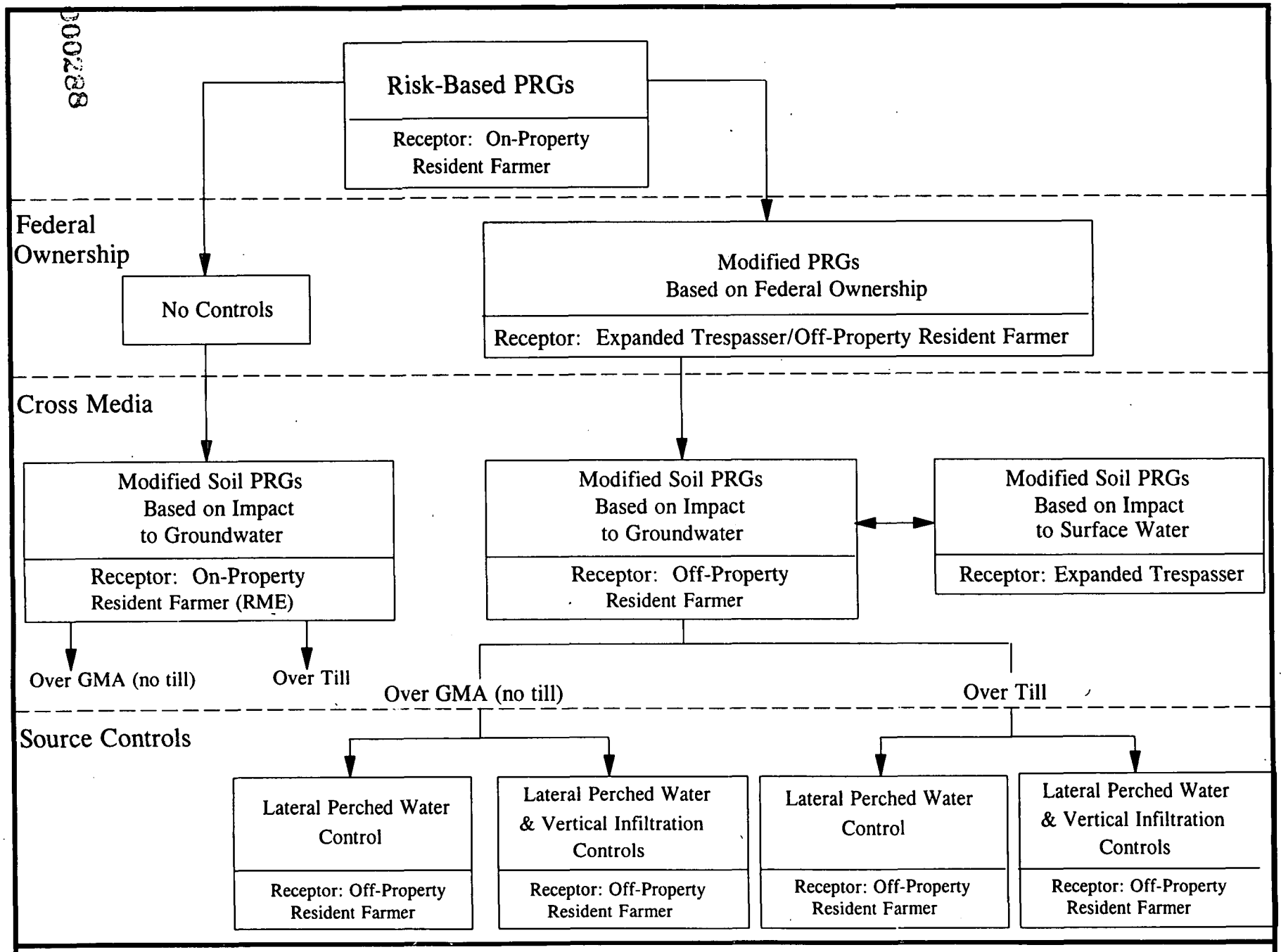

FIGURE 2-2 OPERABLE UNIT 2 PRG DEVELOPMENT

The risk-based PRGs were increased when adding administrative controls to restrict the use of the Operable Unit 2 subunits. Conversely, when considering the effect of cross-media migration of contaminants from soil to other media, the risk-based PRGs may be reduced for contaminants identified in the Baseline Risk Assessment to be a concern for that pathway. The cross-media (sediment, surface water, Great Miami River surface water, perched groundwater, radon, and groundwater) COCs are identified in Table 2-1 for each subunit and each media.

Proposed source-control modifications and reduced contaminant migration increased the PRGs. The two cases considered in this FS address lateral control of perched water and reduction of vertical infiltration. The source control to reduce infiltration also provided a barrier to the receptor, thereby eliminating the direct-exposure pathway. The use of source controls is considered only in conjunction with federal ownership, because release of the property to private ownership cannot ensure the integrity of the source control. The loss of integrity of a source control will result in risks to potential receptors as defined in the Baseline Risk Assessment, which were determined to be unacceptable.

Additionally, different modified soil PRGs for cross-media migration were developed for different hydrogeologic conditions within a subunit. Specifically, the Inactive Flyash Pile, South Field, and Active Flyash pile lie partly over the Great Miami Aquifer and partly over a terrace of glacial overburden (till). Figure 2-3 shows the glacial overburden slope that forms the transition between the till terrace and the exposed portions of the Great Miami Aquifer. One set of modified soil PRGs was developed for source soils located on top of the glacial overburden terrace (above the slope), and another set of modified soil PRGs was developed for source soils directly underlain by the Great Miami Aquifer. The area of the terrace slope was considered equivalent to the no-till condition.

2.4.3 Modified Soil PRGs for Federal Ownership

Administrative controls physically limit access, movement, and activities of potential receptors. The federal ownership scenario considered in this FS is one in which future uses of the Operable Unit 2 subunit area are controlled. Under the federal ownership scenario, it was assumed that the Operable Unit 2 area has restricted access provided by fences. The modified PRGs for this scenario were developed to protect an expanded trespasser (an adult or child who makes repeated unauthorized entries to the Operable Unit 2 area). This receptor is consistent with the trespasser considered in the

Operable Unit 2 Baseline Risk Assessment. Modified PRGs for the protection of the expanded trespasser must also be protective of the use of the property surrounding the FEMP site. Therefore, the modified PRGs protective of the expanded trespasser may need to be decreased to also be protective of an off-property resident farmer. Table 2-5 presents the modified soil PRGs for the expanded trespasser, calculated using Equation 2-1, and the risks determined in the Baseline Risk Assessment. The list of COCs in Table 2-5 is shorter than that for the risk-based PRGs in Table 2-3, because restricting access limits exposure to contaminants, thus reducing the number of contaminants causing greater than 1 x 10^{-6} ILCR or 0.2 HI (Table 2-1).

The off-property resident farmer is affected by surface soils only from the South Field. Table 2-6 lists the PRGs for the South Field. The off-property resident farmer is also exposed to groundwater. Table 2-7 lists the groundwater PRGs protective of the off-property resident farmer. These groundwater PRGs are the same as the risk-based groundwater PRGs for private ownership.

The PRGs presented in Table 2-5 were determined to be protective of the expanded trespasser. The PRGs presented in Table 2-6 were determined to be protective of the off-property resident farmer. The PRGs in Table 2-5, or Table 2-6 when the PRG for a specific COC is lower than in Table 2-5, will at a minimum need to be met if no additional modifier is deemed to be more restrictive, or if a source control does not reduce the exposure to the expanded trespasser.

2.4.4 Modified Soil PRGs for Cross Media Without Source Controls

Cross-media contamination is the potential for contaminants in the soil to impact other media (e.g., groundwater) via migration. Modified soil PRGs evaluating cross-media migration were developed for receptors for both the federal ownership and private ownership scenarios. These modified soil PRGs (cross media) represent the concentrations of a contaminant in the source material that will not create a concentration in other media that exceeds a selected risk-based criteria or ARARs for that media at the exposure point. For example, groundwater risk-based PRGs or ARARs based on MCLs were used as criteria at the selected exposure points for the development of modified soil PRGs.

The following sections outline the approach to and present a summary of the results of the modified soil PRG development for the Operable Unit 2 FS. A detailed description of the modified soil PRG development process and a complete summary of results for cross-media impact on surface water, sediment, and groundwater are presented in Appendix D.

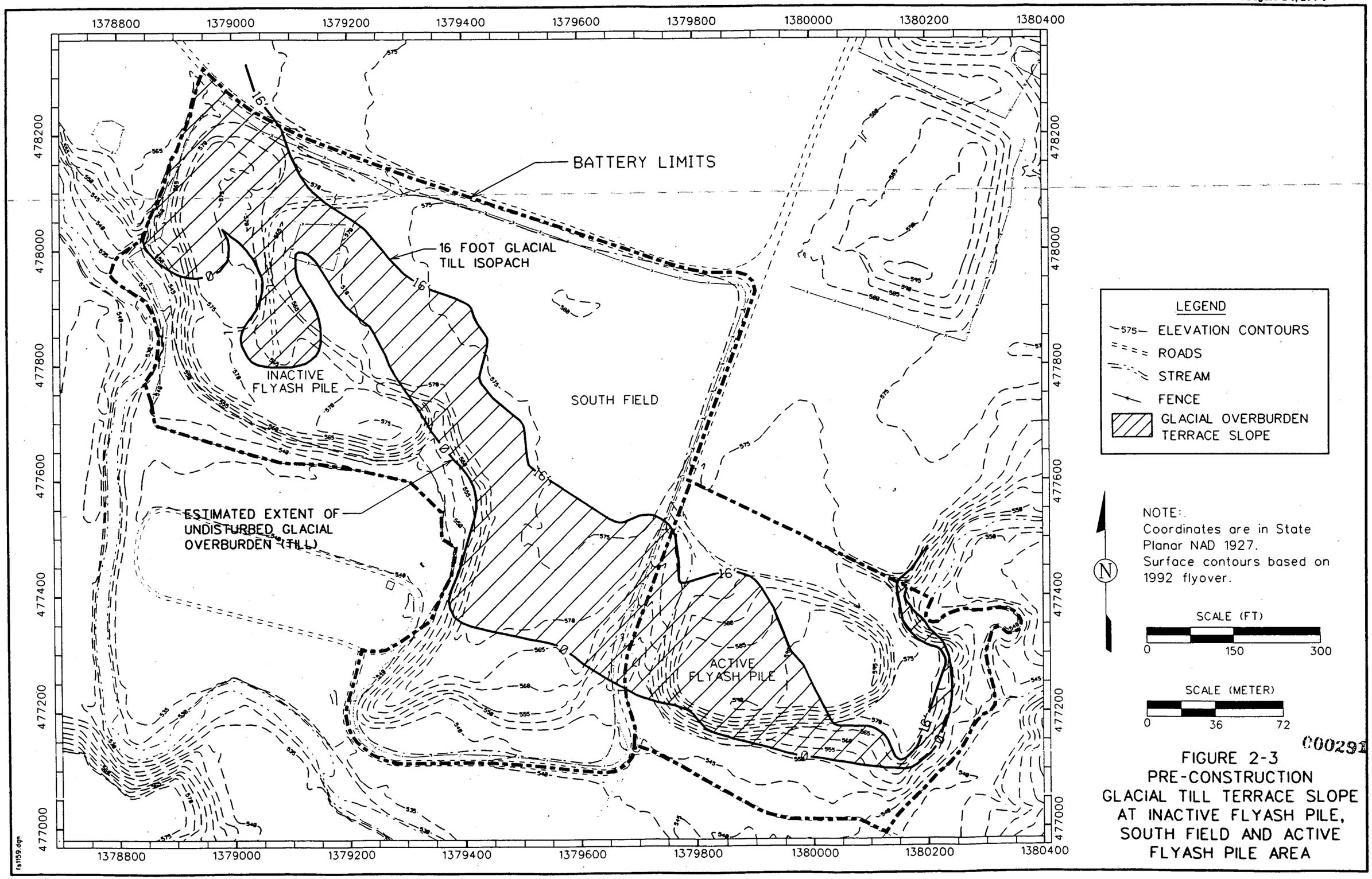

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FIGURE 2-3
PRE-CONSTRUCTION
GLACIAL TILL TERRACE SLOPE
AT INACTIVE FLYASH PILE,
SOUTH FIELD AND ACTIVE
FLYASH PILE AREA

TABLE 2-5

SUMMARY OF OPERABLE UNIT 2 MODIFIED SOIL PRELIMINARY REMEDIATION GOALS (PRGs)[a] FOR THE EXPANDED TRESPASSER WITH FEDERAL OWNERSHIP

CARCINOGENIC

COC	FEDERAL OWNERSHIP Expanded Trespasser (pCi/g or mg/kg)			ARAR/ TBC	Surface Soil Background (pCi/g or mg/kg)
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		
Neptunium-237	4.99E+02	4.99E+01	4.99	-	0.0
Radium-226	3.69E+01	3.69	3.69E-01	5 pCi/g[c]	1.42
Radium-228	7.7E+01	7.7	7.7E-01	5 pCi/g[c]	1.25
Thorium-228	3.99E+01	3.99	3.99E-01		1.43
Thorium-232	2.63E+01	2.63	2.63E-01	5 pCi/g[d]	1.36
Uranium-238	5.36E+03	5.36E+02	5.36E+01		1.22
Arsenic	1.69E+03	1.69E+02	1.69E+01		8.20
Benzo(a)pyrene	2.86E+02	2.86E+01	2.86		0.00

NONCARCINOGENIC

COC	FEDERAL OWNERSHIP Expanded Trespasser (pCi/g or mg/kg)			ARAR/ TBC	Surface Soil Background (pCi/g or mg/kg)
	HI[c] = 0.1	HI = 0.2	HI = 1.0		
Arsenic	560	1000	5600		8.20
Uranium - Total	102	200	1020		3.7

[a]Modified soil PRGs in this table represent the minimum PRGs for any of the Operable Unit 2 subunits. Specific subunits' modified soil PRGs for the expanded trespasser are presented in Appendix D.

[b]ILCR = incremental lifetime cancer risk.

[c]First 15 cm (6 in.) depth (40 CFR 192) for radium-226 + 5 progeny and 15 pCi/g added for each additional 15 cm in depth.

[d]First 15 cm (6 in.) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC and 15 pCi/g added for each additional 15 cm in depth.

[e]HI = hazard index.

TABLE 2-6

SOUTH FIELD
SUMMARY OF MODIFIED SOIL
PRELIMINARY REMEDIATION GOALS (PRGs)
FOR THE OFF-PROPERTY RESIDENT FARMER WITH FEDERAL OWNERSHIP

COC	FEDERAL OWNERSHIP Off-Property Resident Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Surface Soil Background (pCi/g or mg/kg)
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR		
Carcinogenic					
Thorium-228	1.5E+4	1.5E+3	1.5E+2		1.43
Thorium-230	4.0E+4	4.0E+3	4.0E+2	5[b]	1.97
Thorium-232	1.1E+4	1.1E+3	1.1E+2	5[b]	1.36
Uranium-238	2.2E+4	2.2E+3	2.2E+2		1.22
Benzo(a)pyrene	5.1E+3	5.1E+2	5.1E+1		0.0
Dibenzo(a,h)anthracene	1.3E+3	1.3E+2	1.3E+1		0.0
Indeno(1,2,3-cd)pyrene	2.0E+4	2.0E+3	2.0E+2		0.0
Aroclor-1260	2.5E+3	2.5E+2	2.5E+1		0.0

[a]ILCR = incremental lifetime cancer risk.

[b]First 15 cm (6 in.) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC and 15 pCi/g added for each additional 15 cm in depth.

000293

TABLE 2-7

SUMMARY OF MODIFIED GROUNDWATER PRELIMINARY REMEDIATION GOALS (PRGs) FOR THE OFF-PROPERTY RESIDENT FARMER WITH FEDERAL OWNERSHIP

COC	FEDERAL OWNERSHIP				ARAR/ TBC	Surface Soil Background (mg/kg)
	Off-Property Resident Farmer (RME)[a] PRG (pCi/L)					
	HI[b] = 0.2 μg/L	10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR		
Uranium-234		127	13	1.27		1.24
Uranium-235/236		125	13	1.25		0.15
Uranium-238		72	7.2	0.73		1.22
Uranium-Total	21 μg/L	NA[d]	NA	NA	20 ug/L[e]	

[a]RME = reasonable maximum exposure.

[b]HI = hazard index.

[c]ILCR = incremental lifetime cancer risk.

[d]NA = carcinogenic risk not applicable to this parameter.

[e]56 Federal Register 33050 (July 18, 1991) TBC

2.4.4.1 Cross-Media Impact on Sediments

Modified soil PRGs were developed to be protective of sediments. Modified PRGs were required for the Solid Waste Landfill, South Field, and Active Flyash Pile. The Lime Sludge Ponds and Inactive Flyash Pile had no COCs that impacted sediments; therefore, no modified soil PRGs were necessary for these two subunits.

Modified soil PRGs were calculated from the results of the RI modeling and the Baseline Risk Assessment. The relationship between surface soil concentrations and sediment concentration is linear. The relationship between sediment concentration and the risk is also linear. Therefore, the modified PRGs can be calculated from Equation 2-1 by substituting the risk due to exposure to sediment summed over each exposure pathway (ingestion, direct radiation, and dermal contact) into the denominator. Leaving the surface soil concentration in the numerator produces a surface soil PRG that is protective of an ILCR risk in sediment.

Table 2-8 presents the modified soil PRGs that were calculated to be protective of sediments. These modified soil PRGs were developed assuming no source controls and apply to continued federal ownership (i.e., expanded trespasser). The COCs for sediment exposure are listed in Table 2-1. Table 2-8 shows that cross-media soil PRGs protective of sediment for radium-226 at the South Field and Active Flyash Pile are more restrictive than those calculated for the expanded trespasser in Table 2-5 (risk-based modified for federal ownership). In contrast, cross-media modified soil PRGs for total uranium at the Solid Waste Landfill and arsenic at the Active Flyash Pile protective of sediment (Table 2-8) are not as restrictive as modified soil PRGs for the expanded trespasser (Table 2-5).

2.4.4.2 Cross-Media Impact on Surface Water

Great Miami River

Modified soil PRGs were developed to be protective of the Great Miami River surface water for the South Field. Other Operable Unit 2 subunits had no COCs that impacted the Great Miami River surface water. Modified soil PRGs were calculated from the results of the RI modeling and the Baseline Risk Assessment. The relationships between surface soil concentrations, the Great Miami River concentrations, and risk are linear. Therefore, the modified PRGs can be calculated using Equation 2-1 by substituting the risk due to exposure to Great Miami River surface water summed

TABLE 2-8

CROSS-MEDIA MODIFIED SOIL PRGs PROTECTIVE OF SEDIMENTS WITHOUT SOURCE CONTROLS

COCs Impacting Sediments	Units	FEDERAL OWNERSHIP				Background
		Expanded Trespasser Modified PRGs[a]				
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[c]	
Solid Waste Landfill						
Uranium-Total	mg/kg	-[d]	-	-	180	3.7
South Field						
Radium-226	pCi/g	240	24	2.4	NA[e]	1.42
Active Flyash Pile						
Radium-226	pCi/g	230	23	2.3	NA	1.42
Arsenic	mg/kg	8600	860	86	NA	8.2

[a]Modified PRGs were developed using Equation 2-1.

[b]ILCR = incremental lifetime cancer risk.

[c]HI = hazard index.

[d]For total uranium, PRGs/PRLs were developed for a non-carcinogenic HI of 0.2.

[e]NA = not applicable.

over each exposure pathway (inhalation, ingestion, dermal contact, ingestion of fish, and ingestion of produce and beef/milk irrigated with surface water) into the denominator. This substitution produces a soil PRG protective of each target ILCR for users of the Great Miami River surface water.

Table 2-9 presents modified soil PRGs protective of the Great Miami River surface water from the South Field surface soils. These modified soil PRGs were developed assuming no source controls and apply for continued federal ownership as well as private ownership of the FEMP. The COCs for Great Miami River surface water exposure are listed in Table 2-1.

Paddys Run

Surface water concentrations within the subunit boundaries determined in the Baseline Risk Assessment (no action alternative) were compared to water quality standards (ARARs) for Paddys Run (see Appendix B). Only the South Field surface water concentrations were high enough to cause the surface water concentrations in Paddys Run to exceed water quality standards for dieldrin and polynuclear aromatic hydrocarbons (PAHs). Therefore, modified soil PRGs were developed for the South Field so that concentrations in Paddys Run surface water will not exceed ARARs. Other Operable Unit 2 subunits had no COCs with concentrations exceeding ARARs for Paddys Run.

The ARARs are concentration-based requirements; therefore, the PRGs are calculated by the following equation:

$$\frac{\text{ARAR Concentration}}{\text{PRG (Soil)}} = \frac{\text{Paddys Run Concentration}}{\text{Surface Soil Concentration}}$$

$$\text{PRG (Soil)} = \frac{\text{ARAR} * \text{Surface Soil Concentration}}{\text{Paddys Run Concentration}} \qquad (2\text{-}2)$$

This equation is possible because the relationship between surface soil concentrations and Paddys Run concentrations is linear. For total PAHs, the ratio of the concentration of one PAH to the total PAH concentration is assumed to be the same for the PRG (e.g., benzo(a)pyrene contributes 10 percent of

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the total PAH concentration in Paddys Run; therefore, it contributes 10 percent of the PRG concentration). Table 2-10 presents modified soil PRGs for the South Field contaminated material/soil that would not exceed ARAR water quality standards for Paddys Run. These modified soil PRGs were developed assuming no source controls and apply for continued federal ownership as well as private ownership of the FEMP.

2.4.4.3 Cross-Media Impacts on Groundwater

Technical Approach

Figure 2-4 that shows the technical approach used to develop modified soil PRGs based on cross-media contamination of groundwater. Based on the conceptual model and site-specific data, fate and transport models were used to predict future concentrations at the receptor points. In the Operable Unit 2 RI Report, modeling was performed to develop groundwater exposure point concentrations for on- and off-property resident farmers. The modeled groundwater concentrations were used to calculate risk for the farmer scenarios. The calculated risk values were then used to determine COCs for the groundwater pathway. In the Operable Unit 2 FS, iterative groundwater modeling was performed to determine the COC soil concentrations that would meet the groundwater levels (Table 2-4 or 2-7) that have been determined to be protective at acceptable risk ranges (1×10^{-4} to 1×10^{-6} ILCR or 0.2 HI). The model input (soil) concentration was varied until the desirable groundwater concentration was achieved. For compliance with MCLs, the soil input concentration was varied until the MCL was achieved at the point of compliance, which is the subunit boundary.

The approach to the fate and transport modeling in developing modified soil PRGs was to use ECTran, a screening model, to evaluate numerous conditions in a time-efficient manner. The modified soil PRGs determined from the cross-media impacts using ECTran were used as an initial estimate of modified soil PRGs. A complete assessment of modified soil PRGs was performed in a more complex fate and transport model, ODAST/improved SWIFT. A discussion of the Operable Unit 2 FS fate and transport modeling and values for all area-specific hydrogeological information used to develop modified soil PRGs are presented in Appendix D.

Similar to the Operable Unit 2 RI Report, the Operable Unit 2 FS quantifies the local vertical migration and the lateral migration of groundwater toward the edge of the till in or near the South Field and Inactive Flyash Pile subunits where the glacial till pinches out and the infiltrated perched water can directly migrate into the Great Miami Aquifer (Figures 2-5 and 2-6). The Hydrologic

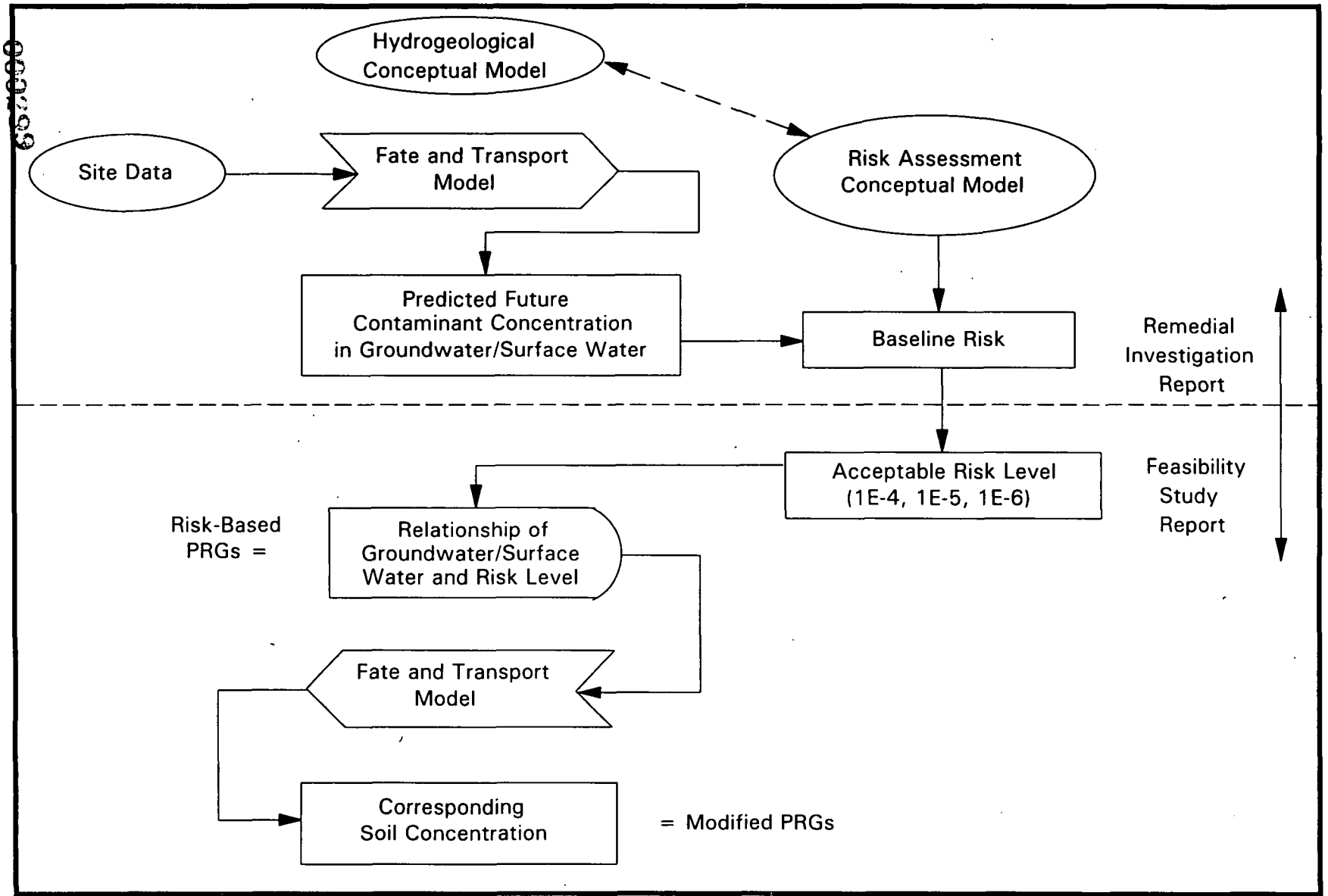

Figure 2-4

Development of Modified PRGs from the Baseline Risk Assessment Based on Cross-Media Contamination and/or Source Control

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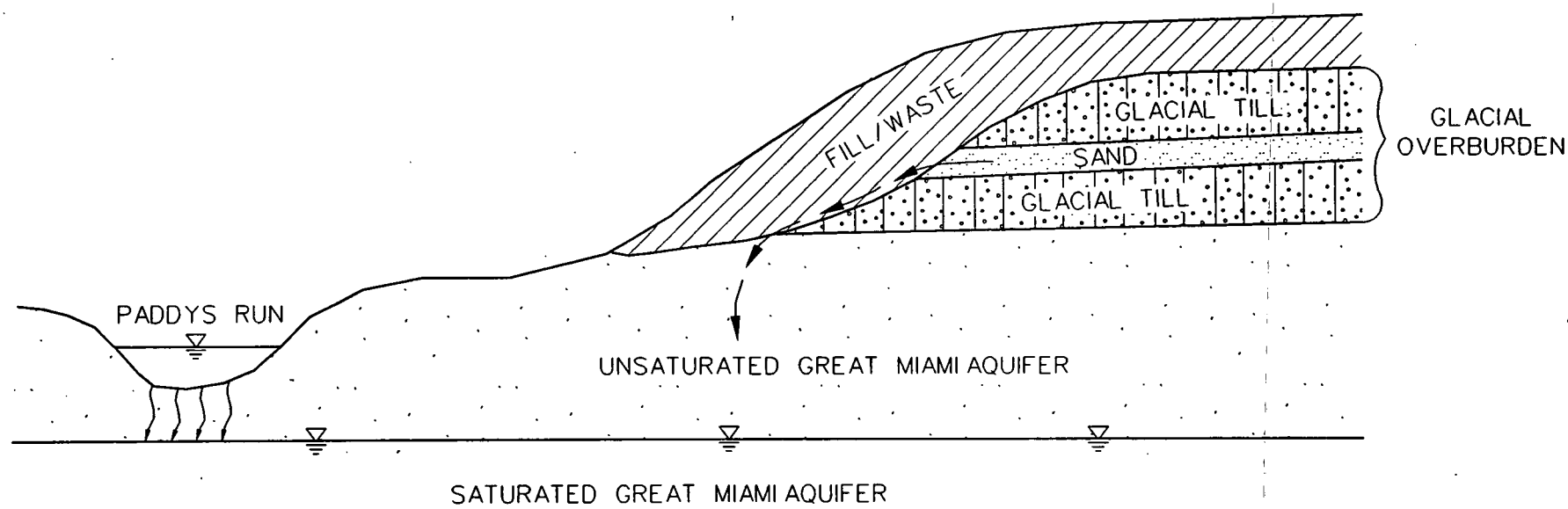

FIGURE 2-5
CONCEPTUAL MODEL FOR PERCHED WATER SUBSURFACE SEEPS

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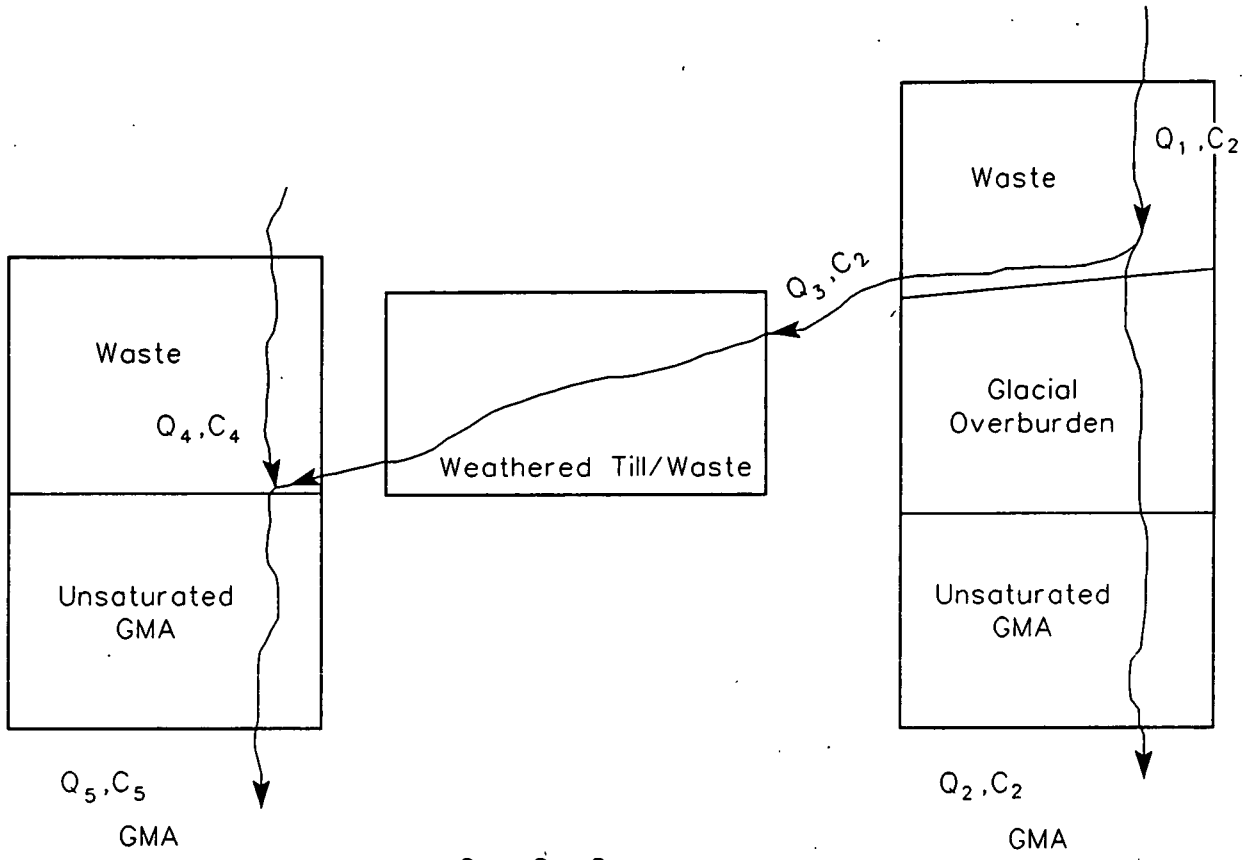

$$Q_1 = Q_2 + Q_3$$

$$Q_5 = Q_3 + Q_4$$

$$C_5 = \frac{Q_3 C_2 + Q_4 C_4}{Q_3 + Q_4}$$

NOTE:

C_i - CONSTITUENT CONCENTRATION
Q_i - FLOW RATE

CASE 1: Q_4, C_4; Q_3, C_2

CASE 2: Q_4; Q_3, C_2

CASE 3: Q_2, C_2

CASE 4: Q_4, C_4; Q_3, C_2; with initial background concentration is layer 1 and layer 2, where Q_1, Q_2 and Q_4 are vertical flows and Q_3 is lateral flow.

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FIGURE 2-6
CONCEPTUAL MODEL FOR LATERAL DRAINAGE INFILTRATING TO THE UNSATURATED GREAT MIAMI AQUIFER FOR THE OPERABLE UNIT 2 WASTE SUBUNITS

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TABLE 2-9

SOUTH FIELD
CROSS-MEDIA MODIFIED PRGs
PROTECTIVE OF THE GREAT MIAMI RIVER SURFACE WATER
WITHOUT SOURCE CONTROLS

COCs Impacting Great Miami River	Units	Modified Soil PRGs[a]			Background
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	
Radium-226	pCi/g	2400	240	24	1.42
Technetium-99	pCi/g	7100	710	71	0

[a]Modified soil PRGs were calculated using Equation 2-1.

[b]ILCR = incremental lifetime cancer risk.

000302

TABLE 2-10

SOUTH FIELD
CROSS-MEDIA MODIFIED SOIL PRGs
MEETING ARARs IN PADDYS RUN WITHOUT SOURCE CONTROLS

COCs Impacting Paddys Run	Modified Soil PRGs[a] (mg/kg)
Dieldrin	9.57×10^{-3}
Benzo(a)anthracene	4.55×10^{-1}
Benzo(a)pyrene	7.77×10^{-1}
Benzo(b)fluoranthene	5.13×10^{-1}
Benzo(k)fluoranthene	6.03×10^{-1}
Dibenzo(a,h)anthracene	1.57×10^{-1}
Indeno(1,2,3-cd)pyrene	4.96×10^{-1}
Phenanthrene	1.90×10^{-1}

[a]Modified soil PRGs were calculated using Equation 2-2.

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Evaluation of Landfill Performance (HELP) model was used to estimate local vertical and lateral infiltration rates for the Operable Unit 2 waste units.

Modified PRGs for groundwater protection were evaluated for two source areas: source soils over glacial till and source soils directly over the Great Miami Aquifer sands and gravels. These two source soils were evaluated individually, because COC travel times are vastly different depending on the presence of glacial till. Modified soil PRGs were required for all Operable Unit 2 subunits, because each subunit had COCs that had the potential to adversely impact groundwater.

The COCs that impacted groundwater were determined in the Baseline Risk Assessment (Section 6.0 and Appendix B of the Operable Unit 2 RI Report) and are summarized in Table 2-1. Uranium-234, uranium-235/236, uranium-238, and total uranium were added as groundwater COCs for the Solid Waste Landfill and the Lime Sludge Ponds in the FS due to modifications to site-specific distribution coefficients (K_ds) and other parameters used in the fate and transport models (see Appendix D).

Section 5.0 and Appendix A.2 of the Operable Unit 2 RI Report discussed the conceptual models used for the RI modeling. These models were also used to conceptualize the Operable Unit 2 subunits for modified soil PRG development modeling. K_ds were used (Appendix D.1). Details of the study to define site-specific K_d values are included in Appendices D.3 and D.4. PRGs shown in this section use a K_d of 24 for glacial till. The impact of uncertainty in the K_d value is discussed in Appendix D.1. Based on ODAST/SWIFT calibrations, 1.78 mL/g was used as a distribution coefficient for the Great Miami Aquifer (Appendix D.1). Other hydrogeological data, such as vertical and horizontal hydraulic conductivity, porosity, and soil density, were taken from the Operable Unit 2 RI Report. Specific hydrogeologic information used in PRG development is presented in Appendix D.1.

The Great Miami Aquifer under the containment source and the Great Miami Aquifer at the FEMP fenceline were the exposure points used for modeling. The selection of groundwater exposure points for modified soil PRG development was based on two scenarios: private ownership and federal ownership. Under private ownership, there are two potential receptors that may come in contact with groundwater from the Great Miami Aquifer: the on-property resident farmer and the off-property resident farmer. It was assumed that no administrative controls exist to limit access to the Great Miami Aquifer. The greatest impact is to the on-property resident farmer with an exposure point from the Great Miami Aquifer groundwater under the subunits. In contrast to the private ownership

scenario, federal ownership includes administrative controls that limit access to the Great Miami Aquifer under the waste units. Therefore, the only exposure point to a receptor (i.e., off-property resident farmer) from groundwater is the Great Miami Aquifer at the FEMP fenceline. However, ARARs require that the COC concentrations at the edge of the subunit not exceed the MCL under both federal and private ownership of the Operable Unit 2 area.

Modified PRG Results

Solid Waste Landfill - Table 2-11 presents the modified soil PRGs for the Solid Waste Landfill without controls. Note that cross-media soil PRGs (Table 2-11) are greater than risk-based soil PRGs (Table 2-3), but are less than the federal-ownership modified soil PRGs (Table 2-5) for the expanded trespasser.

Lime Sludge Ponds - Table 2-12 presents the modified soil PRGs for the Lime Sludge Ponds without source controls. Note that cross-media soil PRGs are greater than risk-based soil PRGs, but are less than the modified soil PRGs for the expanded trespasser.

Inactive Flyash Pile/South Field - Table 2-13 shows the modified soil PRGs for the Inactive Flyash Pile/South Field. These modified soil PRGs were developed assuming no source controls and that at the Inactive Flyash Pile and South Field lateral movement of perched water will not be controlled. The modified soil PRGs for the Inactive Flyash Pile and South Field are developed considering future impacts on perched groundwater, not current perched groundwater concentrations. Modified soil PRGs at the Inactive Flyash Pile/South Field could be 2.5 picoCuries per gram (pCi/g) uranium-238 at 10^{-6} ILCR for the off-property resident farmer and 0.89 pCi/g uranium-238 at 10^{-6} ILCR for the on-property resident farmer.

Active Flyash Pile - The Operable Unit 2 RI Report determined that uranium isotopes are COCs for the Active Flyash Pile. The RI data also indicate that flyash in the Active Flyash Pile is homogeneous with respect to the uranium concentration. Therefore, to be protective of groundwater, all flyash from the Active Flyash Pile must be removed, or source controls must be applied. For the residual soils, modified soil PRGs are shown in Table 2-14. The modified soil PRG for uranium-238 at 10^{-6} ILCR is 5.0 pCi/g for the off-property resident farmer.

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TABLE 2-11

SOLID WASTE LANDFILL CROSS-MEDIA MODIFIED SOIL PRGs PROTECTIVE OF THE GREAT MIAMI AQUIFER WITHOUT SOURCE CONTROLS

COCs Impacting Groundwater	Units	Private Ownership On-Property Resident Farmer PRGs					Federal Ownership Off-Property Resident Farmer PRGs					Background Concentration
		10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[b]	ARAR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	0.2 HI	ARAR	
Uranium-234	pCi/g	191	19.1	1.91	NA[c]	NA	6190	619	61.9	NA	NA	1.04
Uranium-235/236	pCi/g	191	19.1	1.91	NA	NA	6190	619	61.9	NA	NA	0.15
Uranium-238	pCi/g	125	12.5	1.25	NA	NA	4050	405	40.5	NA	NA	1.12
Uranium-Total	mg/kg	NA	NA	NA	32.8	38.6	NA	NA	NA	956	38.6	3.4

[a]ILCR = incremental lifetime cancer risk.

[b]HI = hazard index.

[c]NA = not applicable.

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TABLE 2-12

LIME SLUDGE PONDS
CROSS-MEDIA MODIFIED SOIL PRGs
PROTECTIVE OF THE GREAT MIAMI AQUIFER
WITHOUT SOURCE CONTROLS

COCs Impacting Groundwater	Units	Private Ownership On-Property Resident Farmer PRGs					Federal Ownership Off-Property Resident Farmer PRGs					Background Concentration
		10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[b]	ARAR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	0.2 HI	ARAR	
Uranium-234	pCi/g	712	71.2	7.12	NA[c]	NA	19500	1950	195	NA	NA	1.04
Uranium-235/236	pCi/g	712	71.2	7.12	NA	NA	19500	1950	195	NA	NA	0.15
Uranium-238	pCi/g	466	46.6	4.66	NA	NA	12700	1270	127	NA	NA	1.12
Uranium-Total	mg/kg	NA	NA	NA	115	136	NA	NA	NA	3000	136	3.4

[a]ILCR = incremental lifetime cancer risk.

[b]HI = hazard index.

[c]NA = not applicable.

000507

TABLE 2-13

INACTIVE FLYASH PILE/SOUTH FIELD CROSS-MEDIA MODIFIED SOIL PRGs PROTECTIVE OF THE GREAT MIAMI AQUIFER[a]

COCs Impacting Groundwater	Units	Private Ownership On-Property Resident Farmer PRG					Federal Ownership Off-Property Resident Farmer PRGs					Background Concentration
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[c]	ARAR[d]	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	0.2 HI	ARAR	
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER												
Uranium-234	pCi/g	136	13.6	1.36	NA[e]	NA	1250	91	7.64	NA	NA	1.04
Uranium-235/236	pCi/g	136	13.6	1.36	NA	NA	1250	91	7.64	NA	NA	0.15
Uranium-238	pCi/g	89	8.9	0.89	NA	NA	819	60	5	NA	NA	1.12
Uranium-Total	mg/kg	NA	NA	NA	21	24.8	NA	NA	NA	118	24.8	3.4
SOURCE MATERIAL ON THE TOP OF THE TERRACE (GLACIAL TILL)												
Uranium-234	pCi/g	136	13.6	1.36	NA	NA	320	32	3.2	NA	NA	1.04
Uranium-235/236	pCi/g	136	13.6	1.36	NA	NA	320	32	3.2	NA	NA	0.15
Uranium-238	pCi/g	89	8.9	0.89	NA	NA	210	21	2.1	NA	NA	1.12
Uranium-Total	mg/kg	NA	NA	NA	21	24.8	NA	NA	NA	50	24.8	3.4

[a]This data was developed by considering future impacts on perched groundwater from Operable Unit 2 and does not include current perched groundwater concentrations.

[b]ILCR = incremental lifetime cancer risk.

[c]HI = hazard index.

[d]ARAR refers to drinking water standard of 20 mg/l. Value shown is soil concentration protective of this standard.

[e]NA = not applicable.

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TABLE 2-14

ACTIVE FLYASH PILE
CROSS-MEDIA MODIFIED SOIL PRGs
PROTECTIVE OF THE GREAT MIAMI AQUIFER
WITHOUT SOURCE CONTROLS

COCs Impacting Groundwater	Units	Private Ownership On-Property Resident Farmer PRG					Federal Ownership Off-Property Resident Farmer PRGs					Background Concentration
		10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[b]	ARAR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	0.2 HI	ARAR	
Uranium-234	pCi/g	155	15.5	1.55	NA[c]	NA	760	76	7.6	NA	NA	1.04
Uranium-235/236	pCi/g	155	15.5	1.55	NA	NA	760	76	7.6	NA	NA	0.15
Uranium-238	pCi/g	101	10.1	1.01	NA	NA	500	50	5.0	NA	NA	1.12
Uranium-Total	mg/kg	NA	NA	NA	24	28	NA	NA	NA	172	28	3.4

[a]ILCR = incremental lifetime cancer risk.

[b]HI = hazard index.

[c]NA = not applicable.

2.4.4.4 Cross-Media Impacts on Perched Water

Table 2-1 lists the COCs for cross-media impacts on perched water. COCs were identified for the perched water at the Solid Waste Landfill and the Lime Sludge Ponds. Perched groundwater was not considered a source of drinking water at the South Field, Inactive Flyash Pile, or Active Flyash Pile due to limited yield from the perched water and close proximity of the Great Miami Aquifer.

The perched water is typically discontinuous under the FEMP, and downgradient transport of COCs was not considered in this FS. The full extent of COC migration on perched groundwater will be considered in the Operable Unit 5 RI/FS Reports. Therefore, the only applicable perched water exposure point for modified soil PRG development was the perched water directly below the subunit. The potential receptor for the perched water was the on-property resident farmer. For modified soil PRG development, this was considered a conservative approach, since the closest exposure point, the perched water under the source, resulted in the lowest modified soil PRGs.

It was assumed that no protective barrier exists between the source and the perched water. Furthermore, dilution in the perched water was not considered while developing PRGs. Therefore, perched water concentrations were assumed to be the same as the leachate concentration. Modified soil PRGs were calculated by multiplying the risk-based ILCR groundwater concentrations found in Table 2-3 by the desorption distribution coefficient (see Appendix D).

Solid Waste Landfill

Table 2-15 presents the modified soil cross-media impact on perched groundwater PRGs for the Solid Waste Landfill without source controls. Note that the PRG for cross-media soil impact on perched groundwater is less than the risk-based soil PRGs.

Lime Sludge Ponds

Table 2-16 presents the modified soil cross-media impact on perched groundwater PRGs for the Lime Sludge Ponds without source controls. Note that the PRG for cross-media soil impact on perched groundwater PRGs is greater than the risk-based soil PRGs.

2.4.4.5 Cross-Media Impact to Air (Radon)

Cross-media impacts from radium-226 in surface and subsurface soils resulting in radon exposure were found to exceed the target risk level (1×10^{-6}) at all of the subunits except the Lime Sludge

TABLE 2-15

SOLID WASTE LANDFILL CROSS-MEDIA MODIFIED SOIL PRGs PROTECTIVE OF PERCHED WATER

COCs Impacting Perched Water	Units	PRIVATE OWNERSHP On-Property Resident Farmer (RME)[a] PRG[b]					Current Concentration	Background Concentration
		10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[d]	ARAR		
CARCINOGENIC								
Technetium-99	pCi/g	1.89×10^{-1}	1.89×10^{-2}	1.89×10^{-3}	NA[e]	NA	7.5E-1	0
Uranium-234	pCi/g	8.25	0.825	0.0825	NA	NA	97	1.04
Uranium-235/236	pCi/g	8.25	0.825	0.0825	NA	NA	8.04	0.15
Uranium-238	pCi/g	5.4	0.54	0.054	NA	NA	107.2	1.12
Uranium-total	mg/kg	NA	NA	NA	1.275	1.5	0.48	3.4
Carbazole	mg/kg	6.43×10^{-1}	6.43×10^{-2}	6.43×10^{-3}	NA	NA	4.2E+0	0

[a]RME = reasonable maximum exposure.

[b]PRGs were calculated by multiplying leachate (desorption) distribution coeffecient and groundwater risk-based concentration.

[c]ILCR = incremental lifetime cancer risk.

[d]HI = hazard index.

[e]NA = not applicable.

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TABLE 2-16

LIME SLUDGE PONDS
CROSS-MEDIA MODIFIED SOIL PRGs
PROTECTIVE OF PERCHED WATER

COCs Impacting Perched Water	Units	PRIVATE OWNERSHIP On-Property Resident Farmer (RME)[a] PRG[b]					Current Concentration	Background Concentration
		10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[d]	ARAR		
CARCINOGENIC								
Neptunium-237	pCi/g	5.1×10^{-1}	5.1×10^{-2}	5.1×10^{-3}	NA[e]	NA	0.32	0
Strontium-90	pCi/g	5.6×10^{-1}	5.6×10^{-2}	5.6×10^{-3}	NA	NA	0.84	0.56
Technetium-99	pCi/g	1.89×10^{-1}	1.89×10^{-2}	1.89×10^{-3}	NA	NA	1.05	00
Uranium-234	pCi/g	22.0	2.20	0.22	NA	NA	6.18	1.04
Uranium-235/236	pCi/g	22.0	2.20	0.22	NA	NA	0.43	0.15
Uranium-238	pCi/g	14.4	1.44	0.144	NA	NA	7.25	1.12
Uranium-Total	mg/kg	NA	NA	NA	3.40	4.0	22.2	3.4

[a]RME = reasonable maximum exposure.

[b]PRGs were calculated by multiplying leachate (desorption) distribution coefficient by groundwater risk-based concentration.

[c]ILCR = incremental lifetime cancer risk.

[d]HI = hazard index.

[e]NA = not applicable.

Pond. Table 2-17 shows the soil PRGs that are protective of the air within the indicated subunit. Note that inhalation of airborne contaminated particles was included in the risk-based PRGs in Section 2.4.1 and federal-ownership modified PRGs in Section 2.4.3.

2.4.5 Modified Soil PRGs for Cross Media with Source Controls

Two potential Operable Unit 2 source controls were evaluated for modified soil PRG development. These source controls assume federal ownership; therefore, applicable receptors include the expanded trespasser and the off-property resident farmer.

The first source control prevented lateral migration of the perched water at the Inactive Flyash Pile and South Field. This source control prevented contaminants from migrating laterally from the perched water to areas where glacial till was not present and then vertically to the Great Miami Aquifer (see Figure 2-6). This pathway is known as the perched water subsurface seep pathway, and by eliminating this pathway, COC loading to the Great Miami Aquifer was significantly reduced. This can be accomplished by various means, including installation of a collector trench or by excavating the interbedded granular material.

The second source control reduced vertical infiltration rates. This reduced the COC mass loading to the Great Miami Aquifer. While the first source control was applied only to the Inactive Flyash Pile and the South Field, the second source control was applied to all Operable Unit 2 subunits. Reduction of vertical infiltration would be accomplished by a capping system.

A capping system would prevent COCs in surface soils from coming in contact with the receptors and all transport media except infiltration to groundwater. Therefore, direct contact with surface soils and cross-media impacts to sediments, Great Miami River surface water, and impacts from dust on beef/milk and homegrown produce were no longer applicable. Furthermore, source controls assumed federal ownership; therefore, applicable receptors were the expanded trespasser and the off-property resident farmer. Since the receptor point for the perched water was the on-property resident farmer, cross-media impacts to perched water were also not applicable for the source-control scenario. As only cross-media impacts to groundwater would be affected from the described source controls (with the exception of eliminating pathways) modified PRGs were developed only for cross-media impacts to groundwater.

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TABLE 2-17

CROSS-MEDIA MODIFIED SOIL PRGs PROTECTIVE OF AIR (RADON EXPOSURE)

Subunit	PRIVATE OWNERSHIP	FEDERAL OWNERSHIP	
	On-Property Resident Farmer 10^{-6} ILCR (pCi/g of Radium-236)	Expanded Trespasser 10^{-6} ILCR (pCi/g of Radium-226)	Off-Property Resident Farmer 10^{-6} ILCR (pCi/g of Radium-226)
Solid Waste Landfill	1.0	-[a]	-
Inactive Flyash Pile	0.47	-	-
South Field	0.51	16	7
Active Flyash Pile	3.1	-	-

[a]Not a COC for this scenario.

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2.4.5.1 Solid Waste Landfill

Table 2-18 presents the modified soil PRGs for the Solid Waste Landfill with a cap. Note that cross-media soil PRGs are greater than the maximum soil concentrations (577 pCi/g uranium-238) determined at the Solid Waste Landfill during the RI field investigations.

2.4.5.2 Lime Sludge Ponds

Table 2-19 presents the modified soil PRGs for the Lime Sludge Ponds with a cap. Note that cross-media soil PRGs are greater than the maximum soil concentrations (20.4 pCi/g uranium-238) determined at the Lime Sludge Ponds during the RI field investigations.

2.4.5.3 Inactive Flyash Pile and South Field

Tables 2-20 and 2-21 present modified soil PRGs protective of the Great Miami Aquifer using source controls for (1) preventing lateral migration of the perched water alone, and (2) with reduced infiltration and preventing lateral migration of the perched water, respectively. With lateral migration controls only, the modeling indicated that the uranium-238 PRGs for 10^{-6} ILCR for source material overlying the Great Miami Aquifer were 5 pCi/g and for material over the glacial till terrace were 70. A cap over the source material directly underlain by the Great Miami Aquifer was not considered, because this area is in the Paddys Run floodplain.

When considering infiltration controls and the prevention of lateral migration of perched groundwater, the PRGs for 10^{-6} ILCR were greater than 10,000 pCi/g. Since the maximum uranium-238 concentration measured in soil samples at the South Field was 397 pCi/g and at the Inactive Flyash Pile was 1,570 pCi/g, it is believed that the source material currently on the top of the terrace at the South Field will not impact the Great Miami Aquifer at the fenceline if perched water lateral migration is controlled.

2.4.5.4 Active Flyash Pile

A large of portion of Active Flyash Pile is directly underlain by the Great Miami Aquifer. Furthermore, the Active Flyash Pile is very close to the Storm Sewer Outfall Ditch. Installing a cap over the Active Flyash Pile may require relocating the Storm Sewer Outfall Ditch or moving the flyash pile north of its current position. Due to these considerations, modified PRGs for a capped Active Flyash Pile scenario were not developed. However, consolidation and containment of the

TABLE 2-18

SOLID WASTE LANDFILL
MODIFIED SOIL PRGs
PROTECTIVE OF THE GREAT MIAMI AQUIFER USING A CAP

COCs Impacting Groundwater	Units	Modified Soil PRGs[a] (Off-Property Resident Farmer)			Background Concentration
		10^{-6} ILCR[b]	0.2 HI[c]	ARAR	
Uranium-234	pCi/g	>100,000	NA[d]	NA	1.04
Uranium-235/236	pCi/g	>100,000	NA	NA	0.15
Uranium-238	pCi/g	>100,000	NA	NA	1.12
Uranium-Total	mg/kg	NA	>100,000	>100,000	3.4

[a]Modified soil PRGs are based on ODAST/SWIFT modeling and assume an infiltration rate of 1.14 in./yr through the cap and soils (HELP model results). Glacial till K_d and Great Miami Aquifer K_d were assumed to be 24 mL/g and 1.78 mL/g, respectively.

[b]ILCR = incremental lifetime cancer risk.

[c]HI = hazard index.

[d]NA = not applicable.

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TABLE 2-19

LIME SLUDGE PONDS
MODIFIED SOIL PRGs
PROTECTIVE OF THE GREAT MIAMI AQUIFER USING A CAP

COCs Impacting Groundwater	Units	Modified Soil PRGs[a] (Off-Property Resident Farmer)			Background Concentration
		10^{-6} ILCR[b]	0.2 HI[c]	ARAR	
Uranium-234	pCi/g	>100,000	NA[d]	NA	1.04
Uranium-235/236	pCi/g	>100,000	NA	NA	0.15
Uranium-238	pCi/g	>100,000	NA	NA	1.12
Uranium-Total	mg/kg	NA	>100,000	>100,000	3.4

[a]Modified soil PRGs are based on ODAST/SWIFT modeling and assume an infiltration rate of 1.14 in./yr through the cap and soils (HELP model results). Glacial till K_d and Great Miami Aquifer K_d were assumed to be 24 mL/g and 1.78 mL/g, respectively.

[b]ILCR = incremental lifetime cancer risk.

[c]HI = hazard index.

[d]NA = not applicable.

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TABLE 2-20

INACTIVE FLYASH PILE/SOUTH FIELD CROSS-MEDIA MODIFIED SOIL PRGs PROTECTIVE OF THE GREAT MIAMI AQUIFER USING LATERAL MIGRATION SOURCE CONTROLS

COCs Impacting Groundwater	Units	Federal Ownership Off-Property Resident Farmer PRGs					Background Concentration
		10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[b]	ARAR	
Source Material Over The Great Miami Aquifer							
Uranium-234	pCi/g	1250	91	7.64	NA[c]	NA	1.04
Uranium-235/236	pCi/g	1250	91	7.64	NA	NA	0.15
Uranium-238	pCi/g	819	60	5	NA	NA	1.12
Uranium-Total[d]	mg/kg	NA	NA	NA	172	28	3.4
Source Material On The Top Of The Terrace (Glacial Till)							
Uranium-234	pCi/g	10700	1070	107	NA	NA	1.04
Uranium-235/236	pCi/g	10700	1070	107	NA	NA	0.15
Uranium-238	pCi/g	7000	700	70	NA	NA	1.12
Uranium-Total	mg/kg	NA	NA	NA	2975	450	3.4

[a]ILCR = incremental lifetime cancer risk.

[b]HI = hazard index.

[c]NA = not applicable.

[d]Total uranium PRGs and PRLs were developed for a HI of 0.2.

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TABLE 2-21

INACTIVE FLYASH PILE/SOUTH FIELD/ACTIVE FLYASH PILE CROSS-MEDIA MODIFIED SOIL PRGs PROTECTIVE OF THE GREAT MIAMI AQUIFER USING A CAP AND LATERAL MIGRATION SOURCE CONTROLS

COCs Impacting Groundwater	Units	Federal Ownership Off-Property Resident Farmer PRGs[a]					Background
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	0.2 HI[c]	ARAR	
Source Material On The Top Of The Terrace (Glacial Till)							
Uranium-234	pCi/g	> 100,000	> 100,000	> 10,000	NA	NA	1.04
Uranium-235/236	pCi/g	> 100,000	> 100,000	> 10,000	NA	NA	0.15
Uranium-238	pCi/g	> 100,000	> 100,000	> 10,000	NA	NA	1.12
Uranium-Total[d]	mg/kg	NA	NA	NA	> 10,000	> 10,000	3.4

[a]Cap is not considered in an area where source material is directly underlain by the Great Miami Aquifer. Therefore, no PRGs were developed for this case.

[b]ILCR = incremental lifetime cancer risk.

[c]HI = hazard index.

[d]Total uranium PRGs and PRLs were developed only for a HI of 0.2.

Active Flyash Pile source together with the South Field/Inactive Flyash Pile is possible in that case. Table 2-21 also applies for the Active Flyash Pile.

The perched water subsurface seep pathway does not apply to the Active Flyash Pile. (See Operable Unit 2 RI Report, Appendix A.2.) Therefore, source controls for the perched water at the Active Flyash Pile were not evaluated.

2.5 EXAMPLE OF PRG/PRL DEVELOPMENT

To clarify the process used to develop PRGs/PRLs, Figure 2-7 was prepared as an example to summarize the development pathway for uranium-238 soil PRGs at a 10^{-6} ILCR for the South Field. The process begins with the development of a risk-based PRG, as described in Section 2.4.1. Next, the federal ownership scenario is applied to limit the exposure of receptors to the source materials. By limiting the direct exposure routes, the PRGs increase. Cross-media evaluations consider the future impact on groundwater from contaminated soils. The cross-media modified soil PRGs are evaluated with federal ownership and private ownership. Cross-media impacts are altered by geologic conditions, so the cross-media modified soil PRGs are also evaluated for source material directly over the Great Miami Aquifer and source material over a layer of glacial till. Evaluating the cross-media impacts resulted in low PRGs even under federal ownership with administrative control. Finally, source controls are considered to limit cross-media impacts and exposure pathways. The source controls increase the PRGs to levels that allow some flexibility in consideration of remediation technologies.

Figure 2-7 shows the cross-media modified soil PRGs for the two land-use cases (expanded trespasser and on-property resident farmer) and the two geologic conditions. For the expanded trespasser 1×10^{-6} ILCR with no source controls, the direct exposure PRL is 54.8 pCi/g. Since the expanded trespasser is not exposed to groundwater, the cleanup level also has to be protective of the off-property resident farmer. The off-property resident farmer has a direct exposure PRL of 221 pCi/g and a 6.1 pCi/g and 3.2 pCi/g PRL for cross-media impacts to groundwater without source controls for source material over the Great Miami Aquifer and source material over the glacial till terrace, respectively. The cleanup level has to be protective of all pathways; therefore, it needs to be the lowest applicable PRL. The lowest applicable PRL for the expanded trespasser/off-property resident farmer scenario is 1×10^{-6} ILCR; without source controls that PRL is 6.1 pCi/g for materials over the Great Miami Aquifer and 3.2 pCi/g for materials over the glacial till terrace. One more

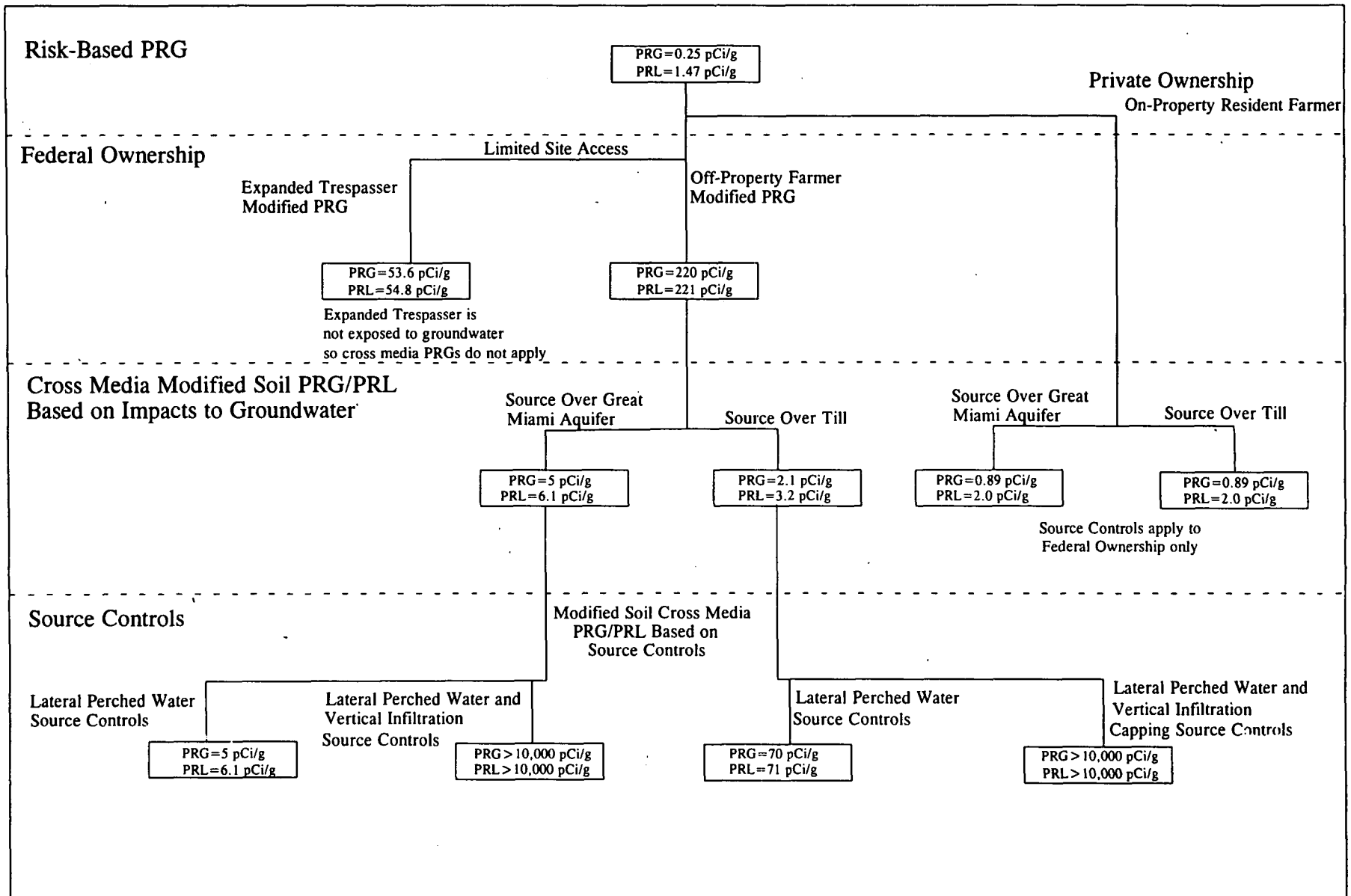

FIGURE 2-7 SUMMARY OF SOIL PRG/PRL AT 10^{-6} ILCR FOR URANIUM-238 IN THE SOUTH FIELD

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modification to the cleanup level will occur if lateral migration of perched groundwater is eliminated in the glacial till terrace. Once this migration is prevented by installation of an interception system or excavation of the interbedded sand and gravel, the cleanup level for materials over the glacial till terrace increases from 3.2 pCi/g to 71 pCi/g. For the on-property resident farmer scenario, the risk based PRL is 1.47 pCi/g and the cross media modified PRL is 2.0 pCi/g for both geologic conditions. Since the risk-based PRL is lower than the cross-media modified PRL, the cleanup level for the on-property resident farmer 1 x 10^{-6} ILCR scenario is 1.47 pCi/g.

2.6 REMEDIAL ACTION OBJECTIVES

RAOs for Operable Unit 2 are based on site-specific contaminants and various exposure pathways. The RAOs establish goals for protecting human health and the environment for the soil/waste material in Operable Unit 2 subunits.

The goals for protecting human health and the environment depend on the contaminated media and the exposure pathways. The exposure pathways are very dependent on the future land use designated for the FEMP site. As described in Section 2.4, the two land-use scenarios considered in this FS are continuing federal ownership of the FEMP (with restricted access) and the use by a resident farmer with no use limitations. These future land-use scenarios envelope any future land use. Corresponding PRLs have been determined to meet the acceptable risk range determined by the NCP (10^{-4} to 10^{-6} and a HI = 0.2).

The RAOs for Operable Unit 2 are the following or any combination of the following actions:

(1) Reduce the contaminant source to meet PRL

(2) Restrict access to the contaminant source or media impacted by the contaminant source

(3) Reduce transport of contaminants

(4) Eliminate receptors' exposure to the contaminant source

Table 2-22 presents the PRLs for the protection of an on-property resident farmer with unrestricted use of the Operable Unit 2 areas. The PRLs provided are the most restrictive levels needed to be protective for all exposure pathways associated with the on-property resident farmer scenario. Uranium-238 has a second PRL listed in Table 2-22 for alternatives that remediate perched groundwater. Once perched groundwater is remediated it is no longer a pathway of concern, and the

TABLE 2-22

SUMMARY OF OPERABLE UNIT 2 PRLS FOR PRIVATE OWNERSHIP

COC	Background Value[b]	Private Ownership				
		On-Property Resident Farmer (RME)[a] PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR	HI[d] 0.2	ARAR
ALL SUBUNITS						
Radium-226	1.42	1.81	1.46	1.43	-	6.42
Radium-228	1.25	2.07	1.33	1.26	-	6.25
Thorium-228	1.43	1.85	1.44	1.43	-	-
Thorium-232	1.36	1.64	1.39	1.36	-	6.36
SOLID WASTE LANDFILL						
Neptunium-237	0.0	4.3	4.3E-1	4.3E-2	-	-
Thorium-230	1.97	79	9.6	2.74	-	6.97
Technetium-99	0.0	1.89E-1	1.89E-2	1.89E-3	-	-
Strontium-90	0.0	1.6	1.6E-1	1.6E-2	-	-
Plutonium-238	0.0	4.0E+1	4.0	4.0E-1	-	-
Uranium-234	1.04	9.29	1.86	1.12	-	-
Uranium-235/236	0.15	8.4	0.97	0.23	-	-
Uranium-238	1.12	6.52	1.66	1.17	1.12[e]	1.12[e]
Uranium-238[f]	1.22	26.2	3.72	1.47	-	-
Antimony	0.0	-	-	-	1.33	-
Arsenic	8.2	8.2	8.2	8.2	-	-
Beryllium	0.6	3.3	0.6	0.6	-	-
Benzo(a)anthracene	0.0	2.3	2.3E-1	2.3E-2	-	-
Benzo(a)pyrene	0.0	1.5E-1	1.5E-2	1.5E-3	-	-
Benzo(b)fluoranthene	0.0	1.4	1.4E-1	1.4E-2	-	-
Carbazole	0.0	6.43E-1	6.43E-2	6.43E-3	-	-
Dibenzo(a,h)anthracene	0.0	4.6E-2	4.6E-3	4.6E-4	-	-
Indeno(1,2,3-cd)pyrene	0.0	7.3E-1	7.3E-2	7.3E-3	-	-
Uranium-Total	3.4	-	-	-	3.4	3.4
LIME SLUDGE POND						
Cesium-137	0.71	1.8	0.89	0.72	-	-
Neptunium-237	0.0	5.1E-1	5.1E-2	5.1E-3	-	-
Strontium-90	0.0	5.6E-1	5.6E-2	5.6E-3	-	-
Technetium-99	0.0	1.89E-1	1.89E-2	1.89E-3	-	-
Thorium-230	1.97	79	9.6	2.74	-	6.97
Uranium-234	1.04	23	3.24	1.26	-	-
Uranium-235/236	0.15	9.2	1.05	0.24	-	-
Uranium-238	1.12	15.5	2.56	1.26	1.12[e]	1.33[e]
Uranium-238[f]	1.22	26.2	3.72	1.47	-	-
Uranium-Total	3.4	-	-	-	3.4	4.0

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See footnotes at end of table.

TABLE 2-22
(Continued)

COC	Background Value[b]	Private Ownership: On-Property Resident Farmer (RME)[a] PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR	HI[d] 0.2	ARAR
ACTIVE FLYASH PILE						
Cesium-137	0.71	1.8	0.89	0.72	-	-
Neptunium-237	0.0	4.3	4.3E-1	4.3E-2	-	-
Arsenic	8.2	8.2	8.2	8.2	-	-
Beryllium	0.6	3.3	0.6	0.6	-	-
Uranium-234	1.24	78.2	8.9	2.0	-	-
Uranium-235/236	0.15	9.2	1.05	0.24	-	-
Uranium-238	1.22	26.2	3.72	1.47	8[e]	9.3[e]
Uranium-Total	3.4	-	-	-	24	28
INACTIVE FLYASH PILE						
Arsenic	8.2	8.2	8.2	8.2	-	-
Dibenzo(a,h)anthracene	0.0	4.6E-2	4.6E-3	4.6E-4	-	-
Uranium-234	1.24	78.2	8.9	2.0	-	-
Uranium-235/236	0.15	9.2	1.05	0.24	-	-
Uranium-238	1.22	26.2	3.72	1.47	7[e]	8.3[e]
Uranium-Total	3.4	-	-	-	21	24.8
SOUTH FIELD						
Cesium-137	0.71	1.8	0.89	0.72	-	-
Neptunium-237	0.0	4.3	4.3E-1	4.3E-2	-	-
Thorium-230	1.97	79	9.6	2.74	-	6.97
Strontium-90	0.0	1.6	1.6E-1	1.6E-2	-	-
Technetium-99	0.0	1.74	1.74E-1	1.74E-2	-	-
Uranium-234	1.24	78.2	8.9	2.0	-	-
Uranium-235/236	0.15	9.2	1.05	0.24	-	-
Uranium-238	1.22	26.2	3.72	1.47	7[e]	8.3[e]
Uranium-Total	3.4	-	-	-	21	24.8
Arsenic	8.2	8.2	8.2	8.2	-	-
Beryllium	0.6	3.3	0.6	0.6	-	-
Aroclor-1254	0.0	1.5E-1	1.5E-2	1.5E-3	-	-
Aroclor-1260	0.0	2.3E-2	2.3E-3	2.3E-4	-	-
Benzo(a)anthracene	0.0	2.3	2.3E-1	2.3E-2	-	0.455
Benzo(a)pyrene	0.0	1.5E-1	1.5E-2	1.5E-3	-	0.777
Benzo(b)fluoranthene	0.0	1.4	1.4E-1	1.4E-2	-	0.513
Benzo(k)fluoranthcene	0.0	4.7	4.7E-1	4.7E-2	-	0.603
Dibenzo(a,h)anthracene	0.0	4.6E-2	4.6E-3	4.6E-4	-	0.157
Dieldrin	0.0	4.0E-3	4.0E-4	4.0E-5	-	9.57E-3

See footnotes at end of table.

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TABLE 2-22
(Continued)

COC	Background Value[b]	Private Ownership				
		On-Property Resident Farmer (RME)[a] PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR	HI[d] 0.2	ARAR
SOUTH FIELD (Continued)						
Indeno(1,2,3-cd)pyrene	0.0	7.3E-1	7.3E-2	7.3E-3	-	0.496
Phenanthrene	0.0	-	-	-	-	0.19

[a]RME = reasonable maximum exposure.

[b]Background value from RI Report, Table 4-1a, surface concentrations.

[c]ILCR = incremental lifetime cancer risk; value shown is ILCR plus background.

[d]HI = hazard index.

[e]This value determined by calculating the uranium-238 concentration in uranium-total.

[f]This PRL applies for direct contact with surface soils and becomes significant in the Solid Waste Landfill and Lime Sludge Ponds when the perched groundwater is remediated and no longer applies.

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PRL is adjusted to direct contact pathways. Uranium-238 has a HI and an ARAR value as a result of converting uranium total into its uranium-238 factor. The specific RAO associated with this land use is reducing the contaminant source to meet the PRLs listed in Table 2-22.

Table 2-23 presents PRLs for the protection of an expanded trespasser and an off-property resident farmer under a continued federal ownership land-use scenario with access restrictions. The PRLs contained in this table are the most restrictive levels for the COCs from all direct and cross-media exposure pathways identified as concerns in the Baseline Risk Assessment. The specific RAOs associated with this land use of Operable Unit 2 are reducing the contaminant source to meet the PRLs in Table 2-23 and restricting access to the contaminant source or media impacted by the contaminant source. To allow additional alternatives to be evaluated in this FS, two source controls were also evaluated. Table 2-24 provides the PRLs for the protection of an expanded trespasser and an off-property resident farmer under continued federal ownership if the lateral movement of water is controlled at the Inactive Flyash Pile and South Field. The specific RAOs associated with this land use and source control include reducing the contaminant source to meet the PRLs listed in Table 2-24, restricting access to the contaminant source or media impacted by the contaminant source, and reducing transport of contaminants by controlling lateral movement of water at the Inactive Flyash Pile and the South Field.

Table 2-25 presents the PRLs for the protection of an expanded trespasser and off-property resident farmer under a continued federal ownership land-use scenario if all the subunits had a source control that would reduce infiltration and prevent direct contact. These PRLs also reflect the source control for the Inactive Flyash Pile and South Field that would control the lateral movement of water. The specific RAOs associated with this land use and source controls include reducing the contaminant source to meet the PRLs listed in Table 2-25, restricting access to the contaminant source or media impacted by the contaminant source, and reducing transport of contaminants.

A summary of the specific Operable Unit 2 subunit RAOs for the scenarios is provided in Table 2-26. In Section 3.0, these RAOs will be addressed by GRAs which serve as the basis for the development of specific technologies and process options.

TABLE 2-23

SUMMARY OF OPERABLE UNIT 2 RISK-BASED SOIL PRLs FOR FEDERAL OWNERSHIP

COC	Background[a]	FEDERAL OWNERSHIP PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	HI[c] 0.2	ARAR
ALL SUBUNITS						
Radium-226	1.42	38.3	5.1	1.8	-	6.42
Radium-228	1.25	78.3	8.9	2.0	-	6.25
Thorium-228	1.43	41.3	5.4	1.8	-	-
Thorium-232	1.36	27.6	3.9	1.5	-	6.36
SOLID WASTE LANDFILL						
Uranium-234[d]	1.04	6191	620	62.9	-	-
Uranium-235/236[d]	0.15	6190	619	63.1	-	-
Uranium-238	1.22	5361	537	54.8	318.7[e]	12.9[e]
Uranium-Total	3.4	-	-	-	200	38.6
LIME SLUDGE POND						
Uranium-234[d]	1.04	19501	1951	196	-	-
Uranium-235/236[d]	0.15	19500	1950	195	-	-
Uranium-238	1.22	5361	537	54.8	1000[e]	45.3[e]
Uranium-Total	3.4	-	-	-	200	136
ACTIVE FLYASH PILE						
Arsenic	8.2	1690	169	16.9	-	-
Neptunium-237	0.0	4.99E+2	4.99E+1	4.99	-	-
Uranium-234[d]	1.04	761	77.0	8.64	-	-
Uranium-235/236[d]	0.15	760	76.2	7.75	-	-
Uranium-238[d]	1.12	501	51.1	6.12	57.3[e]	9.3[e]
Uranium-Total[d]	3.4	-	-	-	172	28
INACTIVE FLYASH PILE (SOURCE OVER THE GREAT MIAMI AQUIFER)						
Arsenic	8.2	1690	169	16.9	-	-
Uranium-234[d]	1.04	1251	92	8.68	-	-
Uranium-235/236[d]	0.15	1250	91	7.79	-	-
Uranium-238[d]	1.12	820	61	6.12	39.3[e]	8.3[e]
Uranium-Total[d]	3.4	-	-	-	118	24.8

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See footnotes at end of table.

TABLE 2-23
(Continued)

COC	Background[a]	FEDERAL OWNERSHIP PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	HI[c] 0.2	ARAR
INACTIVE FLYASH PILE (SOURCE OVER THE GLACIAL TILL TERRACE)						
Arsenic	8.2	1690	169	16.9	-	-
Uranium-234[d]	1.04	321	33	4.24	-	-
Uranium-235/236[d]	0.15	320	32	3.35	-	-
Uranium-238[d]	1.12	211	22	3.22	16.7[e]	8.3[e]
Uranium-Total[d]	3.4	-	-	-	50	24.8
SOUTH FIELD (SOURCE OVER THE GREAT MIAMI AQUIFER)						
Aroclor-1260[d]	0.0	2500	250	25	-	-
Benzo(a)anthracene	0.0	-	-	-	-	0.455
Benzo(a)pyrene	0.0	286	28.6	2.86	-	0.777
Benzo(b)fluoranthene[d]	0.0	-	-	-	-	0.513
Benzo(k)fluoranthene	0.0	-	-	-	-	0.603
Dibenzo(a,h,)anthracene[d]	0.0	1300	130	13	-	0.157
Dieldrin	0.0	-	-	-	-	9.57E-3
Indeno(1,2,3-cd)pyrene[d]	0.0	20000	2000	200	-	0.496
Phenanthrene	0.0	-	-	-	-	0.19
Technetium-99	0.0	7100	710	71	-	-
Thorium-230[d]	1.97	40002	4002	402	-	6.97
Uranium-234[d]	1.04	1251	92	8.68	-	-
Uranium 235/236[d]	0.15	1250	91	7.79	-	-
Uranium-238[d]	1.12	820	61	6.12	57.3[e]	8.3[e]
Uranium-Total[d]	3.4	-	-	-	118	24.8
SOUTH FIELD (SOURCE OVER THE GLACIAL TILL)						
Aroclor-1260[d]	0.0	2500	250	25	-	-
Benzo(a)anthracene	0.0	-	-	-	-	0.455
Benzo(a)pyrene	0.0	286	28.6	2.86	-	0.777
Benzo(b)fluoranthene[d]	0.0	-	-	-	-	0.513
Benzo(k)fluoranthene	0.0	-	-	-	-	0.603
Dibenzo(a,h,)anthracene[d]	0.0	1300	130	13	-	0.157
Dieldrin	0.0	-	-	-	-	9.57E-3
Indeno(1,2,3-cd)pyrene[d]	0.0	20000	2000	200	-	0.496
Phenanthrene	0.0	-	-	-	-	0.19
Technetium-99	0.0	7100	710	71	-	-

TABLE 2-23
(Continued)

COC	Background[a]	FEDERAL OWNERSHIP PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	HI[c] 0.2	ARAR
SOUTH FIELD (SOURCE OVER THE GLACIAL TILL)						
Thorium-230[d]	1.97	40002	4002	402	-	6.97
Uranium-234[d]	1.04	321	33	4.24	-	-
Uranium 235/236[d]	0.15	320	32	3.35	-	-
Uranium-238[d]	1.12	211	22	3.22	16.7[e]	8.3[e]
Uranium-Total[d]	3.4	-	-	-	50	24.8

[a]Background value from RI Report, Table 4-1A, surface concentrations.

[b]ILCR = incremental lifetime cancer risk; value shown is ILCR plus background.

[c]HI = hazard index.

[d]PRL due to off-property resident farmer receptor

[e]This value determined by calculating the uranium-238 concentration in uranium-total.

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TABLE 2-24

SUMMARY OF OPERABLE UNIT 2 RISK-BASED SOIL PRLs FOR FEDERAL OWNERSHIP (LATERAL MIGRATION CONTROLS)

COC	Background[a]	FEDERAL OWNERSHIP PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	HI[c] 0.2	ARAR
ALL SUBUNITS[d]						
Radium-226	1.42	38.3	5.1	1.8	-	6.42
Radium-228	1.25	78.3	8.9	2.0	-	6.25
Thorium-228	1.43	41.3	5.4	1.8	-	-
Thorium-232	1.36	27.6	3.9	1.5	-	6.36
SOLID WASTE LANDFILL[d]						
Uranium-234[e]	1.04	6191	620	62.9	-	-
Uranium-235/236[e]	0.15	6190	619	63.1	-	-
Uranium-238	1.22	5361	537	54.8	318.7[f]	12.9[f]
Uranium-Total	3.4	-	-	-	200	38.6
LIME SLUDGE POND[d]						
Uranium-234[e]	1.04	19501	1951	196	-	-
Uranium-235/236[e]	0.15	19500	1950	195	-	-
Uranium-238	1.22	5361	537	54.8	1000[f]	45.3[f]
Uranium-Total	3.4	-	-	-	200	136
ACTIVE FLYASH PILE[d]						
Arsenic	8.2	1690	169	16.9	-	-
Uranium-234[e]	1.04	761	77.0	8.64	-	-
Uranium-235/236[e]	0.15	760	76.2	7.75	-	-
Uranium-238[e]	1.12	501	51.1	6.12	57.3[f]	9.3[f]
Uranium-Total[e]	3.4	-	-	-	172	28
INACTIVE FLYASH PILE (Source Material over the Great Miami Aquifer)						
Arsenic	8.2	1690	169	16.9	-	-
Uranium-234[e]	1.04	1251	92	8.68	-	-
Uranium-235/236[e]	0.15	1250	91.2	7.79	-	-
Uranium-238[e]	1.12	820	61.1	6.12	57.3[f]	150[f]
Uranium-Total[e]	3.4	-	-	-	172	28
INACTIVE FLYASH PILE (Source Material over the Glacial Till Terrace)						
Arsenic	8.2	1690	169	16.9	-	-
Uranium-234[e]	1.04	10700	1071	108	-	-
Uranium-235/236[e]	0.15	10700	1070	107	-	-
Uranium-238	1.22	5361	537	54.8	-	-
Uranium-238[g]	1.12	7001	701	71	991.7[f]	150[f]
Uranium-Total[e]	3.4	-	-	-	2975	450

See footnotes at end of table.

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TABLE 2-24
(Continued)

COC	Background[a]	FEDERAL OWNERSHIP PRL (pCi/g or mg/kg)				
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	HI[c] 0.2	ARAR
SOUTH FIELD (Source Material over the Great Miami Aquifer)						
Aroclor-1260[e]	0.0	2500	250	25	-	-
Benzo(a)anthracene	0.0	286	28.6	2.86	-	0.455
Benzo(a)pyrene	0.0	286	28.6	2.86	-	0.777
Benzo(b)fluoranthene[e]	0.0	-	-	-	-	0.513
Benzo(k)fluoranthene	0.0	-	-	-	-	0.603
Dibenzo(a,h)anthracene[e]	0.0	1300	130	13	-	0.157
Dieldrin	0.0	-	-	-	-	9.57E-3
Indeno(1,2,3-cd)pyrene[e]	0.0	20000	2000	200	-	0.496
Phenanthrene	0.0	-	-	-	-	0.19
Technetium-99	0.0	7100	710	71	-	-
Thorium-230[e]	1.97	40002	4002	402	-	6.97
Uranium-234[e]	1.04	1251	92	8.68	-	-
Uranium 235/236[e]	0.15	1250	91.2	7.79	-	-
Uranium-238[d]	1.12	820	61.1	6.12	57.3[f]	9.3[f]
Uranium-Total[e]	3.4	-	-	-	172	28
SOUTH FIELD (Source Material over the Top of the Glacial Till Terrace)						
Aroclor-1260[e]	0.0	2500	250	25	-	-
Benzo(a)anthracene	0.0	-	-	-	-	0.455
Benzo(a)pyrene	0.0	286	28.6	2.86	-	0.777
Benzo(b)fluoranthene[e]	0.0	-	-	-	-	0.513
Benzo(k)fluoranthene	0.0	-	-	-	-	0.603
Dibenzo(a,h)anthracene[e]	0.0	1300	130	13	-	0.157
Dieldrin	0.0	-	-	-	-	9.57E-3
Indeno(1,2,3-cd)pyrene[e]	0.0	20000	2000	200	-	0.496
Phenanthrene	0.0	-	-	-	-	0.19
Technetium-99	0.0	7100	710	71	-	-
Thorium-230[e]	1.97	40002	4002	402	-	6.97
Uranium-234[e]	1.04	10700	1071	108	-	-
Uranium 235/236[e]	0.15	10700	1070	107	-	-
Uranium-238	1.22	5361	537	54.8	991.7[f]	150[f]
Uranium-238[g]	1.12	7001	701	71	991.7[f]	150[f]
Uranium-Total[e]	3.4	-	-	-	2975	450

[a]Background value from RI Report, Table 4-1A, surface concentrations.
[b]ILCR = incremental lifetime cancer risk; value shown is ILCR plus background.
[c]HI = hazard index.
[d]Lateral migration controls are only employed for the Inactive Flyash Pile and South Field and only effect groundwater; thus, the only PRLs that change from Table 2-23 are uranium-234, 235/236, 238, and total uranium for the Inactive Flyash Pile and South Field.
[e]PRL due to off-property resident farmer receptor.
[f]This value determined by calculating the uranium-238 concentration in uranium-total.
[g]This PRL applies for protection of groundwater and becomes significant when the lateral migration of perched groundwater is controlled and direct contact no longer applies (i.e., excavations below the impacted till).

TABLE 2-25

SUMMARY OF OPERABLE UNIT 2 RISK-BASED SOIL PRLs FOR FEDERAL OWNERSHIP (LATERAL GROUNDWATER MITIGATION CONTROLS AND INFILTRATION SOURCE CONTROLS)

COC	Background[a]	FEDERAL OWNERSHIP PRL[c] (pCi/g or mg/kg)				
		10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR	HI[d] 0.2	ARAR
SOLID WASTE LANDFILL						
Uranium-234	1.04	> 1E+5	> 1E+5	> 1E+5	-	-
Uranium-235/236	0.15	> 1E+5	> 1E+5	> 1E+5	-	-
Uranium-238	1.12	> 1E+5	> 1E+5	> 1E+5	>30,000[e]	>30,000[e]
Uranium-Total	3.4	-	-	-	>1E+5	> 1E+5
LIME SLUDGE PONDS						
Uranium-234	1.04	> 1E+5	> 1E+5	> 1E+5	-	-
Uranium-235/236	0.15	> 1E+5	> 1E+5	> 1E+5	-	-
Uranium-238	1.12	> 1E+5	> 1E+5	> 1E+5	>30,000[e]	>30,000[e]
Uranium-Total	3.4	-	-	-	> 1E+5	> 1E+5
ACTIVE FLYASH PILE/SOUTH FIELD/INACTIVE FLYASH PILE[d]						
Uranium-234	1.04	> 1E+5	> 1E+5	> 10,000	-	-
Uranium-235/236	0.15	> 1E+5	> 1E+5	> 10,000	-	-
Uranium-238	1.12	> 1E+5	> 1E+5	> 10,000	>3,000[e]	>3,000[e]
Uranium-Total	3.4	-	-	-	> 10,000	> 10,000

[a]Background value from RI Report, Table 4-1A, surface concentrations.

[b]ILCR = incremental lifetime cancer risk; value shown is ILCR plus background.

[c]PRL due to off-property resident farmer receptor only.

[d]HI = hazard index.

[e]This value determined by calculating the uranium-238 concentration in uranium-total.

[f]The Active Flyash Pile, South Field, and Inactive Flyash Pile are consolidated prior to capping. The capping controls are performed in conjunction with lateral perched water controls for these subunits.

TABLE 2-26

OPERABLE UNIT 2
SPECIFIC REMEDIAL ACTION OBJECTIVES

Land Use	Reduction of Contaminant Source	Access Restrictions to Contaminant Source or Impacted Media	Reduce or Eliminate Transport of Contaminants	Elimination of Receptors Exposure to Contaminant Source
Private Ownership	To meet PRLs in Table 2-22	None	None	None
Continued Federal Ownership (No Source Controls)	To meet PRLs in Table 2-23	Restrict use and access of Operable Unit 2 Subunits	None	None
Continued Federal Ownership Lateral Perched Water Control	To meet PRLs in Table 2-24	Restrict use and access of Operable Unit 2 Subunits	Eliminate lateral movement of perched water at the Inactive Flyash Pile and South Field	None
Continued Federal Ownership Lateral Perched Water Control and Vertical Infiltration Control (Capping System)	To meet PRLs in Table 2-25	Restrict use and access of Operable Unit 2 Subunits	(1) Eliminate lateral movement of perched water at the Inactive Flyash Pile and South Field (2) Reduce vertical infiltration of water through the contaminant source (3) Eliminate surface water transport of contaminants. Eliminate air transport of contaminants	Eliminate receptors' direct contact with the waste

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3.0

3.0 GENERAL RESPONSE ACTIONS AND IDENTIFICATION/SCREENING OF REMEDIAL ACTION TECHNOLOGIES AND PROCESS OPTIONS

3.1 INTRODUCTION

The purpose of Section 3.0 is to define the impacted volumes of material based on preliminary remediation levels (PRLs) developed in Section 2.0, and to define applicable remediation technologies. The following items are discussed:

- Estimated volumes of contaminated material/soil for each subunit (Section 3.2)
- Identification of general response actions (GRAs) to meet remedial objectives, including no action (Section 3.3)
- Initial screening of technologies and process options (Section 3.4)
- Description and evaluation of technologies and process options remaining after the initial screening (Section 3.5)
- Summary of process options retained for consideration in remedial alternatives (Section 3.6)

Section 3.0 first presents the volumes of waste material to which GRAs will be applied. Based on the scenarios defined in Section 2.0, uranium isotopes are the primary cross-media contaminants of concern (COCs) (i.e., pose the most risk) in Operable Unit 2. Radium-228 and thorium-228 were the primary direct contact (risk-based) COCs in Operable Unit 2. All other pertinent PRLs were checked to ensure their associated volumes were included in the volumes determined by these three primary COCs. If not, the additional volumes were added to the total volume determined by these three primary COCs.

Next, GRAs are developed in Section 3.3 that address the remedial action objectives (RAOs) presented in Section 2.6. These are medium-specific actions that are compatible with the action-specific applicable or relevant and appropriate requirements (ARARs) discussed in Section 2.0 and Appendix B. The GRAs consider the contaminant volumes identified in Section 3.2 and represent the applicable technologies and process options. The technologies and process options are then screened to provide a short list of viable technologies to carry forward to Section 4.0, Development and Screening of Alternatives. A detailed evaluation is provided for each technology that remains after screening.

3.2 VOLUMES OF CONTAMINATION

The volumes of contaminated material associated with each subunit were determined through a multi-step process as follows:

- Definition of local geology/hydrogeology of each subunit
- Separation of samples by geologic stratum
- Determination of contaminant concentrations in a block model of each subunit by kriging
- Determination of initial volumes based on geostatistical modeling results for uranium-238, radium-228, and thorium-228
- Modification of volumes for risk-based PRLs (i.e., risk from ILCRs and HIs) not included in the geostatistical modeling
- Modification of volumes for ARARs or potential construction considerations

During the remedial investigation (RI), the geology of the subunits was defined. The topography was based on 1992 aerial photographs and topographic maps. Elevations of the base of fill and base of glacial overburden were derived from soil borings, Hydropunch™ data, and preconstruction (1952) surface contours. Aerial photographs from 1951 to 1992 were also used to identify physical features. All validated soil samples from the RI/FS Phase I and Phase II field investigation were categorized according to material type at each subunit. This information is summarized in Section 1 of this report.

Using this site-specific geologic information, a three-dimensional block model was developed for the Operable Unit 2 subunits using the MGE computer application package from Intergraph Corporation. The blocks in the model were 7.6 by 7.6 by 0.76 m (25 by 25 by 2.5 ft). Total fill/till/Great Miami Aquifer material volumes were calculated on a block-by-block basis from the difference between elevations of the grid defining the top and bottom surfaces of material.

Next, concentrations levels and locations for three major contaminants (uranium-238, radium-228, and thorium-228) from Operable Unit 2 field investigations were used as input in the block model. Interpolated concentrations of these contaminants for each block were determined by a geostatistical procedure known as kriging. Kriging uses the discrete analytical results associated with a specific medium and establishes a radius of influence within each medium across which concentrations can be interpolated. This is done by analyzing the relationships between all pairs of available sample results as a function of the distance between the samples. After that, block concentrations are calculated based on weighting factors that account for the influence of sample results within the radius of

influence that was established. The weight accorded to each surrounding result is based on solving a series of equations which minimize the error associated with the selection of the weighting factors.

The resulting block model allowed the determination of volumes for various concentrations of the three isotopes. When the block model was complete, comparisons of uranium-238, radium-228, and thorium-228 PRLs to modeled contaminant concentrations were conducted to determine remediation volumes for the Operable Unit 2 subunits.

The volumes resulting from the model were then checked with other applicable COC PRLs and existing contaminant levels to determine if additional remediation volumes needed to be added. Volumes were established for the remediation of COCs to a 1.0×10^{-6} and 1.0×10^{-5} incremental lifetime cancer risk (ILCR) and/or a 0.20 health index (HI). If the kriged volumes did not encompass areas with other COC concentrations exceeding risk-based PRLs, additional quantities were added to the kriged volumes.

Remediation volumes for each subunit were based on two land-use scenarios: private ownership and federal ownership. Under the private-ownership scenario, the PRLs are those associated with a on-property resident farmer receptor and an off-property resident farmer receptor. For the federal ownership scenario, the PRLs are those associated with the expanded trespasser receptor and the off-property resident farmer receptor. The PRLs used to determine the remediation volumes are based on the more conservative values of the two associated receptors for a given land-use scenario and are provided in Section 2 Tables 2-22 and 2-23.

The federal ownership scenario was also evaluated with the possibility of two types of source controls. For all subunits, a possible source control consists of reduced vertical infiltration and receptor exposure barrier. For the Inactive Flyash Pile and South Field, reduction of lateral perched groundwater migration was also considered. The PRLs for these scenarios are located in Section 2 Tables 2-24 and 2-25.

The final step in the volume calculation was to modify the volumes based on ARAR considerations. This addressed two concerns:

- Limits on radium and thorium under 40 CFR 192.12(a) and DOE 5400.5
- Material at the subunits that is considered to be a solid waste (e.g., lime sludge and flyash)

If these considerations identified volumes of material outside the volumes encompassing the risk-based PRLs, then the additional volume was incorporated and a new total volume of contamination resulted.

Appendix E contains the volume calculations described above. In the subsections that follow, the results of those calculations are presented for each subunit. Because uranium isotopes are the primary cross-media COCs, as well as one of the most prevalent COCs in the Operable Unit 2 subunits, figures showing uranium-238 contamination are included within each subsection. These figures will provide the reader with a general understanding of the location of contaminated material.

3.2.1 Solid Waste Landfill

The total area of the Solid Waste Landfill, within the battery limits, is 0.6 ha (1.5 ac). The area actually used for disposal of waste is slightly more than 0.4 ha (1 ac). Based on three-dimensional block modeling, the Solid Waste Landfill contains approximately 11,600 cu m (15,200 cu yd) of fill material. Figure 3-1 illustrates a the geologic cross section of the Solid Waste Landfill. Superimposed on the geologic cross section are the existing concentrations of uranium-238 at various depths determined by kriging.

The total subunit volumes and estimated volumes of material to be remediated under each proposed scenario are summarized in Table 3-1. The block modeling used the kriging results to calculate volumes associated with varying concentrations of uranium-238, radium-228, and thorium-228, for three material types at the Solid Waste Landfill: fill, impacted till and other remaining till. Fill is defined as soil/debris/waste; impacted till is the top 0.75 m (2.5 ft) of natural soil that contains excess concentrations of uranium as compared to the other remaining till; the remaining till is natural soil existing below the Solid Waste Landfill subunit. In addition to these three material types used for block modeling, sediment from the drainage ditch to the north of the landfill was evaluated for contamination impacts. Any material not previously included in the remediation volume due to radionuclide contamination was evaluated to determine if the risk-based PRLs of other COCs were exceeded.

For the private ownership scenario, the amount of contaminated material above PRL concentrations of uranium-238, radium-228, and thorium-228 is approximately 59,400 cu m (77,700 cu yd). This volume consists of approximately 11,600 cu m (15,200 cu yd) of fill material, 3,300 cu m (4,300 cu yd) of impacted till, and 44,500 cu m (58,200 cu yd) of other remaining till.

TABLE 3-1

SOLID WASTE LANDFILL VOLUMES[a] OF MATERIAL TO BE REMEDIATED

Volume Criteria	Kriging Volumes Based on PRLs for U-238, Ra-228, and Th-228[b]						Additional Volume Due to Other COCs		Construction Volume[c]		TOTAL[d]	
	Fill/Debris		Impacted Till		Other Remaining Till							
	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3
Total Subunit Volume	11600	15200	3300	4300	70500	92200	NA[e]	NA	NA	NA	85400	111700
Remediation Scenario												
Private Ownership No Source Controls	11600	15200	3300	4300	44500	58200	15900	20800	NA	NA	75300	98400
Federal Ownership No Source Controls	11500	15000	3300	4300	1300	1700	150	200	NA	NA	16200	21200
Federal Ownership Source Control[f]	1100[g]	1400[g]	500[g]	600[g]	0	0	0	0	7700	10100	9300	12100

[a]All volumes listed are "in-place" volumes.

[b]All GMA material volumes are zero.

[c]Volume within the capped area to be consolidated to facilitate cap construction.

[d]Totals are rounded to the nearest hundred.

[e]NA = not applicable.

[f]Source control is defined as vertical infiltration control.

[g]Volumes are outside of the area to be capped.

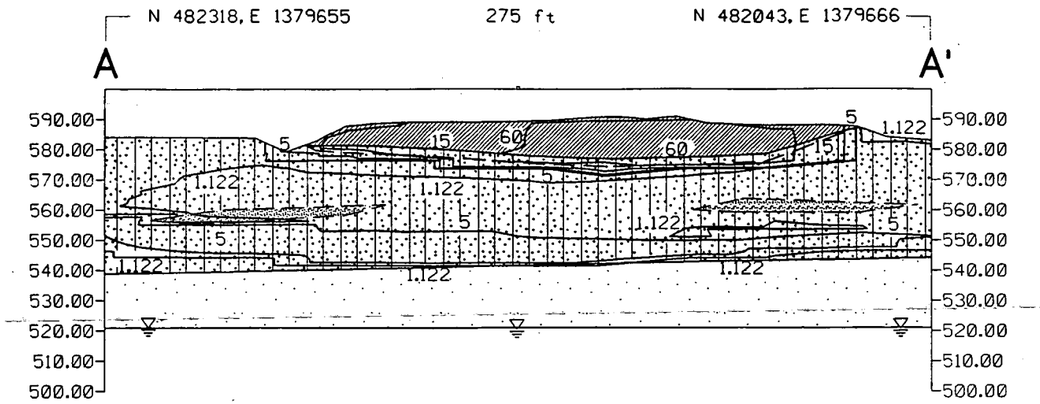
After volumes of material based on uranium-238, radium-228, or thorium-228 were determined, other COCs for the remaining material were evaluated to determine if concentrations exceeded their respective risk-based PRLs. An additional volume of 15,900 cu m (20,800 cu yd) from the remaining till will require remediation due to other COCs, including beryllium and neptunium-237. No additional volume was identified based on ARARs. For the private ownership future land-use scenario an estimated total volume of 75,300 cu m (98,400 cu yd) of material will require remediation.

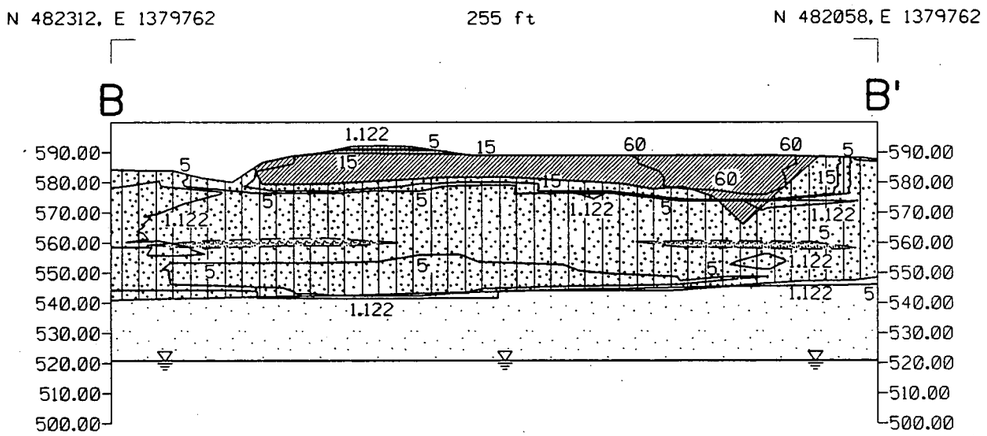
For the federal ownership scenario with no source controls, the PRLs for uranium-238, radium-228, and thorium-228 require a total remediation volume of 16,100 cu m (21,000 cu yd) of material. This volume consists of approximately 11,500 cu m (15,000 cu yd) of fill, 3,300 cu m (4,300 cu yd) of impacted till, and 1,300 cu m (1,700 cu yd) of other remaining till. Other COCs were also evaluated to determine if additional volumes will require remediation. An additional volume of 150 cu m (200 cu yd) of fill was identified due to risk-based PRLs for other COCs (including radium-226 and thorium-232). No additional volume will require remediation based on ARARs. For the federal ownership scenario with no source controls, an estimated total volume of 16,200 cu m (21,200 cu yd) of material will require remediation.

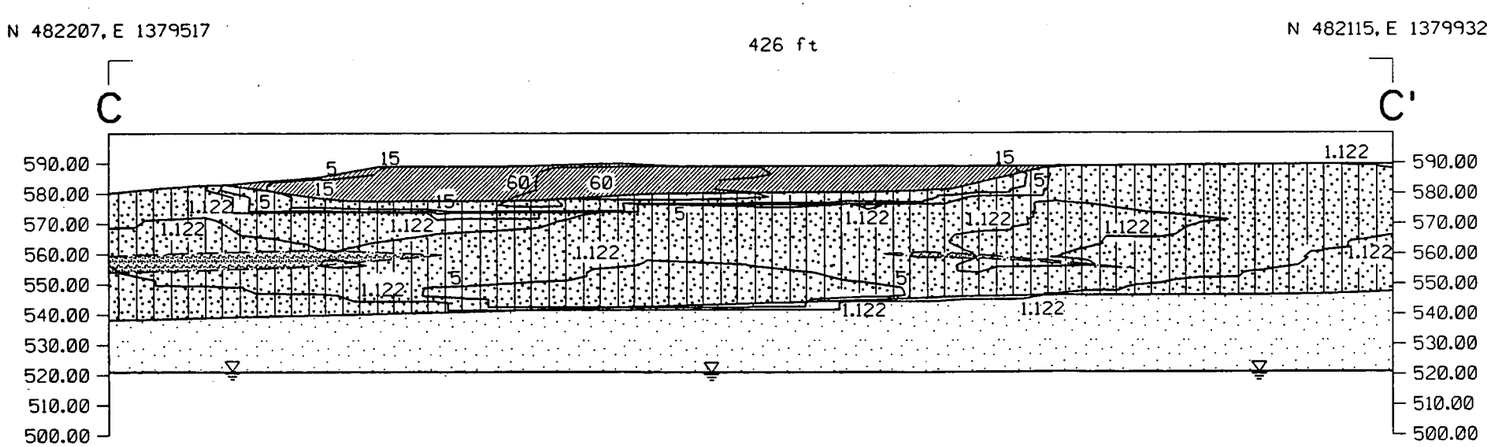
For the federal ownership scenario with source control provided by a capping system, there are no remediation volumes associated with uranium-238, radium-228, or thorium-228 within the area to be capped. Outside the area to be capped, however, a volume of approximately 1,500 cu m (2,200 cu yd) will require remediation due to those contaminants. This volume consists of 1,100 cu m (1,400 cu yd) of fill material and 500 cu m (600 cu yd) of other remaining till. An additional volume of 6,400 cu m (8,400 cu yd) of material within the capped area need to be moved and consolidated to facilitate construction of the cap on the south side of the subunit.

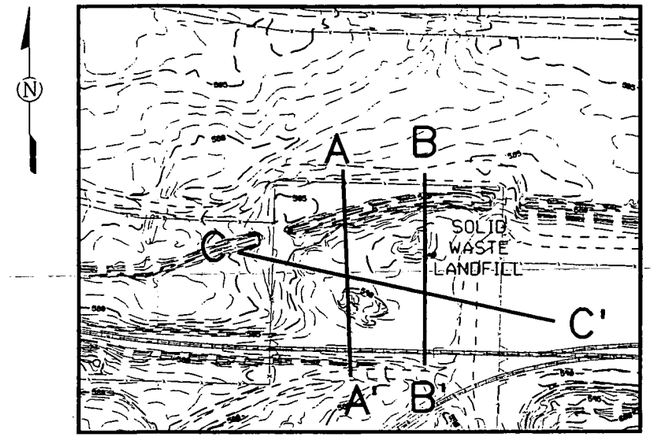
3.2.2 Lime Sludge Ponds

The North and South Lime Sludge Ponds are approximately 38 by 68 m (125 by 225 ft) each. The total volume of lime sludge in the two ponds is estimated at 12,600 cu m (16,500 cu yd). The volume of berm material surrounding the sludge ponds is approximately 4,300 cu m (5,600 cu yd). This volume estimate is based on a comparison of pre-FEMP topography with current topography. Figure 3-2 illustrates the geologic cross section of the Lime Sludge Ponds. Superimposed on the geologic cross section are the existing concentrations of uranium-238 at various depths determined by kriging.









LOCATION KEY (1" = 200')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE: DASHED LINES IN PROFILE SECTIONS REPRESENT INFERRED SAND LAYERS.

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 50'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

000338

FIGURE 3-1
GEOLOGIC CROSS SECTIONS
SOLID WASTE LANDFILL

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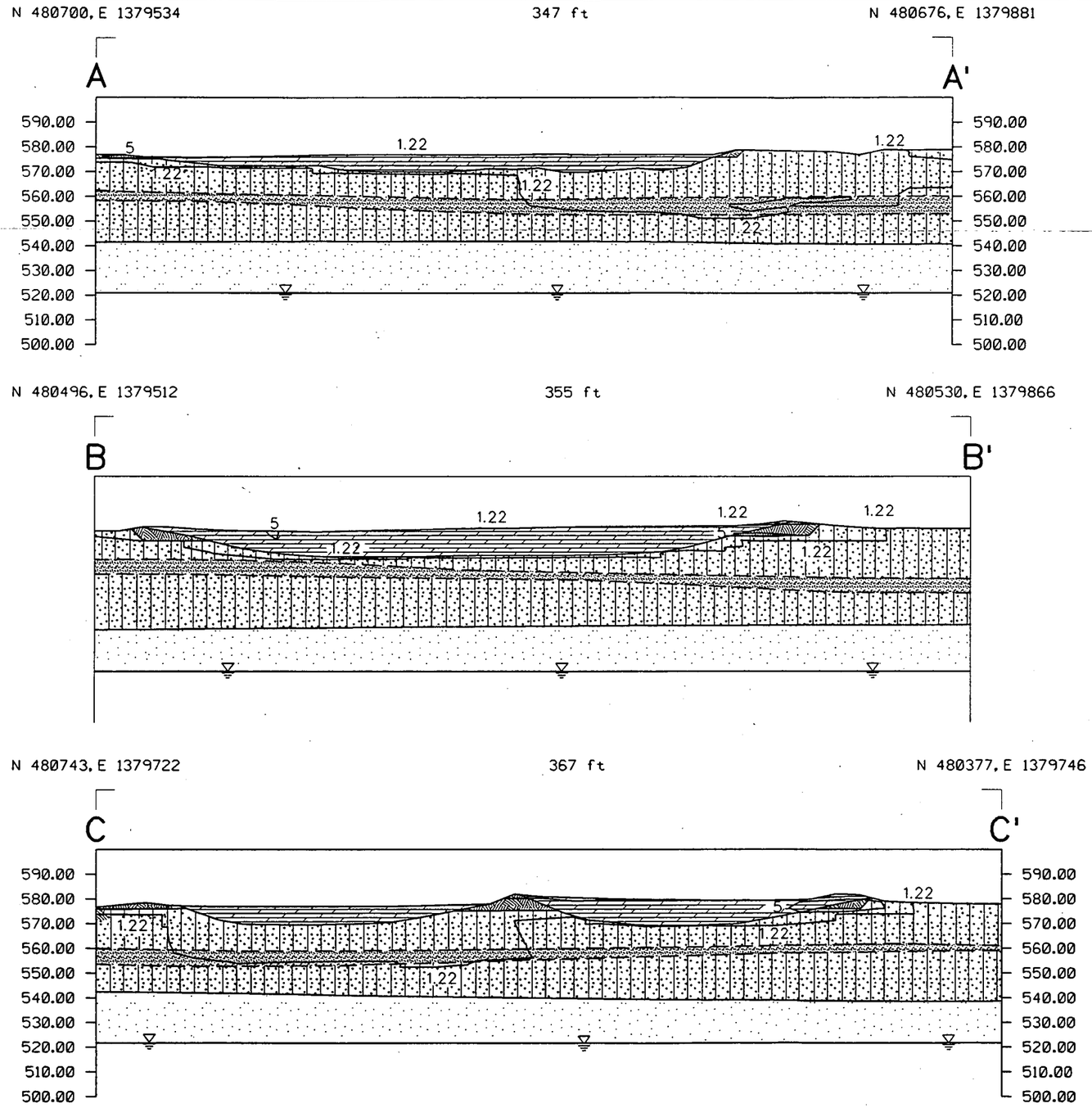

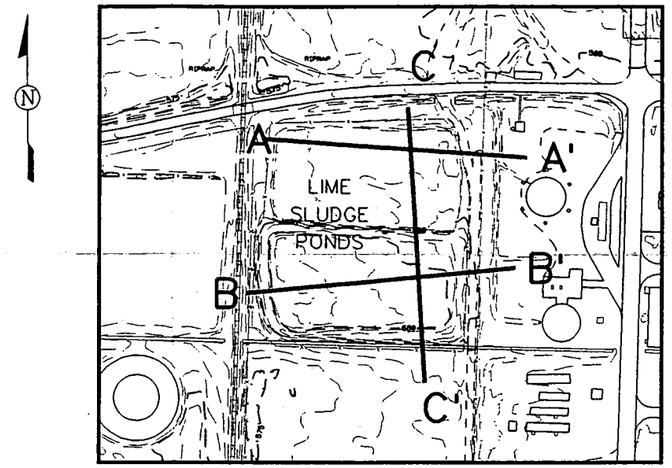

LOCATION KEY (1" = 200')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- RAILROAD
- BERM
- LIME SLUDGE
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface Contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 50'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

000341

FIGURE 3-2
GEOLOGIC CROSS SECTIONS
LIME SLUDGE PONDS

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The total subunit volumes and estimated volumes of material to be remediated for the Lime Sludge Ponds are summarized in Table 3-2. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238, radium-228, and thorium-228 for four material types at the Lime Sludge Ponds: berm material, lime sludge, till, and unsaturated Great Miami Aquifer material. The berm material is defined as the placed soil surrounding the ponds; the lime sludge makes up the ponds' contents; and the till and Great Miami Aquifer material are natural soils existing below the lime sludge and berm material. Any material not previously included in the remediation volume due to radionuclide contamination was evaluated to determine if the risk-based PRLs of other COCs were exceeded or if ARARs were a factor.

For the private ownership scenario, the amount of contaminated material above PRLs for uranium-238, radium-228, and thorium-228 is approximately 27,700 cu m (36,100 cu yd). This volume consists of approximately 4,300 cu m (5,600 cu yd) of berm material, 11,900 cu m (15,500 cu yd) of lime sludge, and 11,500 cu m (15,000 cu yd) of till. An additional volume of 34,000 cu m (44,500 cu yd) of till require remediation because risk-based PRLs for other COCs (including neptunium-237, strontium-90, and technetium-99) were exceeded. Also, the remaining volume [70 cu m (1,000 cu yd)] of sludge will require remediation due to ARAR considerations. For the future land-use private ownership scenario, an estimated total volume of 62,400 cu m (81,600 cu yd) of material will require remediation.

For the federal ownership, no source control scenario, there are no remediation volumes exceeding the PRLs for uranium-238, radium-228, or thorium-228. A volume of 230 cu m (300 cu yd) of material along the roadway north of the ponds and in the berm will require remediation due to other COCs (including radium-226). Also, an additional volume of 12,600 cu m (16,500 cu yd) of sludge will require remediation, because it is considered a solid waste.

For the federal ownership scenario, there are no remediation volumes associated with uranium-238, radium-228, or thorium-228, if source controls are used. However, an estimated total volume of 1,200 cu m (1,600 cu yd) of material outside the proposed capped area would require relocation. That quantity includes 230 cu m (300 cu yd) of till that would require remediation due to other COCs and 1,000 cu m (1,300 cu yd) of material to facilitate construction of a cap and relocation of the K-65 slurry line.

TABLE 3-2

LIME SLUDGE PONDS
VOLUMES[a] OF MATERIAL TO BE REMEDIATED

Volume Criteria	Kriging volumes Based on PRLs for U-238, Ra-228, and Th-228								Additional Volume Due to Other COCs		Additional Volume Due to ARARs or Construction		TOTAL[b]	
	Berm		Lime Sludge		Till		GMA Material							
	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3
Total Subunit Volume	4300	5600	12600	16500	91500	119600	0	0	NA[c]	NA	NA	N/A	108400	141700
Remediation Scenario														
Private Ownership No Source Controls	4300	5600	11900	15500	11500	15000	0	0	34000[d]	44500[d]	770	1000	62400	81600
Federal Ownership No Source Controls	0	0	0	0	0	0	0	0	230	300	12600	16500	12800	16800
Federal Ownership Source Control[e]	0	0	0	0	0	0	0	0	230	300	1000	1300	1200	1600

[a]All volumes listed are "in-place" volumes.

[b]Totals are rounded to the nearest hundred.

[c]NA = not applicable.

[d]The additional volume consists of a combination of sludge and till additional volumes.

[e]Source control is defined as vertical infiltration control.

3.2.3 Inactive Flyash Pile

The total area of the Inactive Flyash Pile is approximately 1.2 ha (3 ac). Based on three-dimensional block modeling, the Inactive Flyash Pile contains approximately 73,400 cu m (95,900 cu yd) of fill and debris. Of that total, approximately 900 cu m (1,200 cu yd) are cover material, 33,400 cu m (43,600 cu yd) are flyash, and 39,100 cu m (51,100 cu yd) are a mixture of construction debris and fill. Figures 3-3 through 3-5 illustrate the geologic cross section of the Inactive Flyash Pile. Superimposed on the geologic cross sections are the existing concentrations of uranium-238 at various depths as determined by kriging.

The total subunit volumes and estimated volumes of material to be remediated for the Inactive Flyash Pile future land-use scenarios are summarized in Table 3-3. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238, radium-228, and thorium-228 for six material types at the Inactive Flyash Pile: cover material, flyash, fill/debris, impacted till, other remaining till, and unsaturated Great Miami Aquifer material. The cover material is the soil cover placed over the flyash and fill/debris; the flyash actually consists of both flyash and bottom ash; the fill/debris is soil mixed with debris and some flyash; the impacted till is the top 0.61 m (2 ft) of the natural till that contains excess concentrations of uranium as compared to the other remaining till; the remaining till and unsaturated Great Miami Aquifer material are natural soils existing below the Inactive Flyash Pile subunit. Any material not previously included in the remediation volume due to radionuclide contamination was evaluated to determine if the risk-based PRLs of other COCs were exceeded or if ARARs were applicable.

For the private ownership scenario, the amount of material contaminated with uranium-238, radium-228, or thorium-228 above PRLs is approximately 76,900 cu m (100,500 cu yd). This volume consists of approximately 900 cu m (1,200 cu yd) of cover material, 33,400 cu m (43,600 cu yd) of flyash, 38,900 cu m (50,800 cu yd) of fill/debris material, 3,400 cu m (4,500 cu yd) of impacted till, and 350 cu m (460 cu yd) of Great Miami Aquifer material. The remaining material not impacted by uranium-238, radium-228, or thorium-228 was evaluated for other COCs to determine if their concentrations exceed PRLs. It was determined that an additional volume of 270 cu m (350 cu yd) of material requires remediation due to additional COCs. No additional volume will require remediation due to ARAR considerations. For the private ownership scenario, an estimated total volume of 77,200 cu m (100,900 cu yd) of material will require remediation.

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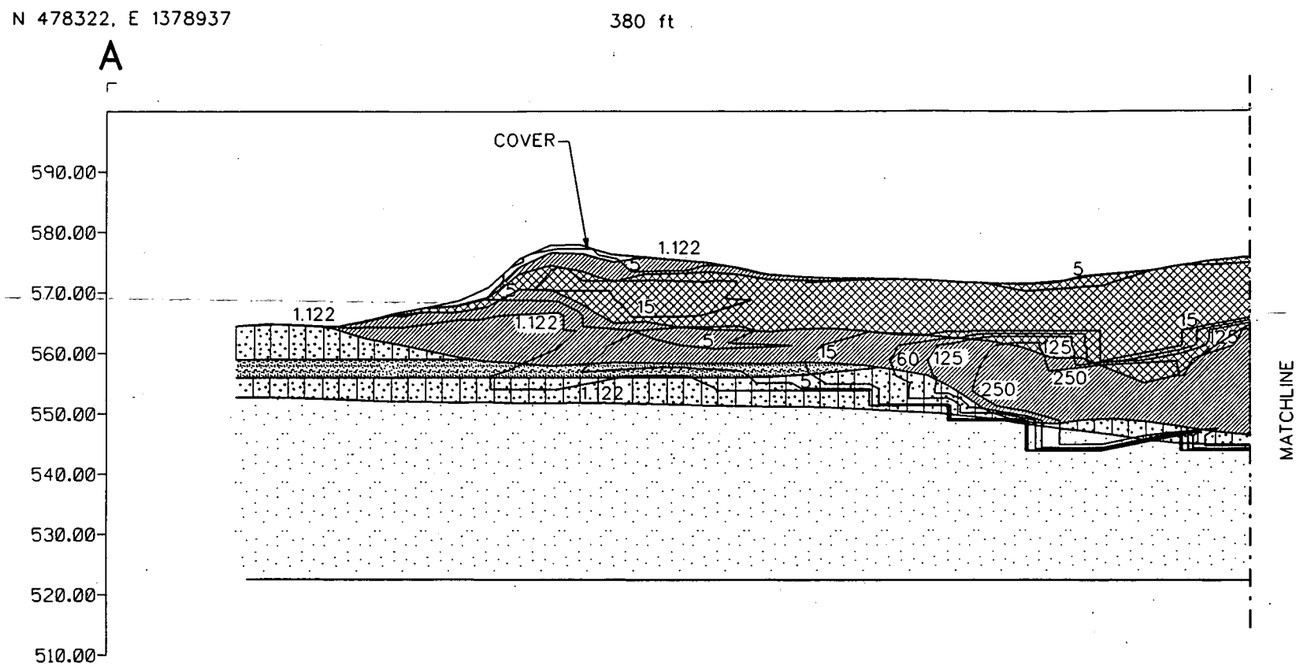
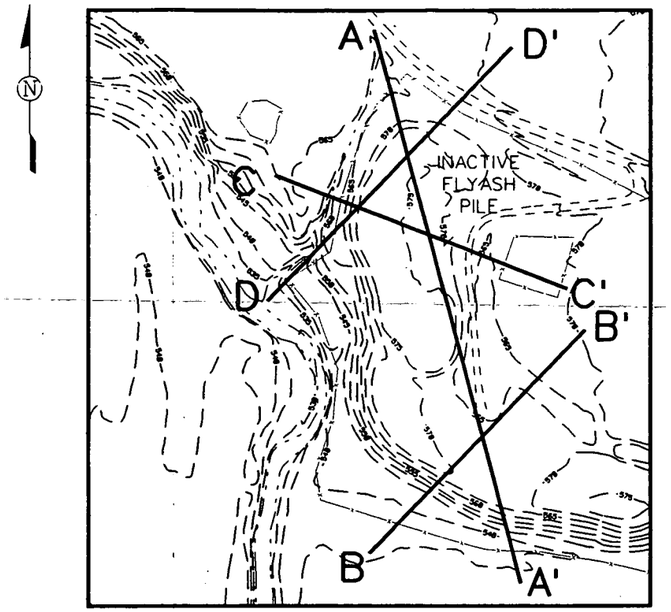
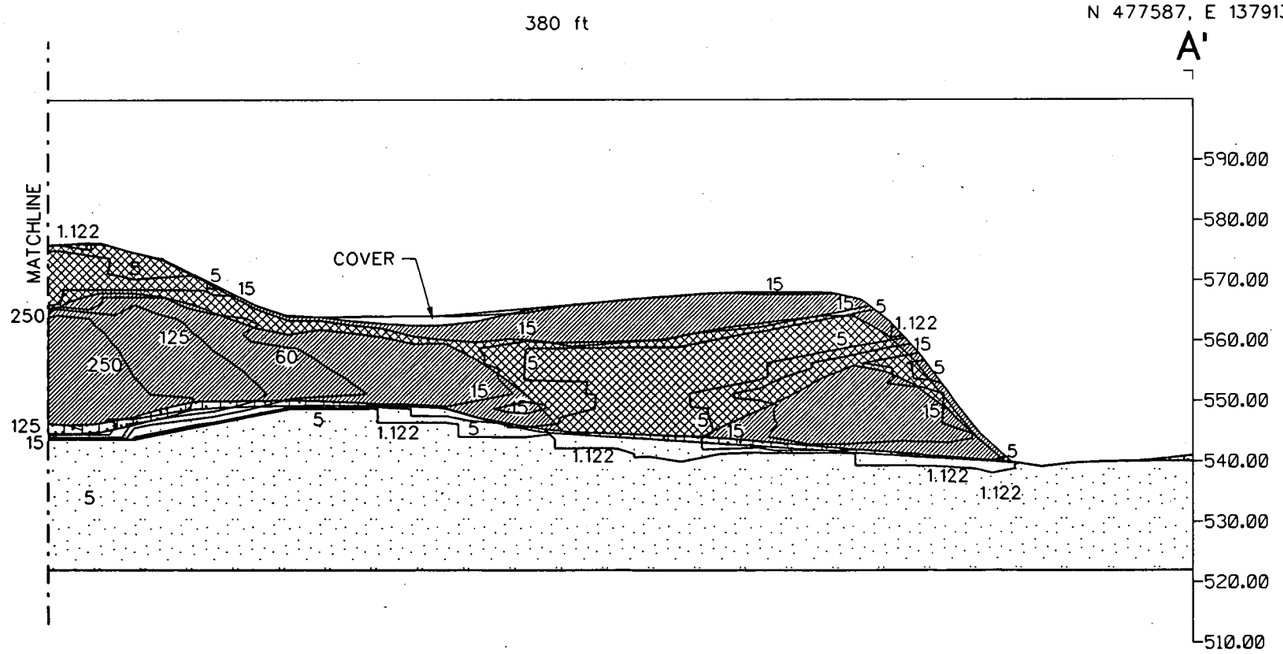




LOCATION KEY (1" = 200')



NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

000346

FIGURE 3-3
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 1 OF 3

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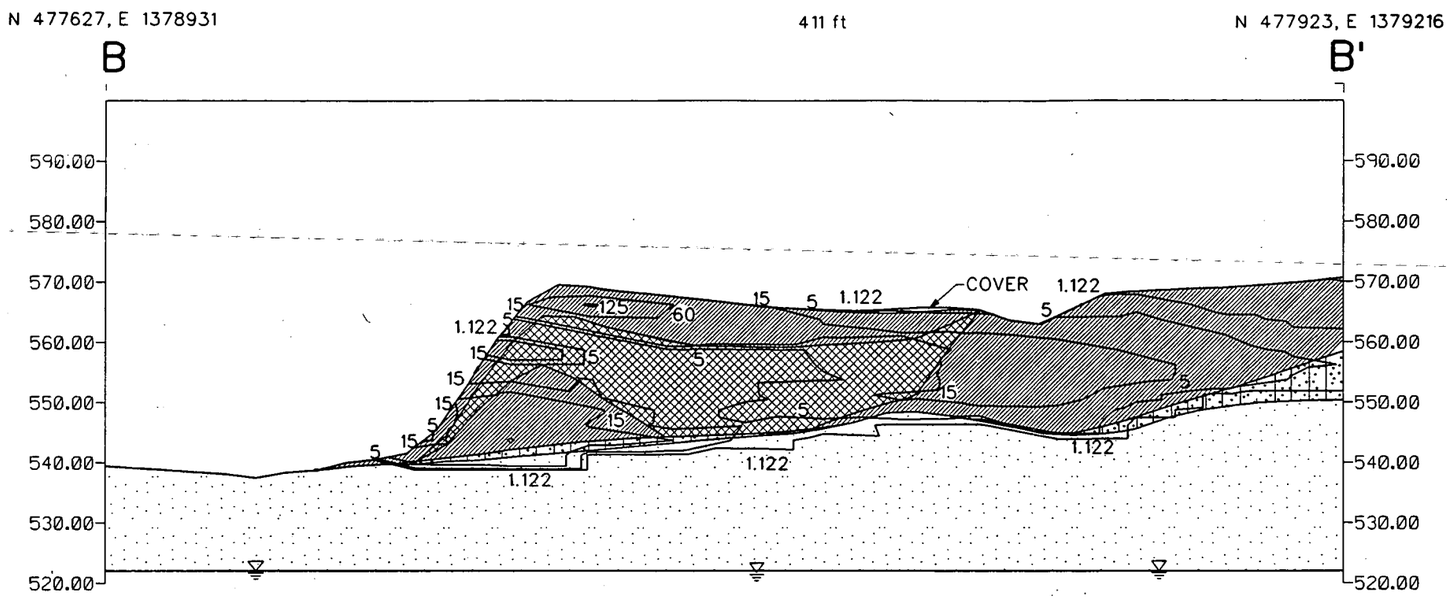
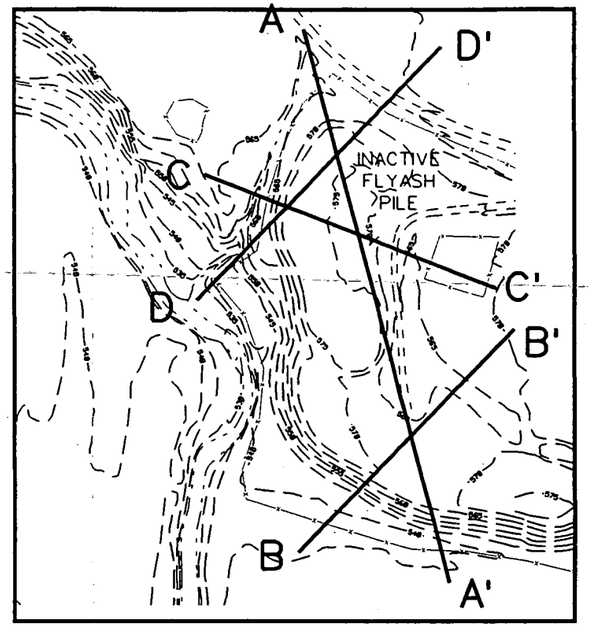
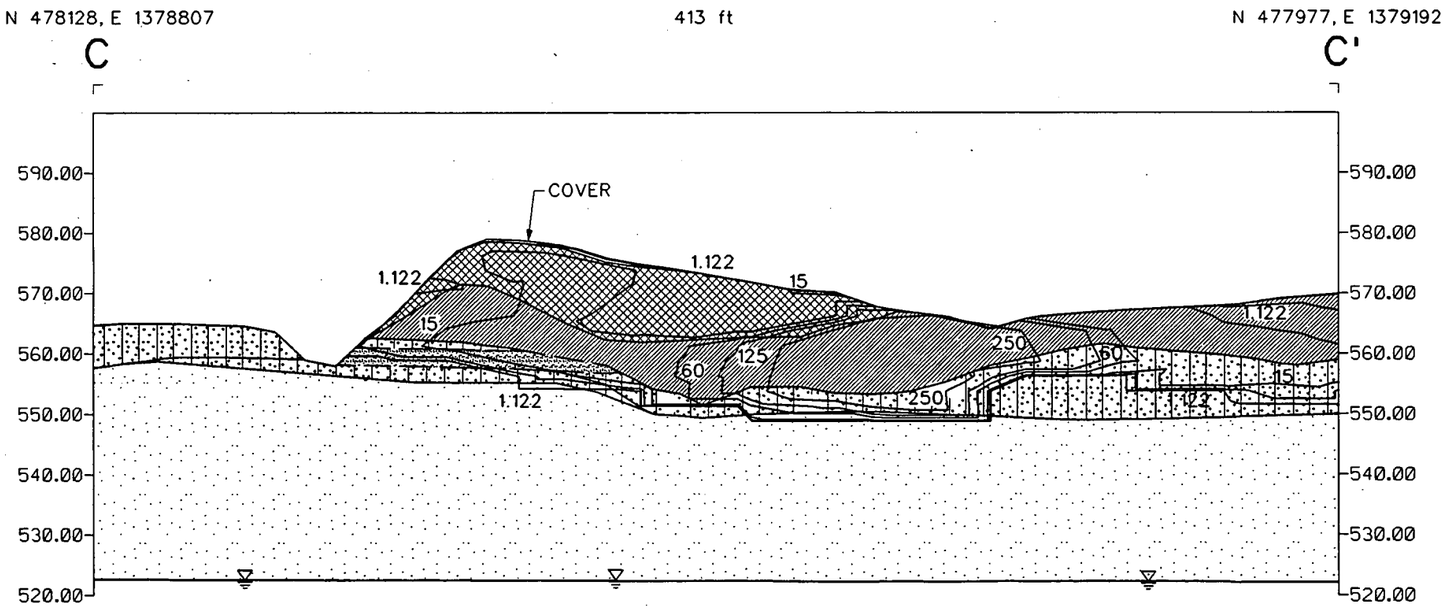




LOCATION KEY (1" = 200')



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONTAMINATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

000347

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

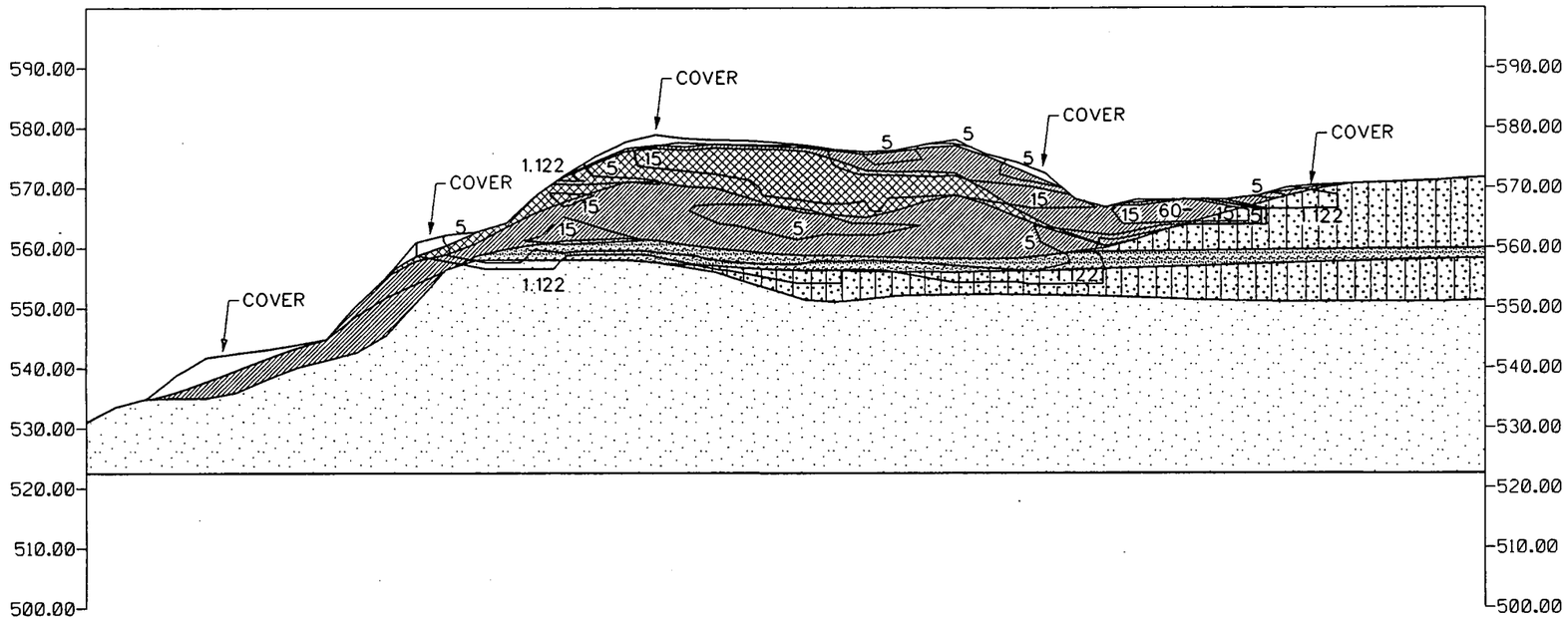
0 25 50 100

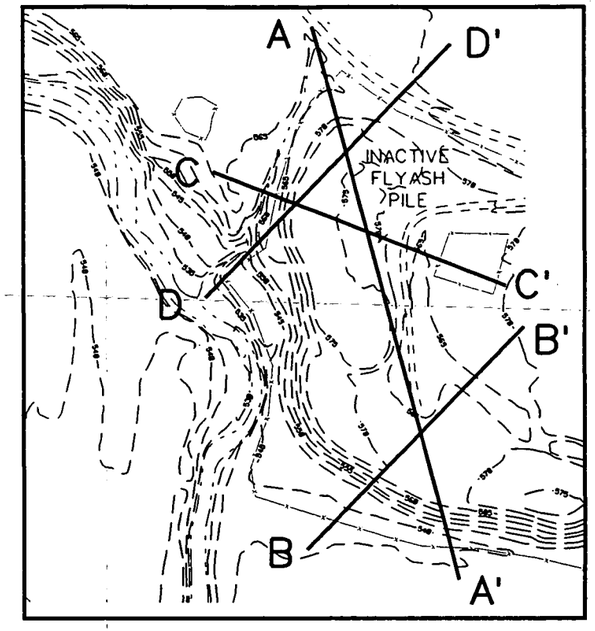
0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

FIGURE 3-4
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 2 OF 3

fs1093.dgn





LOCATION KEY (1" = 200')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONTAMINATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- FLYASH
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

FIGURE 3-5 000348
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 3 OF 3

fs1158.dgn

TABLE 3-3

INACTIVE FLYASH PILE
VOLUMES[a] OF MATERIAL TO BE REMEDIATED

Volume Criteria	Kriging Volumes Based on PRLs for U-238, Ra-228, and Th-228												Additional Volume Due to Other COCs		Additional Volume Due to ARARs		TOTAL[b]	
	Cover Material		Flyash		Fill/Debris		Impacted Till		Other Remaining Till		GMA Material							
	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3
Total Subunit Volume	900	1200	33400	43600	39100	51100	3400	4500	9400	12300	350[c]	400[c]	NA[d]	NA	NA	NA	86600	113200
Remediation Scenario																		
Private Ownership No Source Controls	900	1200	33400	43600	38900	50800	3400	4500	0	0	350	460	270	350	0	0	77200	100900
Federal Ownership No Source Controls	800	1000	33100	43200	35100	45900	2700	3500	0	0	0	0	0	0	300	400	72000	94000
Federal Ownership Source Controls[e]	800	1000	33100	43200	35100	45900	2700	3500	0	0	0	0	0	0	300	400	72000	94000

[a]All volumes listed are "in-place" volumes.

[b]Totals are rounded to the nearest hundred.

[c]Volume of unsaturated GMA material that is considered for possible inclusion in remediation volumes.

[d]NA = not applicable.

[e]Source controls are defined as vertical infiltration control and lateral migration control.

000349

5857

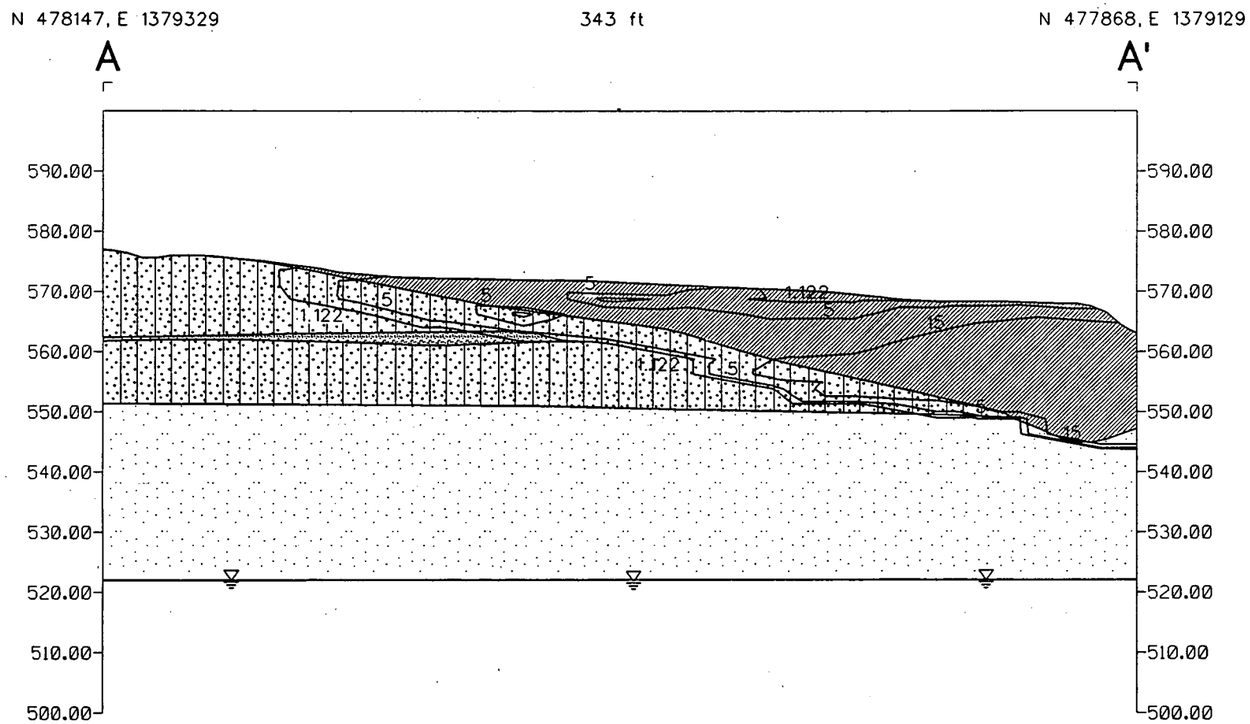
For the federal ownership with no source control scenario, the amount of contaminated material above PRLs for uranium-238, radium-228, and thorium-228 is approximately 71,700 cu m (93,600 cu yd). This volume consists of approximately 800 cu m (1000 cu yd) of cover material, 33,100 cu m (43,200 cu yd) of flyash, 35,100 cu m (45,900 cu yd) of fill/debris, and 2,700 cu m (3,500 cu yd) of impacted till. No additional remediation volume was identified due to other COCs, but an additional volume of 300 cu m (400 cu yd) of flyash will require remediation due to consideration as solid waste. For the federal ownership scenario with no source control, an estimated total volume of 72,000 cu m (94,000 cu yd) of material will require remediation.

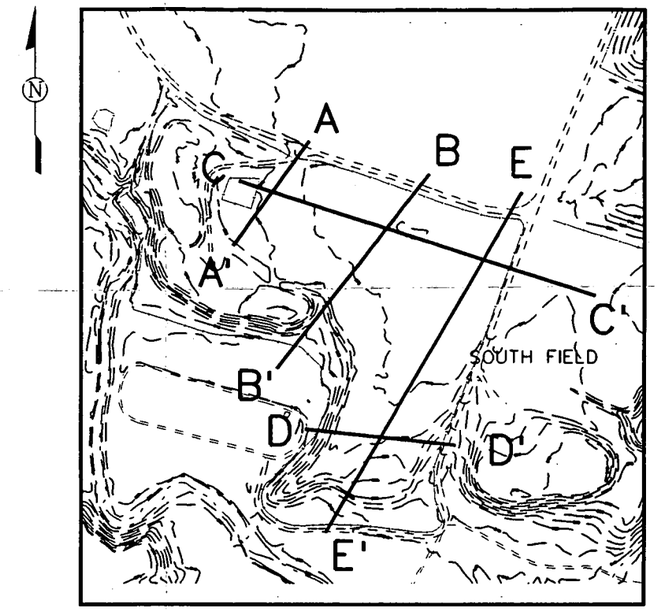
For the federal ownership scenario with source controls, an estimated total volume of 72,000 cu m (94,000 cu yd) of material will require remediation. The volumes for this scenario are the same as the volumes estimated for the federal ownership scenario with no source controls.

3.2.4 South Field

The total area of the South Field is approximately 4.5 ha (11 ac). Based on three-dimensional block modeling, the South Field contains approximately 91,800 cu m (120,100 cu yd) of fill and debris. Figures 3-6 through 3-10 illustrate the geologic cross section of the South Field . Superimposed on the geologic cross section are the existing concentrations of uranium-238 at various depths determined by kriging.

The total subunit volumes and estimated volumes of material to be remediated for the South Field future land-use scenario are summarized in Table 3-4. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238 for four material types at the South Field: fill/debris, impacted till, other remaining till, and unsaturated Great Miami Aquifer material. The fill/debris is the soil and debris disposed in the South Field. The impacted till is the top 1.2 m (4 ft) of natural soil that contains excess concentrations of uranium as compared to the other remaining till; the remaining till and unsaturated Great Miami Aquifer are natural soils existing below the South Field subunit. In addition to these four material types used for block modeling, sediments from drainage ditches were evaluated for contaminant impacts. Any material not previously included in the remediation volume for radionuclide contamination was evaluated to determine if the risk-based PRLs of other COCs were exceeded or if ARAR-based criteria were exceeded.





LOCATION KEY (1" = 400')

LEGEND

- 575 — ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 — URANIUM-238 (pCi/g) CONTAMINATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

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FIGURE 3-6
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 1 OF 5

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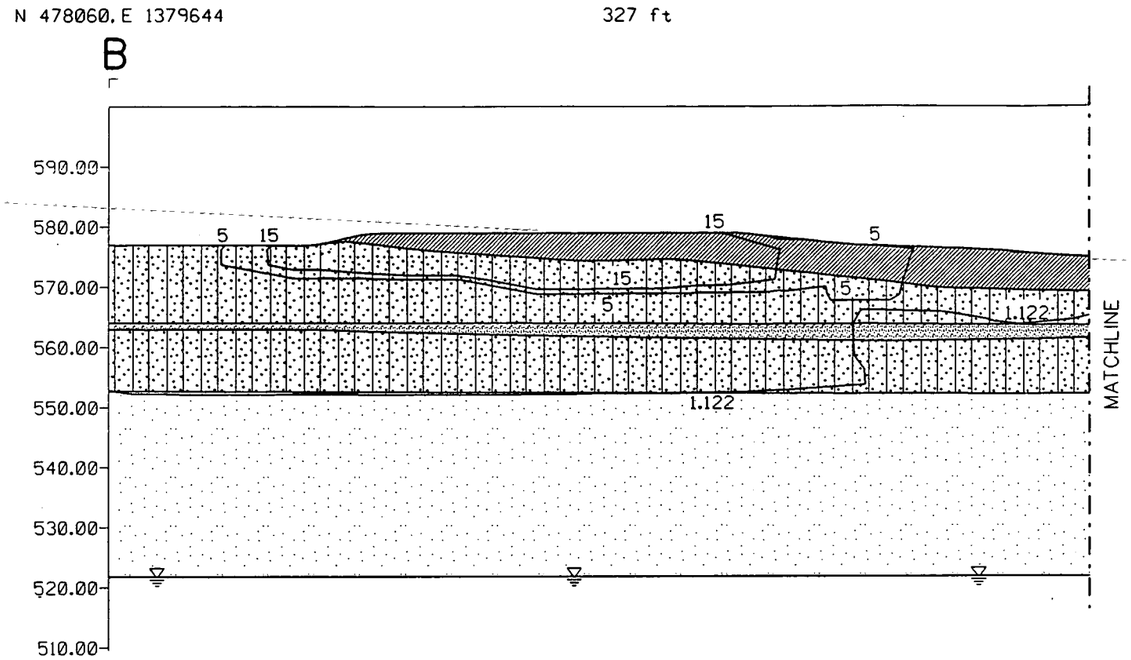
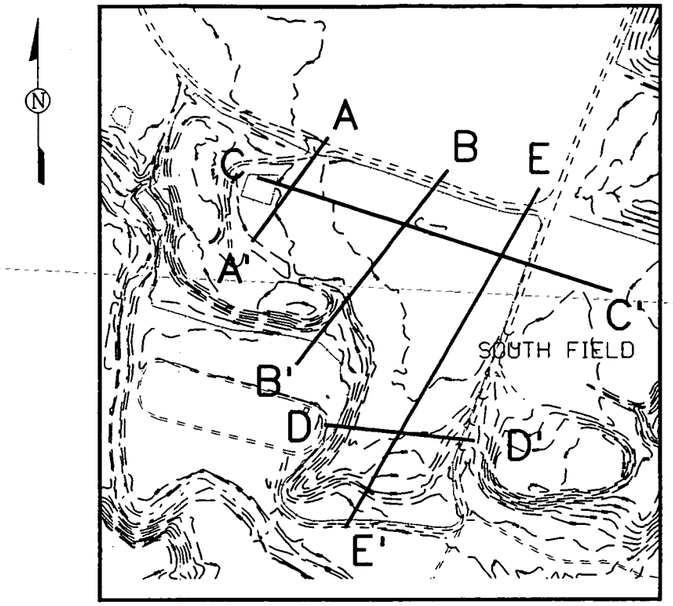
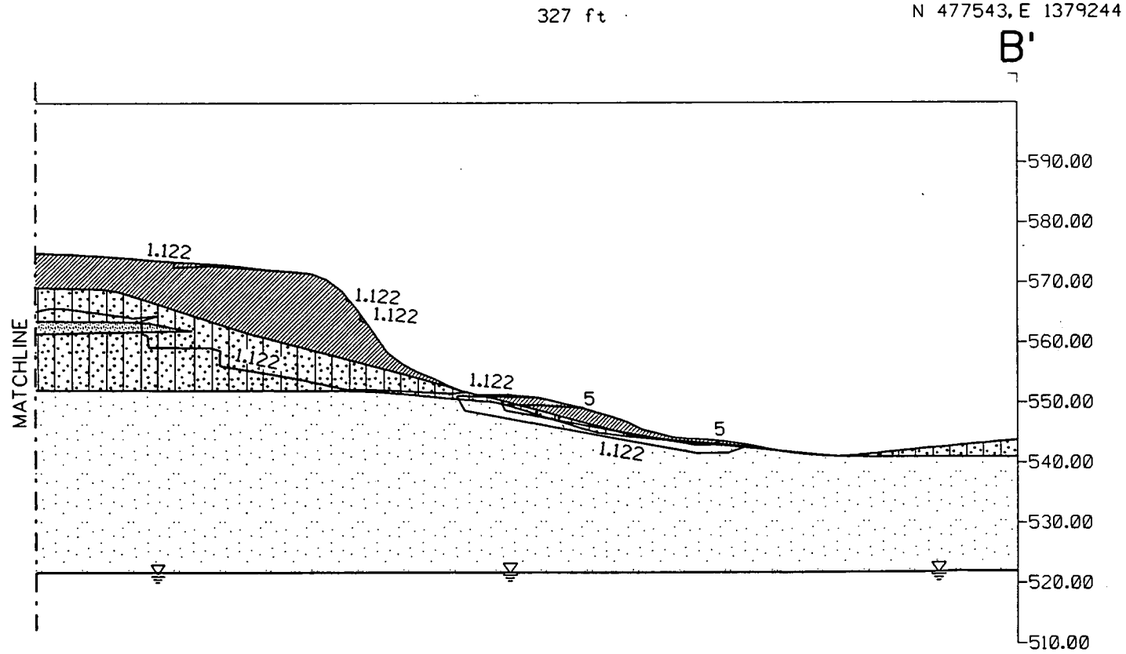




LOCATION KEY (1" = 400')



NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

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FIGURE 3-7
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 2 OF 5

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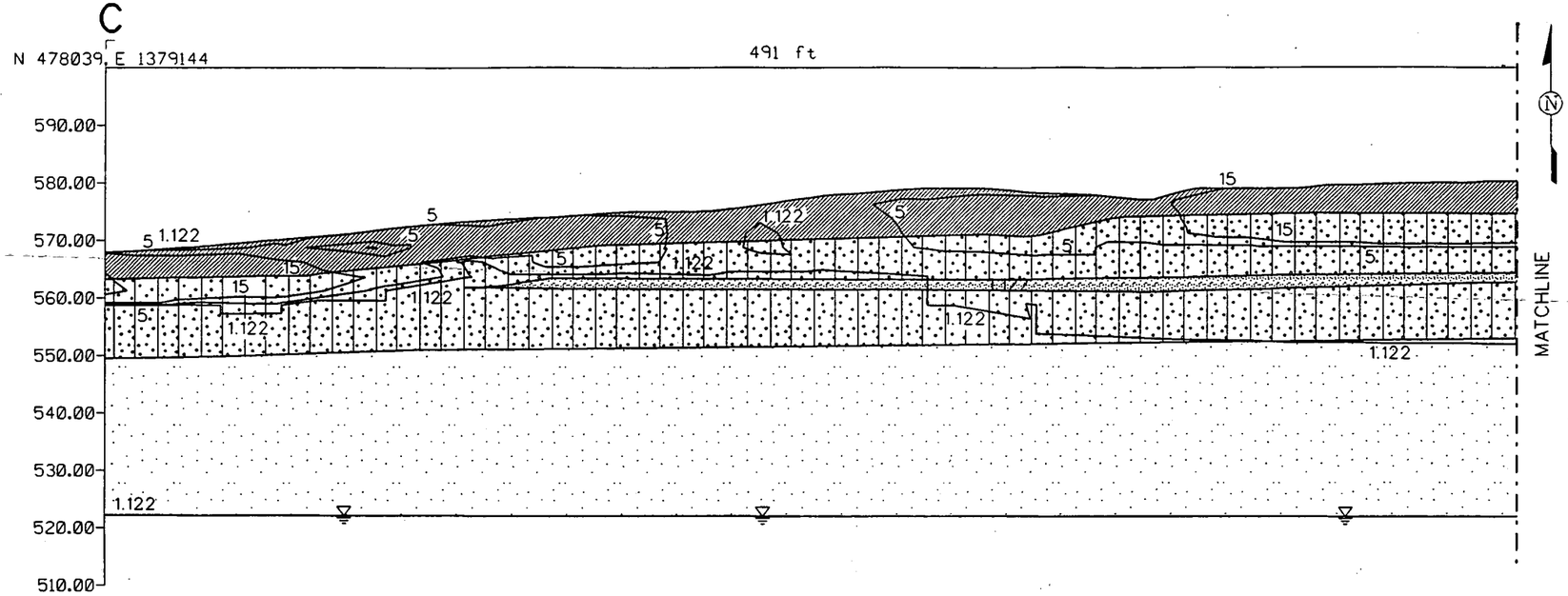
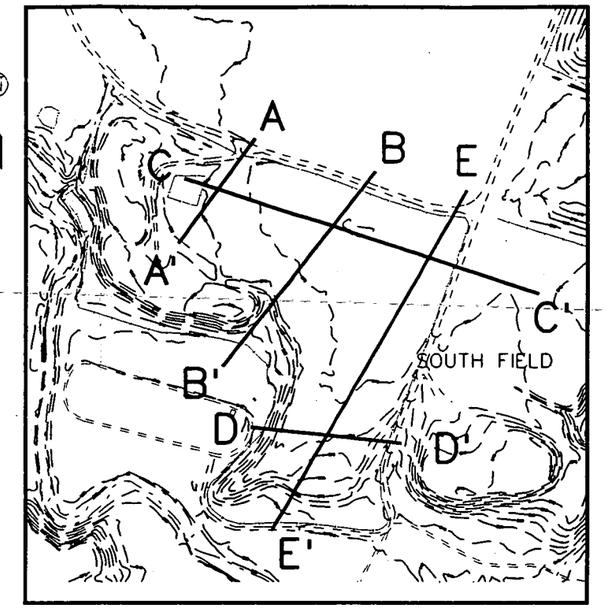
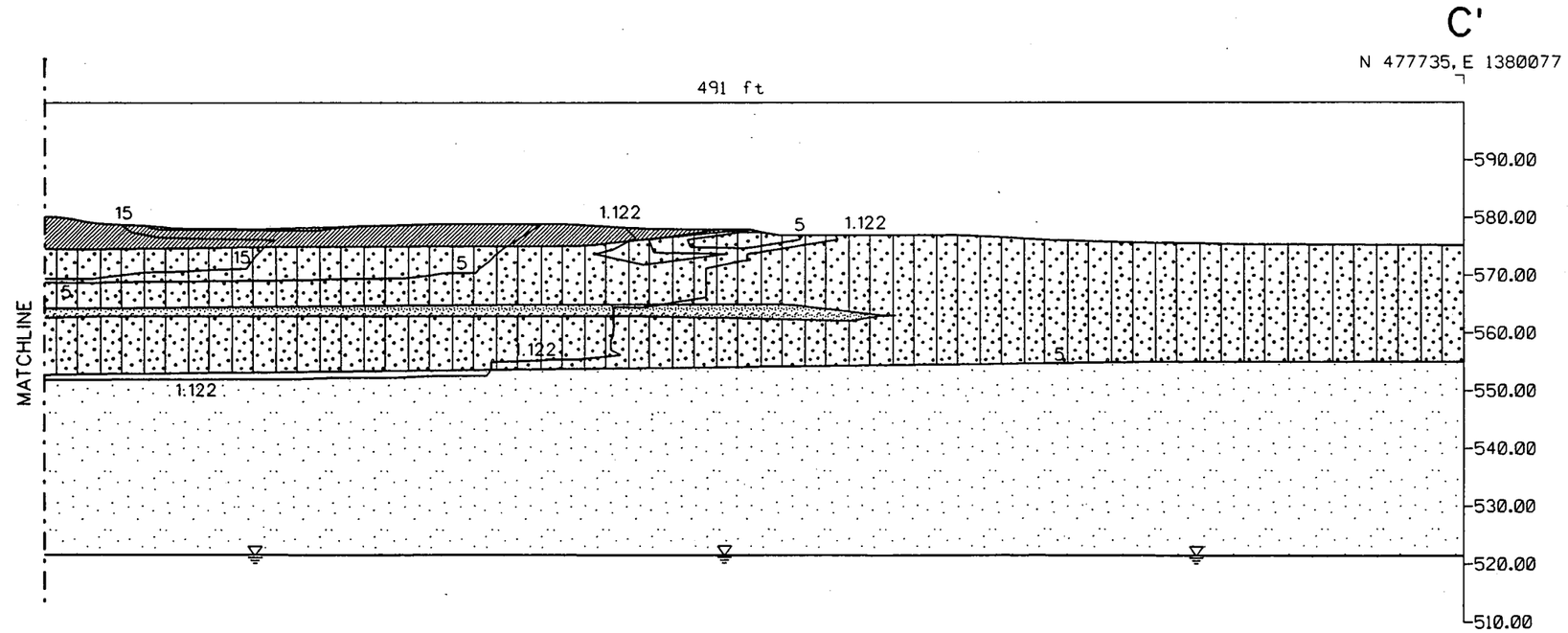




LOCATION KEY (1" = 400')



LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

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FIGURE 3-8
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 3 OF 5

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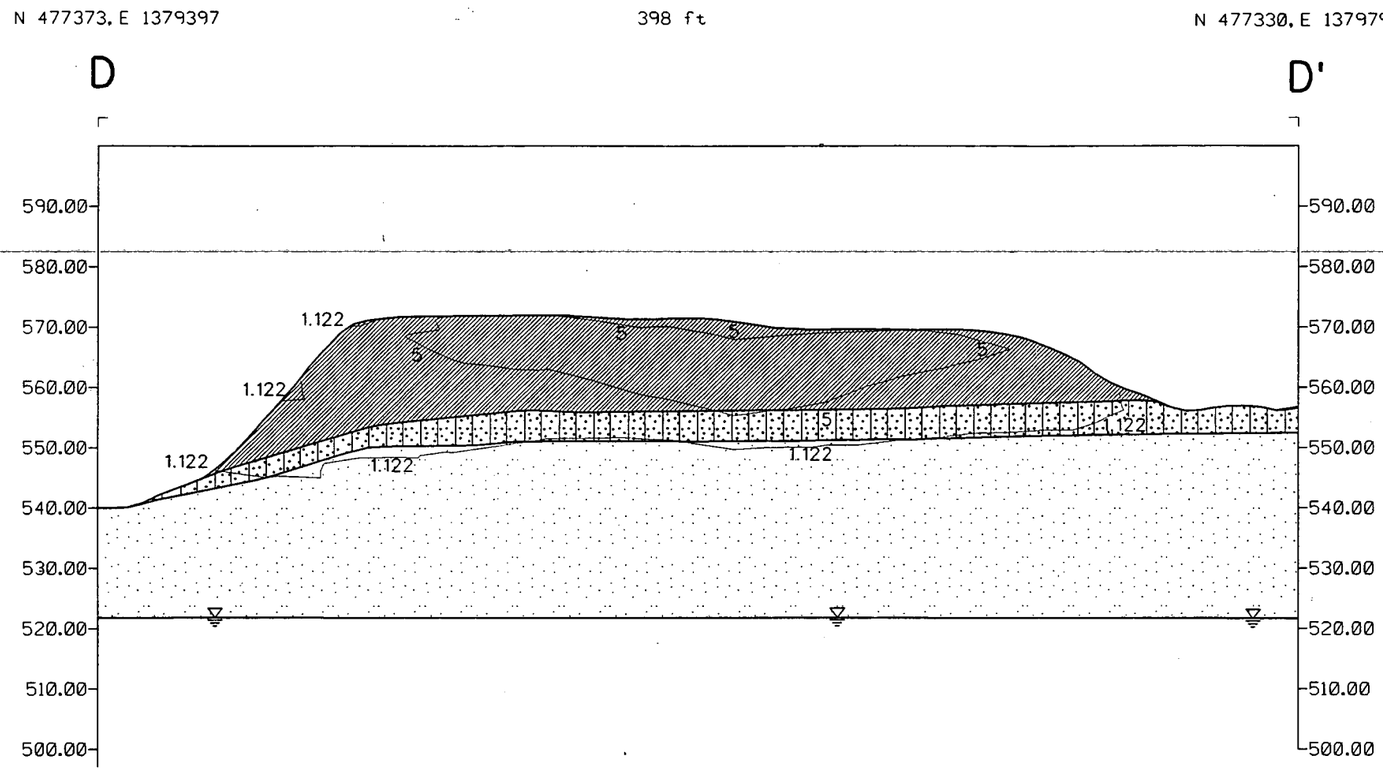

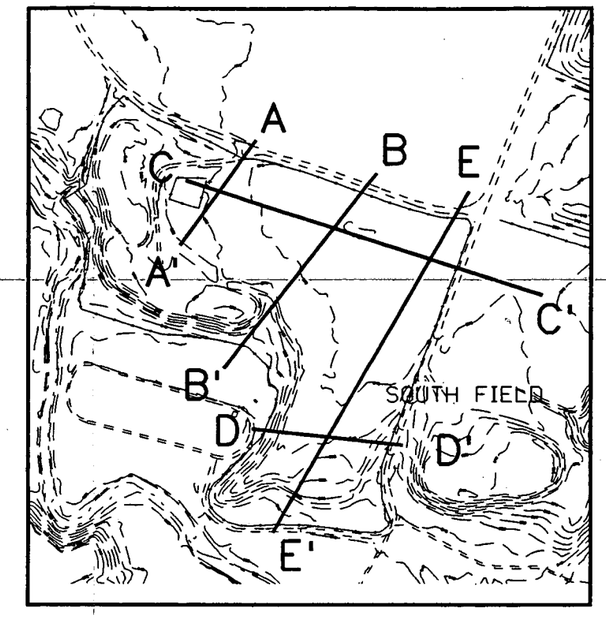

LOCATION KEY (1" = 400')

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

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SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

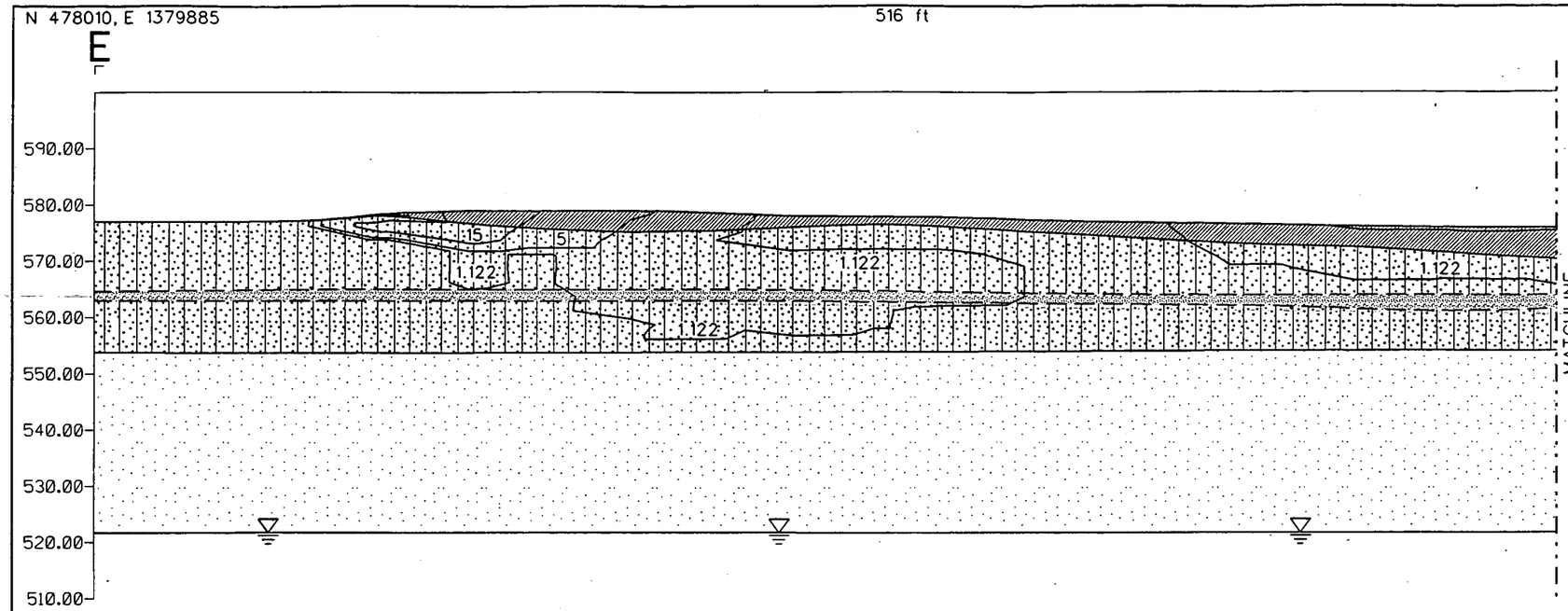
0 25 50 100

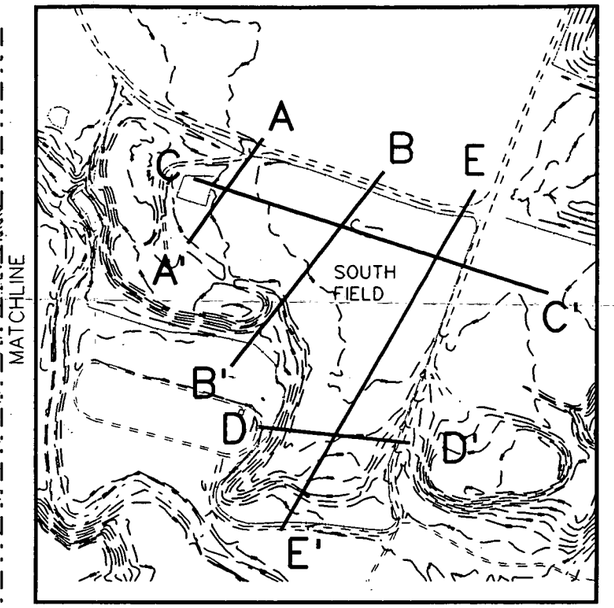
0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

fs1077.dgn

FIGURE 3-9
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 4 OF 5





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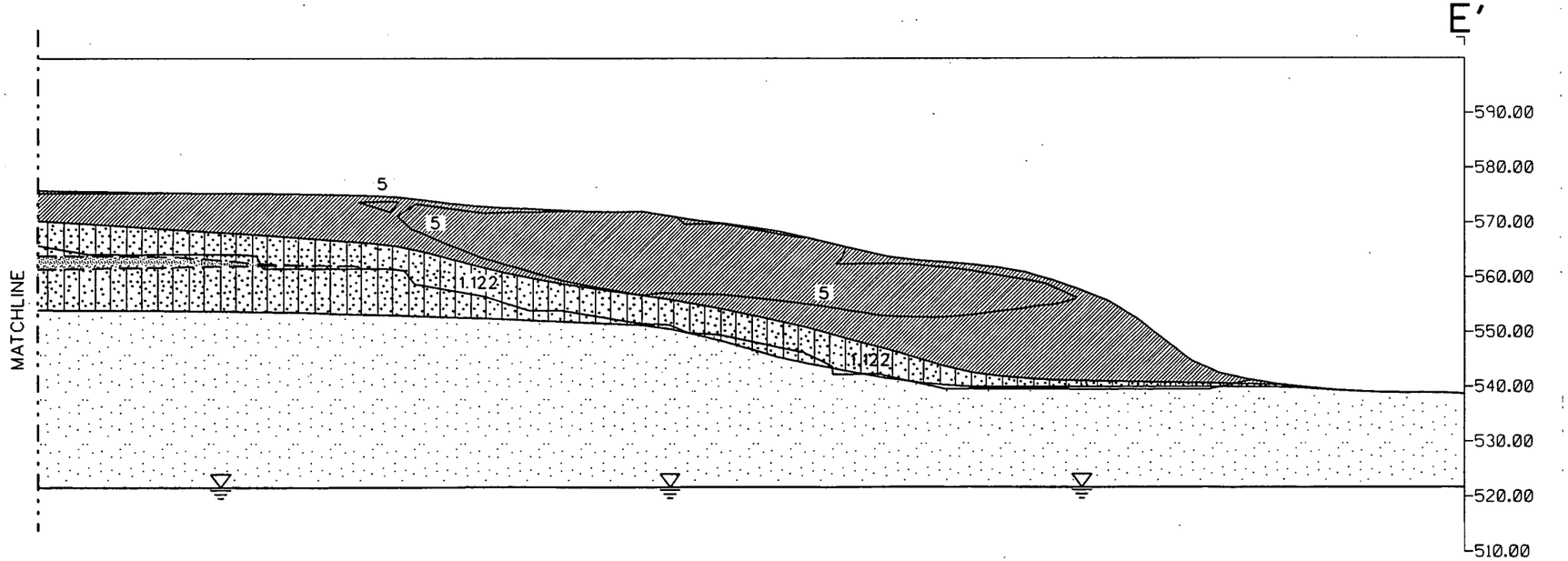

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- RAILROAD
- FILL/DEBRIS
- SAND/GRAVEL
- GLACIAL OVERBURDEN/TILL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

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SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL .1 cm = 6 m

FIGURE 3-10
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 5 OF 5

TABLE 3-4

SOUTH FIELD
VOLUMES[a] OF MATERIAL TO BE REMEDIATED

Volume Criteria	Kriging Volumes Based on PRLs for U-238, Ra-228, and Th-228						Additional Volume Due to Other COCs						Additional Volume Due to ARARs Limits		RCRA[b] Waste Volume		TOTAL[c]	
	Fill/Debris		Impacted Till		Other Remaining Till		GMA Material		Sediment		Fill, Impacted Till, and Other Remaining Till							
	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3
Total Subunit Volume	91800	120100	42800	55900	124600	162800	490[d]	640[d]	18	23	NA[e]	NA	NA	NA	230[f]	300[f]	259700	339400
Remediation Scenario																		
Private Ownership No Source Controls	88000	115000	39300	51300	36400	47600	490	640	18	23	95500	124800	0	0	230[f]	300[f]	259700	339400
Federal Ownership No Source Controls	37200	48600	18700	24400	3300	4300	0	0	0	0	0	0	0	0	230	300	59400	77600
Federal Ownership Source Controls[g]	25500	33300	6500	8400	0	0	0	0	0	0	0	0	0	0	230	300	32200	42100

[a]All volumes listed are "in-place" volumes.

[b]This material orginates from the firing range and is contaminated with levels of lead that have failed the criteria for a RCRA characteristic waste in 40 CFR 261.

[c]Totals are rounded to the nearest hundred.

[d]Volume of unsaturated GMA material that is considered for possible inclusion in remediation volumes.

[e]NA = not applicable.

[f]This volume is also included in Fill/Debris, and so does not contribute to the total.

[g]Source controls are defined as vertical infiltration control and lateral migration control.

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For the private ownership scenario, the amount of material contaminated with uranium-238, radium-228, or thorium-228 above PRLs is approximately 163,700 cu m (213,900 cu yd). This volume consists of approximately 88,000 cu m (115,000 cu yd) of fill/debris material, 39,300 cu m (51,300 cu yd) of impacted till, and 36,400 cu m (47,600 cu yd) of other remaining till.

After remediation volumes were determined for material impacted by uranium-238, radium-228, or thorium-228, the remaining material was evaluated for other COCs to determine if they exceed their respective risk-based PRLs. Based on this evaluation, it was determined that, for the on-property resident farmer receptor, an additional volume of 95,500 cu m (124,800 cu yd) from the combined fill, impacted till, and other remaining till would require remediation. Also, additional volumes of 490 cu m (640 cu yd) of GMA material and 18 cu m (23 cu yd) of sediment will require remediation due to other COCs. No additional volume was determined due to ARARs. For the private-ownership scenario, an estimated total volume of 259,700 cu m (339,400 cu yd) of material would require remediation.

For the federal ownership scenario with no source control, the amount of contaminated material above PRLs for uranium-238, radium-228, or thorium-228 is approximately 59,200 cu m (77,300 cu yd). This volume consists of approximately 37,200 cu m (48,600 cu yd) of fill/debris, 18,700 cu m (24,400 cu yd) of impacted till, and 3,300 cu m (4,300 cu yd) of other remaining till. No additional volume was identified due to ARARs. For the federal ownership scenario with no source control, an estimated total volume of 59,400 cu m (77,600 cu yd) of material will require remediation.

For the federal ownership scenario with source control, the remediation volume for uranium-238, radium-228, or thorium-228, was determined to be 32,000 cu m (41,700 cu yd). This volume consists of 25,500 cu m (33,300 cu yd) of fill/debris and 6,500 cu m (8,400 cu yd) of impacted till. No other till or Great Miami Aquifer material will require remediation due to uranium-238, radium-228, or thorium-228. For the federal ownership scenario with source control an estimated total volume of 32,200 cu m (42,100 cu yd) of material will require remediation.

In addition to the above volumes of material requiring remediation for the private ownership and federal ownership land-use scenarios, approximately 230 cu m (300 cu yd) of Resource Conservation and Recovery Act (RCRA) characteristic waste is present in the South Field. This material is located in the Firing Range area and contains lead bullets. Because of the presence of lead and the general

occurrence of radionuclides in the vicinity of the Firing Range, it is currently assumed that soil from that area will be treated as a mixed waste.

3.2.5 Active Flyash Pile

The total area of the Active Flyash Pile is approximately 1 ha (3 ac). Based on three-dimensional block modeling, the Active Flyash Pile contains approximately 49,800 cu m (65,100 cu yd) of ash. Figures 3-11 and 3-12 illustrate the geologic cross section of the Active Flyash pile. Superimposed on the geologic cross section are the existing concentrations of uranium-238 at various depths determined by kriging.

The total subunit volumes and estimated volumes of material to be remediated for the Active Flyash Pile future land-use scenario are summarized in Table 3-5. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238 for four material types at the Active Flyash Pile: flyash, impacted till, other remaining till, and unsaturated Great Miami Aquifer material. The flyash actually consists of both flyash and bottom ash; the impacted till is the top 0.75 m (2.5 ft) of the natural soil that contains excess concentrations of uranium as compared to the other remaining till; the remaining till and unsaturated Great Miami Aquifer material are natural soils existing below the Active Flyash Pile subunit. In addition to these four material types used for block modeling, sediments surrounding the Active Flyash Pile were evaluated to determine contaminant impacts. Any material not previously in the remediation volume for radionuclide contamination was evaluated to determine if the risk-based PRLs of other COCs were exceeded or if ARAR considerations applied.

For the private ownership scenario, the amount of material contaminated with uranium-238, radium-228, or thorium-228 above PRLs is approximately 52,600 cu m (68,700 cu yd). This volume consists of 49,800 cu m (65,000 cu yd) of flyash, 1500 cu m (2,000 cu yd) of impacted till, and 1300 cu m (1,700 cu yd) of other remaining till. This material will be considered contaminated because it is impacted by radionuclides above risk-based levels. No Great Miami Aquifer material will require remediation. Sediment volumes are included with the impacted till volume calculation.

The material remaining after remediation for uranium-238, radium-228, or thorium-228 was evaluated for other COCs to determine if their concentrations exceed risk-based PRLs. An additional volume of 4,700 cu m (6,200 cu yd) of material from both the impacted till and the other remaining till will

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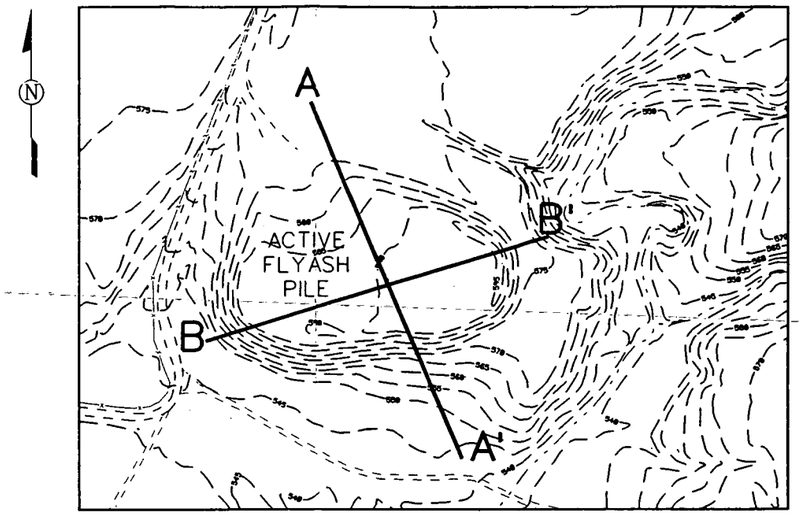
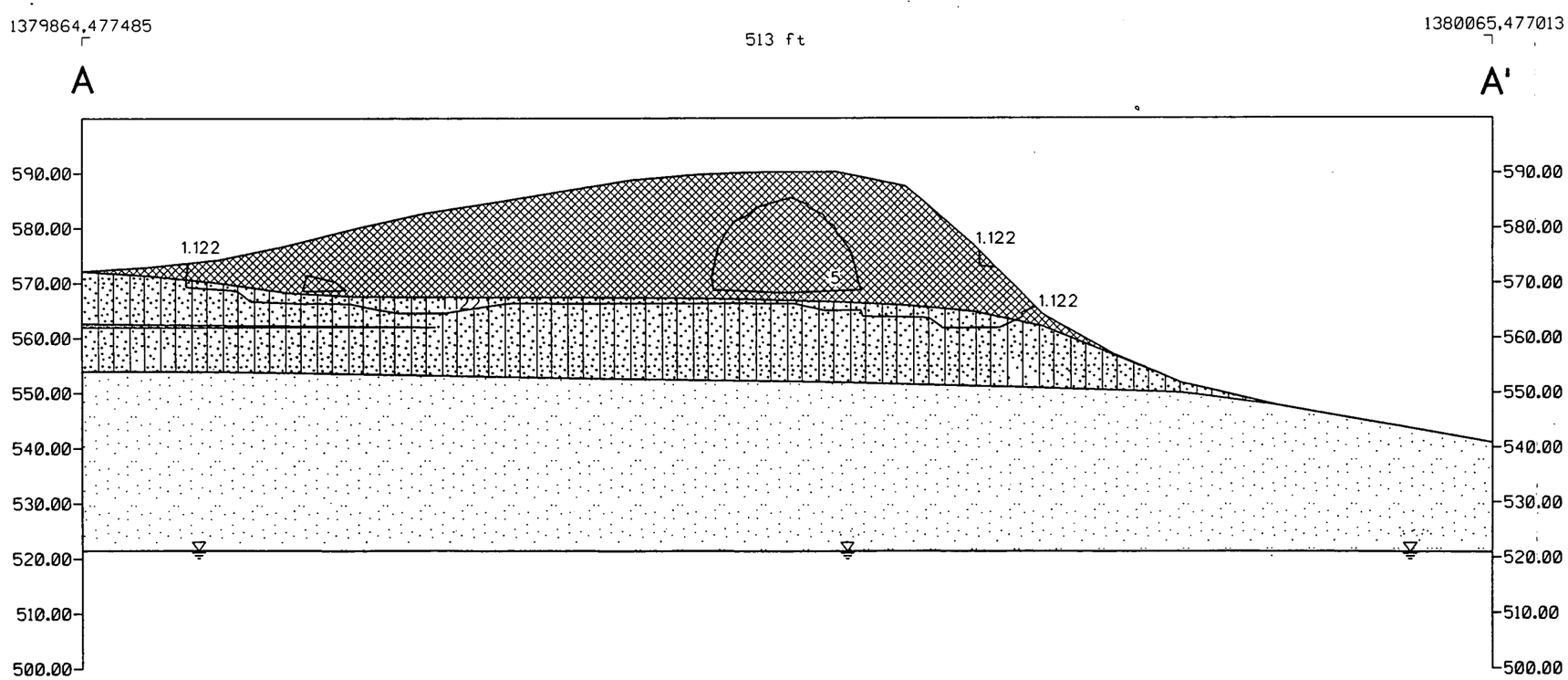


LOCATION KEY (1" = 200')



SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

SCALE (FT)
0 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- FLYASH
- GLACIAL OVERBURDEN/TILL
- SAND/GRAVEL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

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FIGURE 3-11
GEOLOGIC CROSS SECTION
ACTIVE FLYASH PILE
SHEET 1 OF 2

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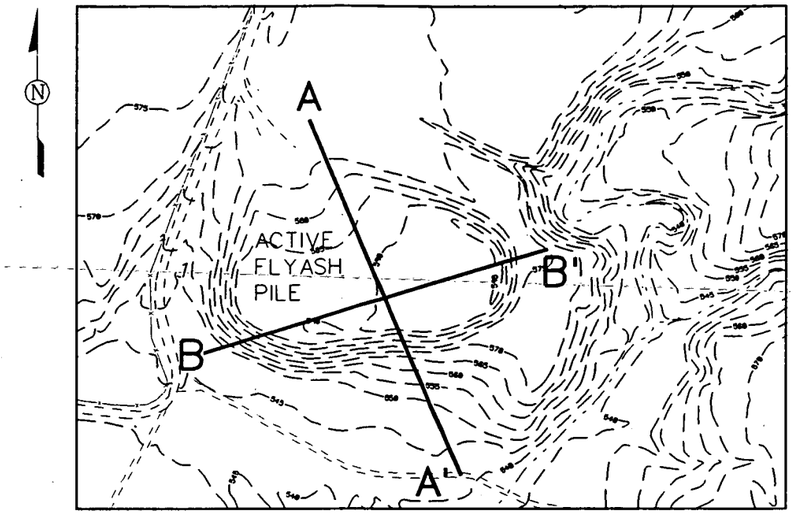

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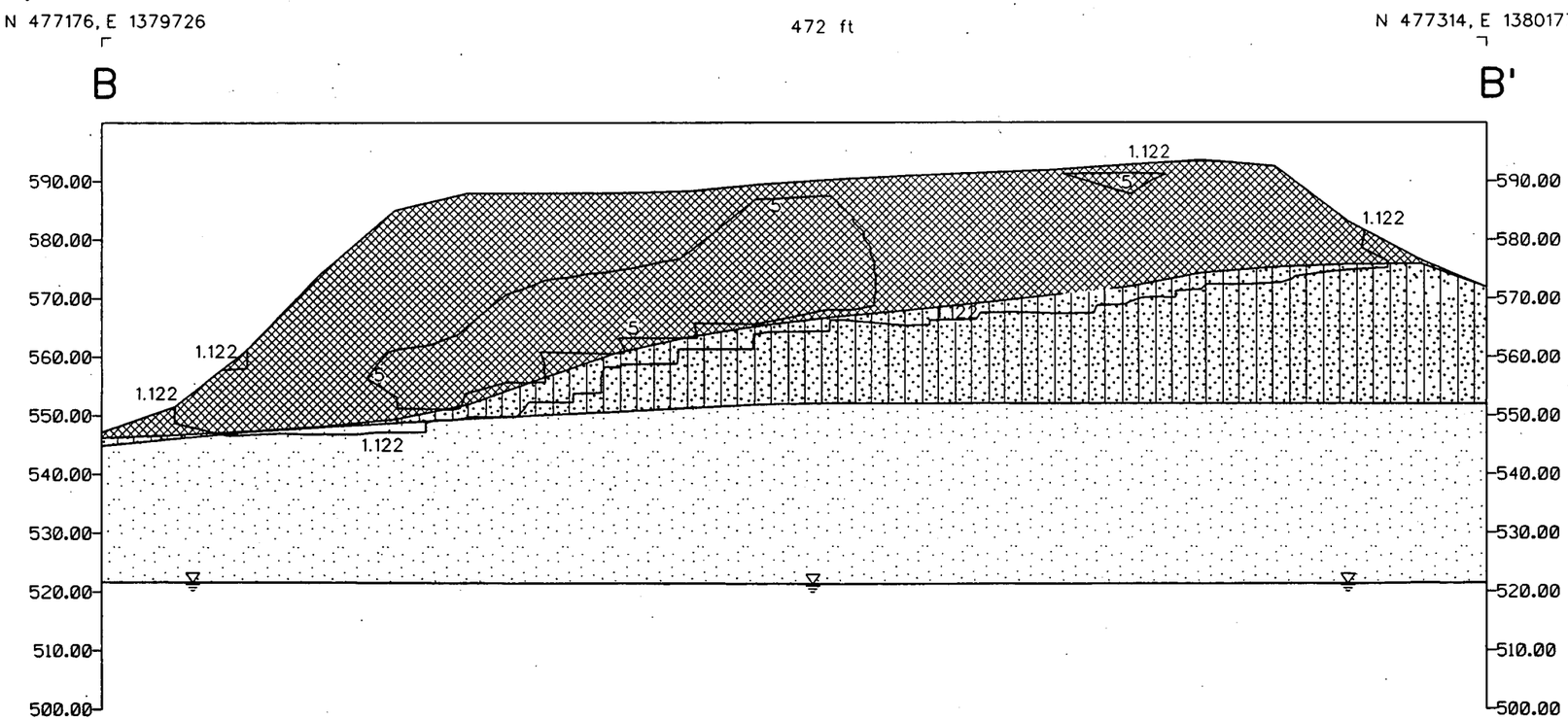

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- 1.122 URANIUM-238 (pCi/g) CONCENTRATION CONTOURS
- FENCE
- FLYASH
- GLACIAL OVERBURDEN/TILL
- SAND/GRAVEL
- GREAT MIAMI AQUIFER

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

SCALE (FT)
0 50 100

0 6 12 24

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 6 m

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FIGURE 3-12
GEOLOGIC CROSS SECTION
ACTIVE FLYASH PILE
SHEET 2 OF 2

fs1074.dgn

TABLE 3-5

ACTIVE FLYASH VOLUMES[a] OF MATERIAL TO BE REMEDIATED

Volume Criteria	Kriging Volumes Based on PRLs for U-238, Ra-228, and Th-228								Additional Volume Due to Other COCs		Additional Volume Due to ARARs		TOTAL[b]	
	Flyash		Impacted Till		Other Remaining Till		GMA Material							
	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3	m^3	yd^3
Total Subunit Volume	49800	65100	1500	2000	30500	39900	0	0	NA[c]	NA	NA	N/A	81800	107000
Remediation Scenario														
Private Ownership No Source Controls	49800	65000	1500[d]	2000[d]	1300	1700	0	0	4700	6200	0	0	57300	74900
Federal Ownership No Source Controls	48300	63100	0	0	0	0	0	0	75	100	1400	1900	49800	65100
Federal Ownership Source Control[e]	48300	63100	0	0	0	0	0	0	75	100	1400	1900	49800	65100

[a]All volumes listed are "in-place" volumes.

[b]Totals are rounded to the nearest hundred.

[c]NA = not applicable.

[d]Includes sediment volume.

[e]Source control is defined as vertical infiltration control.

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require remediation for the other COCs. No additional volume will require remediation based on ARARs. Thus, the total volume of materials requiring remediation under the private-ownership scenario will be 57,300 cu m (74,900 cu yd).

For the federal ownership with no source control scenario, the amount of contaminated material above PRLs for uranium-238, radium-228, and thorium-228 is approximately 48,300 cu m (63,100 cu yd) of flyash. An additional volume of 75 cu m (100 cu yd) of impacted fill and other remaining till will require remediation due to other COCs (including neptunium-237 and beryllium). An additional volume of 1,400 cu m (1,900 cu yd) of flyash material will require remediation based on consideration as a solid waste. For the federal ownership scenario, with no source control, an estimated total volume of 49,800 cu m (65,100 cu yd) of material will require remediation.

For the federal ownership scenario with source controls, the remediation volumes at the Active Flyash Pile are the same as for the no source control scenario.

3.3 GENERAL RESPONSE ACTIONS

The term general response action (GRA) refers to a general category of measures which produce similar results when implemented. A list of GRAs, which when implemented will achieve the RAOs, has been generated for each medium of concern. For the Operable Unit 2 subunits, the media of concern are soil/sediment/waste and perched groundwater/construction water. The soil, sediment, and waste are similar in nature with regard to concentrations and types of contamination; therefore, they have been grouped together as a single medium. Likewise, perched groundwater and construction water are expected to have similar characteristics; thus, they are considered together. However, it should be noted that the Amended Consent Agreement defines groundwater and surface water as being part of Operable Unit 5. Therefore, perched groundwater and construction water as addressed by Operable Unit 2 are limited to those waters that will be impacted by remediation of the soil, sediment, and waste at the individual subunits. Remediation of the remaining perched groundwater, as a separately defined environmental medium, is addressed under the direction of Operable Unit 5.

The GRAs developed for soil, sediment, and waste are common for all of the Operable Unit 2 subunits, as are the perched groundwater and construction water GRAs. The GRAs developed for soil/sediment/waste and perched groundwater/construction water are described in Sections 3.3.1 and 3.3.2, respectively.

3.3.1 Soil/Sediment/Waste GRAs

The GRAs for soil, sediment, and waste are as follows:

- No Action: Represents no remediation of the contaminated media for any of the subunits. The no action scenario is considered in the FS as the baseline to which other remedial alternatives are compared and is retained throughout the FS process as required by the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) (40 CFR § 300.430(e)(6)) regardless of its effectiveness in achieving the RAOs.

- Institutional Actions: Institutional actions apply various access restrictions and/or land-use restrictions to reduce or eliminate exposure pathways related to direct human contact with contaminated media.

- Containment: Physical measures to reduce contaminant migration by isolation of contaminated media. The contaminated media are isolated from primary transport mechanisms such as wind, erosion, infiltration, and surface water through the use of surface and/or subsurface barriers. The technology reduces or eliminates the exposure pathways related to direct human contact with the contaminated material, minimizes infiltration of precipitation, and minimizes movement of contaminated material and thus minimizes contaminant migration.

- Removal: Includes the excavation and material handling/processing of contaminated media in preparation for treatment and/or disposal.

- In Situ Treatment: Includes physical, chemical, and thermal measures which will reduce the toxicity, mobility, or volume of a contaminant by altering its physical or chemical properties. The impacted media are treated in place, without excavation. While the volume may increase or decrease based on the treatment type used, mobility or toxicity is reduced or eliminated through treatment.

- Ex Situ Treatment: Includes physical, chemical, and thermal measures which will reduce the toxicity, mobility, or volume of a contaminant by altering its physical or chemical properties. The impacted media are excavated and handled prior to treatment. While the volume may increase or decrease based on the treatment type used, mobility or toxicity is reduced or eliminated through treatment.

- Disposal: Includes placement of excavated material in an on-site or off-site permanent engineered disposal facility which serves to restrict contaminant migration and mitigate exposure routes. This technology addresses/eliminates exposure pathways related to direct human contact with the contaminated material.

3.3.2 Perched Groundwater/Construction Water GRAs

The GRAs listed below pertain to contaminated perched groundwater in the glacial overburden zone beneath the Operable Unit 2 subunits that would be encountered during or impacted by the remediation of soil/sediment/waste and to construction water generated during the remedial action, including stormwater and construction dewatering. Contaminated groundwater in the Great Miami Aquifer below the Operable Unit 2 subunits is outside of the scope of this FS, but will be considered in the Operable Unit 5 FS.

- No Action: Represents no remediation of the perched groundwater or construction water. The no action scenario is considered in the FS as the baseline to which other remedial alternatives are compared and is retained throughout the FS process as required by the NCP [40 CFR § 300.430(e)(6)] regardless of its effectiveness in achieving the RAOs.

- Institutional Actions: Includes perched groundwater monitoring and/or perched groundwater use restrictions and access controls to reduce or eliminate exposure pathways related to direct human contact with contaminated material.

- Containment/Control: Physical measures to reduce contaminant migration by isolation of contaminated media. Includes subsurface measures, such as vertical barriers, to restrict groundwater movement and thus reduce contaminant migration.

- Removal: Includes extraction wells, sump pumps or interceptor systems to collect and transfer contaminated perched groundwater/construction water to treatment or discharge.

- Treatment: Includes physical and chemical processes at the subunit or advanced wastewater treatment (AWWT) facility to reduce and/or remove contaminants from the perched groundwater/construction water, thereby reducing the toxicity, mobility, or volume of the contamination.

- Disposal: Includes discharge/release of untreated or treated groundwater and construction water.

Operable Unit 5 is currently constructing an AWWT facility to treat contaminated groundwater from the FEMP site. The AWWT facility will be able to treat wastewater from Operable Unit 2. The AWWT facility is currently scheduled to begin accepting Operable Unit 2 groundwater in June 1996.

3.4 DESCRIPTION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

Representative potentially applicable remedial technologies and process options were identified for each GRA. The criteria for identifying potentially applicable technologies are provided in EPA RI/FS guidance (EPA 1988a) and in the NCP (EPA 1990b). The remedial technologies and process options were selected for initial consideration based on their general applicability for waste similar to that at

the subunits. The applicable process options were screened with respect to technical implementability, considering the unique features and COCs at each subunit.

The description and screening of technologies and process options considered for application for the soil/sediment/waste medium are presented in Tables 3-6 through 3-10 for the Solid Waste Landfill, Lime Sludge Pond, Inactive Flyash Pile, South Field, and Active Flyash Pile, respectively. The description and screening of technologies and process options considered for application for the perched groundwater/construction water medium at the Solid Waste Landfill and the Lime Sludge Ponds are presented in Tables 3-11 and 3-12, respectively. Consideration of technologies and process options that potentially address the groundwater/construction water medium at the Inactive Flyash Pile, South Field, and Active Flyash Pile was made addressing these subunits as a group because of their proximity and is presented in Table 3-13. Process options considered as not applicable are indicated by shading on Tables 3-6 through 3-13 and are not discussed further in this FS.

Process options that were considered potentially applicable following screening are discussed further in the following section. Process options which address the soil/sediment/waste medium are described and evaluated further in Section 3.5.1; process options which address the groundwater/construction water medium are described and evaluated further in Section 3.5.2.

3.5 DESCRIPTION AND EVALUATION OF TECHNOLOGIES AND PROCESS OPTIONS

This section provides descriptions and evaluations of the remedial technologies and process options which were indicated in the initial screening process as being potentially applicable as components of remedial action alternatives. The evaluation is summarized in Tables 3-14 through 3-21 organized by medium and subunit. The description and evaluation of process options that address the soil/sediment/waste medium on an Operable Unit 2 wide basis are presented in Section 3.5.1, the description and evaluation of process options that address the groundwater/construction water medium on an Operable Unit 2 wide basis are presented in Section 3.5.2. The technologies and process options were evaluated with respect to effectiveness, implementability, and cost as follows:

- Effectiveness - The effectiveness evaluation focused on:
  - the potential effectiveness of the process option to handle the estimated areas or volumes of media and to meet the RAOs
  - the potential impacts to human health and the environment during the construction and implementation phase

000366

TABLE 3-6

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR THE SOLID WASTE LANDFILL SOIL/SEDIMENT/SOLID WASTE MEDIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Fencing, limited road access, posted signs, etc., used to restrict access.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable.
Containment	Capping System	Clay Cap (multi-layered capping system with clay barrier zone)	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and 24-inch thick vegetative soil cover to reduce potential contact with the waste, reduce vertical infiltration of water, and prevent dust migration. Designed to meet the requirements of OAC 3745-27 and OEPA Policy 4.07.	Not applicable. This capping system does not comply with ARAR (40 CFR Sec 192.02) relative to containment/disposal of radioactive waste.
		Composite Cap (multi-layered capping system with both synthetic and clay barriers)	Cover contaminated material with a cap designed for an effective life of 1,000 years and a minimum life of 200 years to meet the requirements of 40 CFR 192 and DOE Order 5400.5. Cap contains compacted clay, geomembrane liner, drainage layer, 3-foot thick cobble layer, and a vegetative cover soil layer.	Potentially applicable.
		Concrete-Based Cap	A single-layered cap composed of a reinforced portland cement concrete slab placed over a prepared subgrade above the contaminated material.	Not applicable. Concrete caps are very susceptible to weathering and cracking, and not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.
		Asphalt-Based Cap	A single-layered cap composed of bituminous concrete pavement placed over a prepared subgrade above the contaminated material.	Not applicable. Bituminous concrete caps are very susceptible to weathering and progressive cracking, and are not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Surface Controls	Surface Water Controls	Modify topography around perimeter of Solid Waste Landfill to control erosion and manage surface water.	Potentially applicable.
		Revegetation	Grade/backfill to provide suitable surface drainage and cover with soil to support vegetation.	Potentially applicable.
Removal	Excavation	Mechanical Excavation	Backhoes, bulldozers, and loaders used to excavate localized areas with elevated contaminant concentrations, or entire areas.	Potentially applicable.
		Sorting/Separation	Visually sort large debris using mechanical excavating equipment. Use gamma detectors or PIDs in field to identify radiologically contaminated material.	Potentially applicable.
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based upon the waste characteristics (i.e., primarily heterogeneous waste with large objects). Primary COCs are not readily biodegradable. Will not treat radiological contaminants.
		Anaerobic	In situ degradation of organics using microorganisms in an anaerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based upon the waste characteristics (i.e., primarily heterogeneous waste with large objects). Primary COCs are not readily biodegradable. Will not treat radiological contaminants.
	Physical/ Chemical	Stabilization/ Solidification	Wastes are mixed with inert additives, cement, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Not applicable without additional processes. Solid waste and debris would impede adequate mixing.

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Physical/ Chemical (continued)	Soil Washing (Chemical Extraction)	Reagents are injected into the waste mass to solubilize COCs. The resultant solution is then extracted utilizing wells or interceptor systems. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Not applicable for heterogeneous waste. Success of application depends on achieving uniform and total reagent-waste contact. Debris and solid waste would impede the mixing process. Potential for migration of solution to GMA. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce large volume of sludge.
		Vapor (Vacuum) Extraction	Vacuum induced to pull air through the unsaturated region (vadose zone) using an extraction well system to remove VOCs from the soil.	Not applicable based upon the waste characteristics. Primary COCs are not volatile. Vapor extraction is not applicable to semi-VOCs or metals treatment. Success limited to porous media.
		Steam Stripping	A drilling and steam dispensing system injects steam and hot air into soil to remove volatile organic contaminants. Organics are collected at the surface.	Not applicable based on waste characteristics. Primary COCs are not volatile.
	Thermal	Radio Frequency Heating	Soils are heated to between 200 and 1,000°F by exciting electrodes placed in the ground with radio frequency energy. Organics are vaporized and collected at the surface for treatment.	Not applicable based upon the waste characteristics. Primary COCs are not volatile. Not applicable to radiological contaminants.
		Vitrification	Immobilization of inorganic contaminants using electrically generated heat by electrodes to convert soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	Heat would induce combustion of paper/wood products with resultant vapors and incomplete products of combustion. A collection system and off-gas treatment system would be required for the vapors. Effectiveness of process could be inconsistent without homogenization of solid waste and debris with the soil. May require addition of material suitable to form crystalline matrix. No known successful full-scale application.

000269

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on primary waste characteristics. Primary COCs are not readily biodegradable.
		Anaerobic	Degradation of organics in a reactor using microorganisms under anaerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on primary waste characteristics. Primary COCs are not readily biodegradable.
	Physical/ Chemical	Soil Washing (Chemical Extraction)	Reagents are mixed with the waste mass to solubilize COCs. The resultant solution is then drained from the reaction vessel. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Low potential for successful application on heterogeneous waste without homogenization. Success of application depends on achieving uniform and total reagent/waste contact. Debris and solid waste would impede the mixing process. Additional material processing, such as crushing and shredding, would be required. Increased handling increases concern for worker exposure to COCs. Crushing/shredding should be executed in a controlled environment due to the potential for fugitive emissions. For the larger fraction of material, the concentration of COCs is low; therefore, soil washing would not be effective. Potentially applicable to a small fraction of waste at this subunit that contains high concentratios of COCs. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce large volume of sludge.

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical/ Chemical (continued)	Stabilization/ Solidification	Wastes are mixed with inert additives, cement or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Potentially applicable when used in conjunction with other technologies. Processing of debris and solid waste would be required to improve handling/mixing characteristics. Increased handling increases concern for worker exposure to COCs. Material processing should be executed in a controlled environment due to the potential for fugitive emissions. Depending on volume of solid waste and debris, may require the addition of soil material to form the monolithic matrix, and thus result in an increase in the waste volume.
		Crushing/Shredding	Processing of material for size reduction and texturization to improve handling/compaction characteristics or in preparation for treatment.	Potentially applicable when used in conjunction with other technologies. Increased concern for fugitive emissions.
		Drying	Reducing existing moisture in waste media using either a physical treatment such as a filter press or a thermal treatment such as pulse drying.	Potentially applicable when used in conjunction with other technologies. Increased concern for fugitive emissions.
		Plasma Etching/ Fluormation of Debris	Plasma is used to clean contaminants from the surface of concrete and metal debris. This process also includes a means of recovering uranium.	Not applicable for heterogeneous waste. Only suitable for large surface areas with low porosity. Would require elaborate material handling/sorting system. Generally, only feasible for low volume with relatively high concentrations of uranium. Process produces residue requiring additional treatment.
		Sandblasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris.	Not applicable for heterogeneous waste. Only suitable for large surface areas with low porosity. Generates a large volume of waste which requires treatment/disposal. Potential for worker exposure to COCs due to fugitive emissions.

000-71

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical/ Chemical (continued)	High-Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris.	Not applicable for heterogeneous waste. Only suitable for large surface areas with low porosity. Generates a large volume of liquid waste which requires treatment/disposal. Potential for worker exposure to COCs due to fugitive emissions.
	Thermal	Vitrification	Immobilization of inorganic contaminants and radionuclides by placing soils/wastes into a high temperature melter and converting the soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	Low potential for successful application without homogenization. Additional material processing, such as crushing and shredding, would be required. Increased handling increases concern for worker exposure to COCs. Material processing should be executed in a controlled environment due to the potential for fugitive emissions. May require addition of material suitable to form crystalline matrix. Heat would induce combustion of paper/wood products with resultant vapors and incomplete products of combustion. A collection system and off-gas treatment system would be required for the vapors. For the larger fraction of material, the concentration of COCs is low; therefore, treatment would not be warranted. Ex situ vitrification is potentially applicable for that small fraction of waste from isolated areas within the subunit having high concentrations of COCs.
		Low-Temperature Thermal Stripping (Volatilization)	Low-temperature technology uses indirect heating to thermally desorb or volatilize organic contaminants. Since the organics are not destroyed, this must be used in conjunction with another remedial technology.	Not applicable to organics present in landfill. Will not treat radiological contaminants. Primary COCs are not volatile.

000372

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Incineration	Fluidized Bed Incinerators	Incineration of organic material using a refractory-lined changer containing an inert material, usually sand. Waste material with densities greater than the inert material cannot be treated. Normal operating temperatures very from 850 to 2,100°F. Fluidized bed can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs. Typical waste material has densities greater than sand.
		Rotary Kiln Incinerators	Incineration of organic material in a rotating refractory-lined cylinder. Material is rotated, causing turbulence and agitation, while heated combustion air dries and incinerates the waste. Normal operating temperatures vary from 1,475 to 2,900°F. Rotary kilns can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs.
	Pyrolysis	High-Temperature Fluid Wall Reactor	High-temperature fluid-wall reactors use a porous refractory carbon core with electrodes used to heat a gaseous fluid. The gaseous fluid is forced through the porous core to form a fluid wall which keeps wastes from contacting the reactor core. This fluid increases temperatures of the reactor core, which causes pyrolysis of waste. Temperatures of the core can reach 4,000°F. Fluid-wall reactors can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides which are the primary COCs.
Disposal	On-Site Disposal	On-Site Disposal Cell	An on-site disposal cell designed to accept contaminated material and that meets the requirements of OAC 3745-27, OEPA Policy 4-07, 40 CFR 192, and DOE Order 5400.5.	Potentially applicable.
	Off-Site Disposal	Off-Site Disposal Facility	Non-radiologically contaminated material transported to an off-site facility meeting OAC 3745-27 and OEPA Policy 4.07 requirements.	Not applicable. Not technically feasible to screen radionuclides to levels required to verify material is not cross-contaminated.
		Low-Level Radioactive Waste Disposal Facility	Contaminated material transported to an off-site facility meeting 40 CFR 192 and DOE Order 5400.5 requirements.	Potentially applicable.
		Off-Site Mixed Waste Disposal Facility	Facility designed to accept waste that is both radioactive and listed or characteristically hazardous.	Not applicable. No mixed waste identified in the Solid Waste Landfill.

000373

TABLE 3-7

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR THE LIME SLUDGE PONDS SOIL/LIME SLUDGE/WASTE MEDIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Fencing, limited road access, posted signs, etc., used to restrict access.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable.
Containment	Capping System	Clay Cap (multi-layered capping system with clay barrier zone)	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and 24-inch thick vegetative soil cover to reduce potential contact with the waste, reduce vertical infiltration of water, and prevent dust migration. Designed to meet the requirements of OAC 3745-27 and OEPA Policy 4.07.	Not applicable. This capping system does not comply with ARAR (40 CFR Sec 192.02) relative to containment/disposal of radioactive waste.
		Composite Cap (multi-layered capping system with both synthetic and clay barriers)	Cover contaminated material with a cap designed with an effective life of 1,000 years and a minimum life of 200 years which meets the requirements of 40 CFR 192 and DOE Order 5400.5. Cap contains compacted clay, geomembrane liner, drainage layer, 3-foot thick cobble layer, and a vegetative cover soil layer.	Potentially applicable.
		Concrete-Based Cap	A single-layered cap composed of a reinforced portland cement concrete slab placed over a prepared subgrade above the contaminated material.	Not applicable. Concrete caps are very susceptible to weathering and cracking, and are not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Capping System (continued)	Asphalt-Based Cap	A single-layered cap composed of bituminous concrete pavement placed over a prepared subgrade above the contaminated material.	Not applicable. Bituminous concrete caps are very susceptible to weathering and progressive cracking, and are not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.
	Surface Controls	Surface Water Controls	Modify topography around perimeter of Lime Sludge Ponds to control erosion and manage surface water.	Potentially applicable.
		Revegetation	Grade/backfill to provide suitable surface drainage and cover with soil to support vegetation.	Potentially applicable.
Removal	Excavation	Mechanical Excavation	Backhoes, bulldozers, and loaders used to excavate localized areas with elevated contaminant concentrations, or entire areas.	Potentially applicable.
		Sorting/ Separation	Visually sort large debris from soils using mechanical excavating equipment. Use gamma detectors or PIDs in field to identify radiologically/organics contaminated material.	Potentially applicable.
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
		Anaerobic	In situ degradation of organics using microorganisms in an anaerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.

000275

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Physical/ Chemical	Stabilization/ Solidification	Wastes are mixed with inert additives, cements, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Potentially applicable to improve structural stability.
		Soil Washing (Chemical Extraction)	Reagents are injected into the waste mass to solubilize COCs. The resultant solution is then extracted utilizing wells or interceptor systems. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Success of application depends on achieving uniform and total reagent-waste contact. Extensive mixing would be required for low permeability material to separate waste particles and achieve total regent-waste contact. Not effective for treatment of waste with low concentrations of COCs. Potential for migration of solution to GMA. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce large volume of sludge.
		Vapor (Vacuum) Extraction	Vacuum induced to pull air through the unsaturated region (vadose zone) using an extraction well system to remove VOCs from the soil.	Not applicable based on waste characteristics. Primary COCs are not volatile. Vacuum extraction is not applicable to semi-volatile or metal treatment. Success limited to porous medium.
		Steam Stripping	A drilling and steam dispensing system injects steam and hot air into soil to remove volatile organic contaminants. Organics are collected at the surface.	Not applicable based upon the waste characteristics. Primary COCs are not volatile.
	Thermal	Radio Frequency Heating	Soils are heated to between 200 and 1,000°F by exciting electrodes placed in the ground with radio frequency energy. Organics are vaporized and collected at the surface for treatment.	Not applicable based on waste characteristics (i.e., primary inorganics). Primary COCs are not volatile.

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Thermal (continued)	Vitrification	Immobilization of inorganic contaminants using electrically generated heat by electrodes to convert soils/wastes to a glass/crystalize product. High temperatures destroy organics through pyrolysis and combustion.	Not applicable based on waste characteristics. Not appropriate for treatment of lime sludge without addition of silica or other material to form crystalline matrix. A large amount of energy would be required to remove water. This drying operation would generate steam. A steam-collection/treatment system would be required. Not warranted due to low concentration of COCs.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e. primarily inorganics).
		Anaerobic	Degradation of organics in a reactor using microorganisms under anaerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics).

000277

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical/ Chemical	Soil Washing (Chemical Extraction)	Reagents are mixed with the waste mass to solubilize COCs. The resultant solution is then drained from the reaction vessel. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Not applicable. Low potential for successful application. Success of application depends on achieving uniform and total reagent-waste contact. Extensive material processing would be required for low permeability material to separate waste particles and achieve total reagent-waste contact. Not effective for treatment of waste with low concentrations of COCs. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce large volume of sludge.
		Stabilization/ Solidification	Wastes are mixed with inert additives, cement, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Potentially applicable to improve structural stability. Fixation/solidification is not warranted due to the low concentration of COCs.
		Crushing/Shredding	Processing of material for size reduction and texturization to improve handling/compaction characteristics or in preparation for treatment.	Potentially applicable when used in conjunction with other technologies.
		Drying	Reducing existing moisture in waste media using either a physical treatment such as a filter press or a thermal treatment such as pulse drying.	Potentially applicable when used in conjunction with other technologies.
		Plasma Etching/ Fluorination of Debris	Plasma is used to clean contaminants from the surface of concrete and metal debris. This process also includes a means of recovering uranium.	Not applicable for soil or sludge. Only suitable for large surface areas with low porosity. Generally, only feasible for low volume with relatively high concentrations of uranium. Process produces residue requiring additional treatment.

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical/ Chemical (continued)	Sand Blasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris	Not applicable for soil or sludge. Only suitable for large surface areas with low porosity.
		High-Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris.	Not applicable for soil or sludge. Only suitable for large surface areas with low porosity.
	Thermal	Vitrification	Immobilization of inorganic contaminants by placing soils/wastes into a high-temperature melter and converting the soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	Not applicable based on waste characteristics. Not appropriate for treatment of lime sludge without addition of silica or other material to form crystalline matrix. Not warranted due to low concentration of COCs. Extensive dewatering/drying would be required prior to vitrification.
	Incineration	Low-Temperature Thermal Stripping (Volatilization)	Low-temperature technology uses indirect heating to thermally desorb or volatilize organic contaminants. Since the organics are not destroyed, this must be used in conjunction with another remedial technology.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not volatile.
		Fluidized Bed Incinerators	Incineration of organic material using a refractory-lined changer containing an inert material, usually sand. Waste material with densities greater than the inert material cannot be treated. Normal operating temperatures very from 850 to 2,100°F. Fluidized bed can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides which are the primary COCs. Typical waste material has densities greater than sand.
		Rotary Kiln Incinerators	Incineration of organic material in a rotating refractory-lined cylinder. Material is rotated, causing turbulence and agitation, while heated combustion air dries and incinerates the waste. Normal operating temperatures vary from 1,475 to 2,900°F. Rotary kilns can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides which are the primary COCs.

000579

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Pyrolysis	High-Temperature Fluid Wall Reactor	High-temperature fluid-wall reactors use a porous refractory carbon core with electrodes used to heat a gaseous fluid. The gaseous fluid is forced through the porous core to form a fluid wall which keeps wastes from contacting the reactor core. This fluid increases temperatures of the reactor core, which causes pyrolysis of waste. Temperatures of the core can reach 4,000°F. Fluid-wall reactors can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs.
Disposal	On-Site Disposal	On-Site Disposal Cell	An on-site disposal cell designed to accept contaminated material and that meets the requirements of OAC 3745-27, OEPA Policy 4-07, 40 CFR 192, and DOE Order 5400.5.	Potentially applicable.
	Off-Site Disposal	Off-Site Disposal Facility	Non-radiologically contaminated material transported to an off-site facility meeting OAC 3745-27 and OEPA Policy 4-07 requirements.	Not applicable. Not technically feasible to screen radionuclides to levels required to verify material is not cross-contaminated.
		Low-Level Radioactive Waste Disposal Facility	Contaminated material transported to an off-site facility meeting 40 CFR 192 and DOE Order 5400.5 requirements.	Potentially applicable.
		Off-Site Mixed Waste Disposal Facility	Facility designed to accept waste that is both radioactive and listed or characteristically hazardous.	Not applicable. No mixed waste identified in Lime Sludge Ponds.
	Recovery/Reuse	Soil Conditioner	Lime sludge would be added to improve soil quality for agricultural use.	Not implementable. Baseline risk analysis results indicate that lime sludge cannot be free released for uncontrolled use. The lime present in the sludge is no longer chemically active.
		Neutralization	Use lime sludge to adjust pH of acidic materials.	Not implementable. The chemical properties of the lime in the lime sludge are not available for use to neutralize other materials. The hydroxide ion in the lime has already reacted with metals in the water-softening process, which generated the sludge.

TABLE 3-8

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR THE INACTIVE FLYASH PILE SOIL/SEDIMENT/FLYASH/WASTE MEDIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Fencing, limited road access, posted signs, etc., used to restrict access.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable.
Containment	Capping System	Clay Cap (multi-layered capping system with clay barrier zone)	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and 24-inch thick vegetative soil cover to reduce potential contact with the waste, reduce vertical infiltration of water, and prevent dust migration. Design would meet the requirements of OAC 3745.27 and OEPA Policy 4.07.	Not applicable. This capping system does not comply with ARAR (40CFR Sec 190.02) relative to containment/ disposal of radioactive waste.
		Composite Cap (multi-layered capping system with both synthetic and clay barriers)	Cover contaminated material with a cap designed for an effective life of 1,000 years and a minimum life of 200 years, which meets the requirements of 40 CFR 192 and DOE Order 5400.5. Cap contains compacted clay, geomembrane liner, drainage layer, 3-foot thick cobble layer, and a vegetative cover soil layer.	Potentially applicable.
		Concrete-Based Cap	A single-layered cap composed of a reinforced portland cement concrete slab placed over a prepared subgrade above the contaminated material.	Not applicable. Concrete caps are very susceptible to weathering and cracking, and are not considered to be suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Capping System (continued)	Asphalt-Based Cap	A single-layered cap composed of bituminous concrete pavement placed over a prepared subgrade above the contaminated material.	Not applicable. Bituminous concrete caps are very susceptible to weathering and progressive cracking, and are not considered to be suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.
	Surface Controls	Surface Water Controls	Modify topography around perimeter of Inactive Flyash Pile to control erosion and manage surface water.	Potentially applicable.
		Revegetation	Grade/backfill to provide suitable surface drainage and cover with soil to support vegetation.	Potentially applicable.
Removal	Excavation	Mechanical Excavation	Backhoes, bulldozers, and loaders used to excavate localized areas with elevated contaminant concentrations, or entire areas.	Potentially applicable.
		Sorting/Separation	Visually sort large debris using mechanical excavating equipment. Use gamma detectors or PIDs in field to identify radiologically/ organics contaminated material.	Potentially applicable.
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
		Anaerobic	In situ degradation of organics using microorganisms in an anaerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.

000382

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Physical/ Chemical	Stabilization/ Solidification	Wastes are mixed with inert additives, cement, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Fixation or solidification is not warranted due to the low concentration of COCs for a large percentage of the waste. If left in place, a significant volume of waste would remain in the 100-year floodplain and thus would be susceptible to the erosive force of flood waters. Debris, although only a small fraction (approximately 5 percent) of the total waste volume, would impede the mixing process.
		Soil Washing (Chemical Extraction)	Reagents are injected into the waste mass to solubilize COCs. The resultant solution is then extracted utilizing wells or interceptor systems. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Success of application depends on achieving uniform and total soil/reagent-waste contact. Extensive mixing would be required for low permeability material to separate soil/waste particles and achieve total soil/waste-reagent contact. Not effective for treatment of waste with low concentrations of COCs. Potential for migration of solution to GMA. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce large volume of sludge.
		Vapor (Vacuum) Extraction	Induce a vacuum to pull air through the unsaturated region or vadose zone of soils using an extraction well system to remove VOCs from the soil. Vapor extraction is not applicable to semi-VOCs or metals treatment.	Not applicable based on waste characteristics. Primary COCs are not volatile. Vacuum extraction is not applicable to semi-volatile or metal treatment. Success limited to porous medium.
		Steam Stripping	A drilling and steam-dispensing system injects steam and hot air into soil to remove volatile organic contaminants. Organics are collected at the surface.	Not applicable based on waste characteristics. Primary COCs are not volatile.

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TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Thermal	Radio Frequency Heating	Soils are heated to between 200 and 1,000°F by exciting electrodes placed in the ground with radio frequency energy. Organics are vaporized and collected at the surface for treatment.	Not applicable based on waste characteristics. Primary COCs are not volatile.
		Vitrification	Immobilization of inorganic contaminants using electrically generated heat by electrodes to convert soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	This process is not warranted due to low concentration of COCs for large percentage of waste. If left in place, a significant volume of waste would remain in the 100-year floodplain and thus would be susceptible to erosive force of flood waters.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable. Data does not indicate a correlation between particle size and concentration of COCs.
		Anaerobic	Degradation of organics in a reactor using microorganisms under anaerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics and radionuclides).
	Physical/ Chemical	Soil Washing (Chemical Extraction)	Reagents are mixed with the waste mass to solubilize COCs. The resultant solution is then drained from the reaction vessel. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or more mobile form.	Success of application depends on achieving uniform and total soil/reagent-waste contact. Extensive material processing would be required for low permeability material to separate soil/waste particles and achieve total soil/waste-reagent contact. Not effective for treatment of waste with low concentrations of COCs. Applicable for treatment of waste from isolated areas with high concentration of COCs. Reagent may remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce a large volume of sludge.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical/ Chemical (continued)	Physical Separation	Separation of radionuclides based on particle size.	Not applicable. Data does not indicate a correlation between particle size and concentration of COCs.
		Stabilization/ Solidification	Wastes are mixed with inert additives, cement, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Potentially applicable for treatment of waste from isolated areas with high concentration of COCs. May require additional measures to ensure long-term effectiveness. Crushing and shredding of debris would be required.
		Crushing/Shredding	Processing of material for size reduction and texturization to improve handling/compaction characteristics or in preparation for treatment.	Potentially applicable when used in conjunction with other technologies.
		Drying	Reducing existing moisture in waste media using either a physical treatment such as a filter press or a thermal treatment such as pulse drying.	Potentially applicable when used in conjunction with other technologies.
		Plasma Etching/ Fluorination of Debris	Plasma is used to clean contaminants from the surface of concrete and metal debris. This process also includes a means of recovering uranium.	Not applicable for soil or flyash. Only suitable for large surface areas with low porosity. Generally, only feasible for low volume with relatively high concentrations of uranium. Process produces residue requiring additional treatment.
		Sand Blasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris.	Not applicable for soil or flyash. Only suitable for large surface areas with low porosity.
		High-Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris.	Not applicable for soil or flyash. Only suitable for large surface areas with low porosity.
	Thermal	Vitrification	Immobilization of inorganic contaminants by placing soils/wastes into a high-temperature melter and converting the soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	Potentially applicable for treatment of waste from isolated areas with high concentration of COCs. May require additional measures to ensure long-term effectiveness. Crushing and shredding of debris would be required.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Thermal continued)	Low-Temperature Thermal Stripping (Volatilization)	Low-temperature technology uses indirect heating to thermally desorb or volatilize organic contaminants. Since the organics are not destroyed, this must be used in conjunction with another remedial technology.	Not applicable based upon the waste characteristics (i.e., primarily inorganics and radionuclides). Primary COCs are not volatile.
	Incineration	Fluidized Bed Incinerators	Incineration of organic material using a refractory-lined changer containing an inert material, usually sand. Waste material with greater densities than the inert material cannot be treated. Normal operating temperatures very from 850 to 2,100°F. Fluidized bed can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs. Typical waste material has densities greater than sand.
		Rotary Kiln Incinerators	Incineration of organic material in a rotating refractory-lined cylinder. Material is rotated, causing turbulence and agitation, while heated combustion air dries and incinerates the waste. Normal operating temperatures vary from 1,475 to 2,900°F. Rotary kilns can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides which are the primary COCs.
	Pyrolysis	High-Temperature Fluid Wall Reactor	High-temperature fluid wall reactors use a porous refractory carbon core with electrodes used to heat a gaseous fluid. The gaseous fluid is forced through the porous core to form a fluid wall which keeps wastes from contacting the reactor core. This fluid increases temperatures or the reactor core, which causes pyrolysis of waste. Temperatures of the core can reach 4,000°F. Fluid wall reactors can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs.
Disposal	On-Site Disposal	On-Site Disposal Cell	An on-site disposal cell designed to accept contaminated material and that meets the requirements of OAC 3745-27, OEPA Policy 4-07, 40 CFR 192, and DOE Order 5400.5.	Potentially applicable.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Disposal (continued)	Off-Site Disposal	Off-site Disposal Facility	Non-radiologically contaminated material transported to an off-site facility meeting OAC 3745-27 and OEPA Policy 4.07 requirements.	Not applicable. Not technically feasible to screen radionuclides to levels required to verify waste material is not cross-contaminated.
		Low-Level Radioactive Waste Disposal Facility	Contaminated material transported to an off-site facility meeting 40 CFR 192 and DOE Order 5400.5 requirements.	Potentially applicable.
		Off-Site Mixed Waste Disposal Facility	Facility designed to accept waste that is both radioactive and listed or characteristically hazardous.	Not applicable. No mixed waste identified in the Inactive Flyash Pile.

000087

TABLE 3-9

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR THE SOUTH FIELD SOIL/SEDIMENT/WASTE MEDIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required by baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Fencing, limited road access, posted signs, etc., used to restrict access.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable.
Containment	Capping System	Clay Cap (multi-layered capping system with clay barrier zone)	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and 24-inch thick vegetative soil cover to reduce potential contact with the waste, reduce vertical infiltration of water, and prevent dust migration. Design would meet the requirements of OAC 3746.27 and OEPA Policy 4.07.	Not applicable. This capping system does not comply with ARAR (40 CFR Sec 192.02) relative to containment/disposal of radioactive waste.
		Composite Cap (multi-layered capping system with both synthetic and clay barriers)	Cover contaminated material with a cap designed for an effective life of 1,000 years and a minimum life of 200 years which meets the requirements of 40 CFR 192 and DOE Order 5400.5. Cap contains compacted clay, geomembrane liner, drainage layer, 3-foot thick cobble layer, and a vegetative cover soil layer.	Potentially applicable.
		Concrete-Based Cap	A single-layered cap composed of a reinforced portland cement concrete slab placed over a prepared subgrade above the contaminated material.	Not Applicable. Concrete caps are very susceptible to weathering and cracking and are not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Capping System (continued)	Asphalt-Based Cap	A single-layered cap composed of bituminous concrete pavement placed over a prepared subgrade above the contaminated material.	Not Applicable. Bitummous Concrete caps are very susceptible to weathering and progressive cracking and are not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.
	Surface Controls	Surface Water Controls	Modify topography around perimeter of South Field to control erosion and manage surface water.	Potentially applicable.
		Revegetation	Grade/backfill to provide suitable surface drainage and cover with vegetative supporting soil.	Potentially applicable.
Removal	Excavation	Mechanical Excavation	Backhoes, bulldozers, and loaders used to excavate localized areas with elevated contaminated concentrations or entire areas.	Potentially applicable.
		Sorting/Separation	Visually sort large debris using mechanical excavating equipment. Use gamma detectors or PIDs in field to identify radiologically/ organics contaminated material.	Potentially applicable.
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
		Anaerobic	In situ degradation of organics using microorganisms in an anaerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Physical/ Chemical	Stabilization/ Solidification	Wastes are mixed with inert additives, cement, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Debris would impede adequate mixing. Although potentially applicable in areas free of debris, fixation is not warranted for a large percentage of the waste due the low concentration of COCs. If left in place, a significant volume of waste would remain in the 100-year floodplain and thus would be susceptible to the erosive force of flood waters.
		Soil Washing (Chemical Extraction)	Reagents are injected into the waste mass to solubilize COCs. The resultant solution is then extracted utilizing wells or interceptor systems. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Success of application depends on achieving uniform and total reagent-waste contact. Extensive mixing would be required for low permeability material to separate waste particles and achieve total reagent-waste contact. Not effective for treatment of waste with low concentrations of COCs. Potential for migration of solution to GMA. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce large volume of sludge.
		Vapor (Vacuum) Extraction	Induce a vacuum to pull air through the unsaturated region or vadose zone of soils using an extraction-well system to remove VOCs from the soil. Vapor extraction is not applicable to semi-VOCs or metals treatment.	Not applicable based on waste characteristics. Primary COCs are not volatile. Vacuum extraction is not applicable to semi-volatile or metal treatment. Success limited to porous medium.
		Steam Stripping	A drilling and steam-dispensing system injects steam and hot air into soil to remove volatile organic contaminants. Organics are collected at the surface.	Not applicable based on waste characteristics. Primary COCs are not volatile.
	Thermal	Radio Frequency Heating	Soils are heated to between 200 and 1,000°F by exciting electrodes placed in the ground with radio frequency energy. Organics are vaporized and collected at the surface for treatment.	Not applicable based on waste characteristics. Primary COCs are not volatile.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Thermal (continued)	Vitrification	Immobilization of inorganic contaminants using electrically generated heat by electrodes to convert soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	Vitrification is not warranted due to low concentration of COCs for large percentage of waste. If left in place, a significant volume of waste would remain in the 100-year floodplain and thus would be susceptible to erosive force of flood waters.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics and radionuclides).
		Anaerobic	Degradation of organics in a reactor using microorganisms under anaerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based upon the waste characteristics (i.e., primarily inorganics and radionuclides).
	Physical/ Chemical	Soil Washing (Chemical Extraction)	Reagents are mixed with the waste mass to solubilize COCs. The resultant solution is then drained from the reaction vessel. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Success of application depends on achieving uniform and total reagent-waste contact. Debris and solid waste would impede the mixing process. Additional material processing, such as crushing and shredding, would be required. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce large volume of sludge. Not effective for treatment of waste with low concentrations of COCs. Potentially applicable for that fraction of waste from isolated areas within the subunit having high concentration of COCs.
		Physical Separation	Separation of radionuclides based on particle size.	Not applicable. Data does not indicate a correlation between particle size and concentration of COCs.

000_91

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical/ Chemical (continued)	Stabilization/ Solidification	Wastes are mixed with inert additives, cement, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Potentially applicable for treatment of waste from isolated areas with high concentration of COCs. May require additional measures to ensure long-term effectiveness. Crushing and shredding of debris would be required.
		Crushing/Shredding	Processing of material for size reduction and texturization to improve handling/compaction characteristics or in preparation for treatment.	Potentially applicable when used in conjunction with other technologies.
		Drying	Reducing existing moisture in waste media using either a physical treatment such as a filter press or a thermal treatment such as pulse drying.	Potentially applicable when used in conjunction with other technologies.
		Plasma Etching/Fluorination of Debris	Plasma is used to clean contaminants from the surface of concrete and metal debris. This process also includes a means of recovering uranium.	Not applicable for soil or heterogeneous waste. Only suitable for large surface areas with low porosity. Generally, only feasible for low volume with relatively high concentrations of uranium. Process produces residue requiring additional treatment.
		Sand Blasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris.	Not applicable for soil or heterogeneous waste. Only suitable for large surface areas with low porosity.
		High-Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris.	Not applicable for soil or heterogeneous waste. Only suitable for large surface areas with low porosity.
	Thermal	Vitrification	Immobilization of inorganic contaminants by placing soils/wastes into a high temperature melter and converting the soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	Potentially applicable for treatment of waste from isolated areas with high concentration of COCs. May require effectiveness. Crushing and shredding of debris would be required.
		Low-Temperature Thermal Stripping (Volatilization)	Low-temperature technology uses indirect heating to thermally desorb or volatilize organic contaminants. Since the organics are not destroyed, this must be used in conjunction with another remedial technology.	Not applicable based on the waste characteristics (i.e., primarily inorganics and radionuclides). Primary COCs are not volatile.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Incineration	Fluidized Bed Incinerators	Incineration of organic material using a refractory-lined changer containing an inert material, usually sand. Waste material with greater densities than the inert material cannot be treated. Normal operating temperatures very from 850 to 2,100°F. Fluidized bed can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides which are the primary COCs. Typical waste material has densities greater than sand.
		Rotary Kiln Incinerators	Incineration of organic material in a rotating refractory-lined cylinder. Material is rotated, causing turbulence and agitation, while heated combustion air dries and incinerates the waste. Normal operating temperatures vary from 1,475 to 2,900°F. Rotary kilns can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs.
	Pyrolysis	High-Temperature Fluid Wall Reactor	High-temperature fluid wall reactors use a porous refractory carbon core with electrodes used to heat a gaseous fluid. The gaseous fluid is forced through the porous core to form a fluid wall which keeps wastes from contacting the reactor core. This fluid increases temperatures of the reactor core which causes pyrolysis of waste. Temperatures of the core can reach 4,000°F. Fluid wall reactors can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs.
Disposal	On-Site Disposal	On-Site Disposal Cell	An on-site disposal cell designed to accept contaminated material and that meets the requirements of OAC 3745-27, OEPA Policy 4-07, 40 CFR 192, and DOE Order 5400.5.	Potentially applicable.

000293

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Disposal (continued)	Off-Site Disposal	Off-Site Disposal Facility	Non-radiologically contaminated material transported to an off-site facility meeting OAC 3745-27 and OEPA Policy 4.07 requirements.	Not applicable. Not technically feasible to screen radionuclides to levels required to verify material is not cross-contaminated.
		Low-Level Radioactive Waste Disposal Facility	Contaminated material transported to an off-site facility meeting 40 CFR 192 and DOE Order 5400.5 requirements.	Potentially applicable.
		Off-Site Mixed Waste Disposal Facility	Facility designed to accept waste that is both radioactive and listed or characteristically hazardous.	Potentially applicable for lead-containing soil in the South Field.

TABLE 3-10

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR THE ACTIVE FLYASH PILE SOIL/SEDIMENT/FLYASH MEDIA

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Fencing, limited road access, posted signs, etc., used to restrict access.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable.
Containment	Capping System	Clay Cap (multi-layered capping system with clay barrier zone)	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and 24-inch thick vegetative soil cover to reduce potential contact with the waste, reduce vertical infiltration of water, and prevent dust migration. Design would meet the requirements of OAC 4735-27 and OEPA Policy 4.07.	Not applicable. This capping system does not comply with ARAR (40 CFR Sec 190.02) relative to containment/ disposal of radioactive waste.
		Composite Cap (multi-layered capping system with both synthetic and clay barriers)	Cover contaminated material with a cap designed with an effective life of 1,000 years and a minimum life of 200 years which meets the requirements of 40 CFR 192 and DOE Order 5400.5. Cap contains compacted clay, geomembrane liner, drainage layer, biotic barrier and vegetative cover soil layer.	Potentially applicable.
		Concrete-Based Cap	A single-layered cap composed of reinforced portland cement concrete slab placed over a prepared subgrade above the contaminated material.	Not applicable. Concrete caps are very susceptible to weathering and cracking and are not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.

000395

TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment (continued)	Capping System	Asphalt-Based Cap	A single-layered cap composed of bituminous concrete pavement placed over a prepared subgrade above the contaminated material.	Not applicable. Bituminous concrete caps are very susceptible to weathering and progressive cracking, and are not considered suitable for long-term protection. High maintenance cost. Multi-layered capping systems provide superior protection and longevity with lower maintenance cost.
	Surface Controls	Surface Water Controls	Modify topography around perimeter of Active Flyash Pile to control erosion and manage surface water.	Potentially applicable.
		Revegetaion	Grade/backfill to provide suitable surface drainage and cover with soil to support vegetation.	
Removal	Excavation	Mechanical Excavation	Backhoes, bulldozers, and loaders used to excavate localized areas with elevated contaminant concentrations or entire areas.	Potentially applicable.
		Sorting/Separation	Visually separate flyash from soil using mechanical excavating equipment. Use gamma detectors or PIDs in field to identify radiologically contaminated/ organics material.	Potentially applicable.
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/ nutrients requires completion of treatability studies.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
		Anaerobic	In situ degradation of organics using microorganisms in an anaerobic environment. Requires the injection of suitable bacteria and nutrients. Selection of bacteria/ nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.

TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Physical/ Chemical	Stabilization/ Solidification	Wastes are mixed with inert additives, cement, or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Although potentially applicable in areas free of debris, fixation is not warranted for a large percentage of the waste due to the low concentration of COCs. If left in place, a significant volume of waste would remain in the 100-year floodplain and thus would be susceptible to the erosive force of flood waters.
		Soil Washing (Chemical Extraction)	Reagents are injected into the waste mass to solubilize COCs. The resultant solution is then extracted utilizing wells or interceptor systems. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Success of application depends on achieving uniform and total soil/reagent-waste contact. Not effective for treatment of waste with low concentrations of COCs. Potential for migration of solution to GMA. Reagent may not be selective for COCs and could remove/react with other constituents. Resultant liquid waste stream volume could require extensive treatment and produce a large volume of sludge.
		Vapor (Vacuum) Extraction	Induces a vacuum to pull air through the unsaturated region or vadose zone of soils using an extraction well system to remove VOCs from the soil. Vapor extraction is not applicable to semi-VOCs or metals treatment.	Not applicable based on the waste characteristics. Primary COCs are not volatile. Vacuum extraction is not applicable to semi-volatile or metal treatment. Success limited to porous medium.
	Thermal	Steam Stripping	A drilling and steam-dispensing system injects steam and hot air into soil to remove volatile organic contaminants. Organics are collected at the surface.	Not applicable based on waste characteristics. Primary COCs are not volatile.
		Radio Frequency Heating	Soils are heated to between 200 and 1,000°F by exciting electrodes placed in the ground with radio frequency energy. Organics are vaporized and collected at the surface for treatment.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not volatile.

000357

TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment (continued)	Thermal (continued)	Vitrification	Immobilization of inorganic contaminants using electrically generated heat by electrodes to convert soils/wastes to a glass/crystalize product. High temperatures destroy organics through pyrolysis and combustion.	Not applicable due to depth of existing pile (up to 40 feet). In situ vitrification is only proven up to 16 feet. This process is not warranted due to low concentration of COCs for large percentage of waste.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics).
		Anaerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics).
	Physical/ Chemical	Soil Washing (Chemical Extraction)	Reagents are mixed with the waste mass to solubilize COCs. The resultant solution is then extracted utilizing wells or interceptor systems. This liquid waste stream is then treated to remove or reduce the COCs to a less toxic or less mobile form.	Not applicable. Radionuclides are at concentrations which are typical for flyash. Not effective for treatment of waste with low concentrations of COCs.
		Physical Separation	Separation of radionuclides based on particle size.	Not applicable. Data does not indicate a correlation between particle size and concentration of COCs.
		Stabilization/ Solidification	Wastes are mixed with inert additives, cement or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid.	Potentially applicable for treatment of waste from isolated areas with high concentration of COCs. May require additional measures to ensure long-term effectiveness. Crushing and shredding of debris would be required.
		Crushing/Shredding	Processing of material for size reduction and texturization to improve handling/compaction characteristics or in preparation for treatment.	Not applicable. Debris is not anticipated.

TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Physical/ Chemical (continued)	Drying	Reducing existing moisture in waste media using either a physical treatment such as a filter press or a thermal treatment such as pulse drying.	Potentially applicable.
	Thermal	Vitrification	Immobilization of inorganic contaminants by placing soils/wastes into a high temperature melter converting the soils/wastes to a glass/crystalline product. High temperatures destroy organics through pyrolysis and combustion.	Not applicable. Radionuclides are at concentrations which are typical for flyash. Not effective for treatment of waste with low concentrations of COCs.
		Low Temperature Thermal Stripping (Volatilization)	Low temperature technology uses indirect heating to thermally desorb or volatilize organic contaminants. Since the organics are not destroyed, this must be used in conjunction with another remedial technology.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not volatile.
	Incineration	Fluidized Bed Incinerators	Incineration of organic material using a refractory-lined changer containing an inert material, usually sand. Waste material with greater densities than the inert material cannot be treated. Normal operating temperatures very from 850 to 2,100°F. Fluidized bed can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides, which are the primary COCs. Typical waste material has densities greater than sand.
		Rotary Kiln Incinerators	Incineration of organic material in a rotating refractory-lined cylinder. Material is rotating, causing turbulence and agitation, while heated combustion air dries and incinerates the waste. Normal operating temperatures vary from 1,475 to 2,900°F. Rotary kilns can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides which are the primary COCs.

TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex Situ Treatment (continued)	Pyrolysis	High-Temperature Fluid Wall Reactor	High-temperature fluid wall reactors use a porous refractory carbon core with electrodes to heat a gaseous fluid. The gaseous fluid is forced through the porous core, to form a fluid wall which keeps wastes from contacting the reactor core. This fluid increases temperatures or the reactor core, which causes pyrolysis of waste. Temperatures of the core can reach 4,000°F. Fluid-wall reactors can be used on site or off site.	Not applicable. Will not treat inorganics or radionuclides which are the primary COCs.
Disposal	On-Site Disposal	On-Site Disposal Cell	An on-site disposal cell designed to accept contaminated material and that meets the requirements of OAC 3745-27, OEPA Policy 4-07, 40 CFR 192, and DOE Order 5400.5.	Potentially applicable.
	Off-Site Disposal	Off-Site Disposal Facility	Radiologically contaminated material transported to an off-site facility meeting OAC 3745-27 and OEPA Policy 4.07 requirements.	Not applicable. Technically difficult to screen radionuclides at levels required to verify that material is not cross-contaminated.
		Low-Level Radioactive Waste Disposal Facility	Contaminated material transported to an off-site facility meeting 40 CFR 192 and DOE Order 5400.5.	Potentially applicable.
		Off-Site Mixed Waste Disposal Facility	Facility designed to accept waste that is both radioactive and listed or characteristically hazardous.	Not applicable. Mixed wastes are not anticipated.

TABLE 3-11

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR PERCHED GROUNDWATER/CONSTRUCTION WATER SOLID WASTE LANDFILL

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Deed Restrictions	Deed restrictions to prevent the use of contaminated water within the area overlying the contaminated groundwater.	Not applicable under federal ownership. Potentially applicable under private ownership.
	Monitoring	Groundwater Monitoring Wells	Installation of monitoring wells and periodic sampling and analysis of groundwater to detect contaminant migration.	Potentially applicable as an indirect means of assessing the effectiveness of the cleanup of the soil/waste.
Containment/ Control	Subsurface Barriers/ Controls	Slurry Wall	Use of soil/bentonite low permeability material to restrict horizontal migration of groundwater.	Not applicable. Perched groundwater does not migrate through waste; therefore, there is no need to divert groundwater.
		Grout Curtain	Use of cements to restrict horizontal migration of groundwater.	Not applicable. Perched groundwater does not migrate through waste; therefore, there is no need to divert groundwater.
		Extraction/Injection Wells	Combine extraction and injection of groundwater by pumping and injecting this groundwater into wells to impose artificial hydraulic gradients to control groundwater flow.	Not applicable. Perched groundwater does not migrate through waste; therefore, there is no need to divert groundwater.
Removal	Extraction	Extraction Wells	Use of wells to extract groundwater.	Not applicable. Groundwater below Solid Waste Landfill does not require remediation.
		Interceptor Systems	Use of excavated trenches backfilled with permeable fill to collect groundwater.	Not applicable. Groundwater below Solid Waste Landfill does not require remediation.
		Wellpoint System	A series of small-diameter riser pipes connected to a common header to extract shallow groundwater.	Not applicable. Groundwater below Solid Waste Landfill does not require remediation.

000401

TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Removal (continued)	Extraction (continued)	Excavation Dewatering	Collecting and pumping storm water runoff and groundwater seepage (construction water) that collects in the base of excavations. Water is transferred using a suction pump and hose to eliminate need for personnel to enter excavation.	Potentially applicable.
Treatment	Physical Treatment	Sedimentation	Tanks and containers are used to hold groundwater/construction water and allow solids to settle to bottom for removal.	Potentially applicable as a pretreatment.
		Filtration	Groundwater/construction water is passed through a filter bed composed of granular material, typically sand. Process is used to remove particulates in groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.
	Chemical Treatment	Air Stripping	Contact of contaminated water with air to promote removal of volatile compounds.	Not applicable because no volatile organics were found in the perched groundwater beneath the Solid Waste Landfill.
		Adsorption	Removal of constituents by adsorption onto the surface of a medium such as activated carbon.	Not applicable. Not effective for removal of uranium without additional processes. Treatment to be provided at AWWT facility.

TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical Treatment (continued)	Reverse Osmosis	Use of pressure and a semipermeable membrane to separate inorganic ions (salts) from water.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.
		Ion Exchange	Contaminated water flows over resins to selectively adsorb contaminants.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.
		Electrodialysis	Transfer/removal of contaminants by placing an electrically charged membrane in the contaminated groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.
		Ozone Oxidation/ Ultra-violet	Use of ozone and UV light to oxidize organic contaminants in groundwater.	Not applicable based on the waste characteristics (i.e., primarily inorganics).

000403

TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical Treatment (continued)	Reduction	Use of strong reducing agents to chemically react constituents and promote their separation in groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.
		Precipitation	Adding chemicals to groundwater that react with dissolved inorganic contaminants to make them insoluble so they can be separated.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.
		Biosorption	A sorption process for removing toxic metal ions from water is based on the strong affinity of biological materials for heavy metal/radionuclides ions.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.

TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical Treatment (continued)	Solvent Extractions	Separate constituents of a liquid solution by transfer to a second liquid that is immiscible in the first liquid.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the amended consent agreement, Operable Unit 5 is required to handle site groundwater.
		Biological (Aerobic)	Biodegradation of contaminants in an environment containing oxygen. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Anaerobic)	Biodegradation of contaminants in an oxygen-deficient environment. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Oxidation	Injection of oxidizing agents into the groundwater to oxidize contaminants to promote separation.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
	Physical/ Chemical Treatment	FEMP Advanced Wastewater Treatment Facility (AWWT)	On-site treatment plant that uses precipitation, clarifying, activated carbon, pH adjustment, ion exchange, and filtration to treat impacted groundwater and construction water.	Potentially applicable.
Disposal	Discharge	Discharge to Great Miami River	Direct discharge of treated waste-water to the Great Miami River via the AWWT facility.	Potentially applicable.
		Discharge to Paddys Run	Discharge of treated wastewater to Paddys Run via the AWWT facility.	Not applicable. Paddys Run is periodically dry. This affords a direct pathway to the GMA.
		Injection	Injection of treated or untreated groundwater into the aquifer.	Not applicable because Great Miami Aquifer is a sole-source aquifer.

000406

TABLE 3-12

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR PERCHED GROUNDWATER/CONSTRUCTION WATER LIME SLUDGE PONDS

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Deed Restrictions	Deed restrictions to prevent the use of contaminated water within the area overlying the contaminated groundwater.	Not applicable under federal ownership. Potentially applicable under private ownership.
	Monitoring	Groundwater Monitoring Wells	Installation of monitoring wells and periodic sampling and analysis of groundwater to detect contaminant migration.	Potentially applicable as an indirect means of assessing the effectiveness of the cleanup of the soil/waste.
Containment/ Control	Subsurface Barriers/ Controls	Slurry Wall	Use of soil/bentonite low permeability material to restrict horizontal migration of groundwater.	Not applicable. Perched groundwater does not migrate through sludge; therefore, it is not necessary to divert groundwater.
		Grout Curtain	Use of cements to restrict horizontal migration of groundwater.	Not applicable. Perched groundwater does not migrate through sludge; therefore, it is not necessary to divert groundwater.
		Extraction/Injection Wells	Combine extraction and injection of groundwater by pumping and injecting this groundwater into wells to impose artificial hydraulic gradients to control groundwater flow.	Not applicable. Perched groundwater does not migrate through sludge; therefore, it is not necessary to divert groundwater.
Removal	Extraction	Extraction Wells	Use of wells to extract groundwater.	Not applicable. Groundwater below the Lime Sludge Ponds does not require remediation.
		Interceptor Systems	Use of excavated trenches backfilled with permeable fill to collect groundwater.	Not applicable. Groundwater below the Lime Sludge Ponds does not require remediation.
		Wellpoint System	A series of small-diameter riser pipes connected to a common header to extract shallow groundwater.	Not applicable. Groundwater below the Lime Sludge Ponds does not require remediation.
		Excavation Dewatering	Collecting and pumping storm water runoff and groundwater seepage (construction water) that collects in the base of excavations. Water is transferred using a suction pump and hose to eliminate need for personnel to enter excavation.	Potentially applicable.

TABLE 3-12
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment	Physical Treatment	Sedimentation	Tanks and containers are used to hold groundwater/construction water and allow solids to settle to bottom for removal.	Potentially applicable as a pretreatment.
		Filtration	Groundwater/construction water is passed through a filter bed composed of granular material, typically sand. Process is used to remove particulates in groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
	Chemical Treatment	Air Stripping	Contact of contaminated water with air to promote removal of volatile compounds.	Not applicable because no volatile organics were found in the perched groundwater beneath the Lime Sludge Ponds.
		Adsorption	Removal of constituents by adsorption onto the surface of a medium such as activated carbon.	Not applicable. Not effective for removal of uranium without additional processes. Treatment to be provided at AWWT facility.
		Reverse Osmosis	Use of pressure and a semipermeable membrane to separate inorganic ions (salts) from water.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Ion Exchange	Contaminated water flows over resins to selectively adsorb contaminants.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.

TABLE 3-12
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical Treatment (continued)	Electrodialysis	Transfer/removal of contaminants by placing an electrically charged membrane in the contaminated groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Ozone Oxidation/ Ultra-violet	Use of ozone and UV light to oxidize organic contaminants in groundwater.	Not applicable based on the waste characteristics (i.e., primarily inorganics).
		Reduction	Use of strong reducing agents to chemically react constituents and promote their separation in groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Precipitation	Adding chemicals to groundwater that react with dissolved inorganic contaminants to make them insoluble so they can be separated.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.

TABLE 3-12
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical Treatment (continued)	Biosorption	A sorption process for removing toxic metal ions from water is based on the strong affinity of biological materials for heavy metal/radionuclides ions.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Solvent Extractions	Separate constituents of a liquid solution by transferring to a second liquid that is immiscible in the first liquid.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
	Biological	Biological (Aerobic)	Biodegradation of contaminants in an environment containing oxygen. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Anaerobic)	Biodegradation of contaminants in an oxygen-deficient environment. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Oxidation	Injection of oxidizing agents into the groundwater to oxidize contaminants to promote separation.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
	Physical/ Chemical Treatment	FEMP Advanced Waste Water Treatment Facility (AWWT)	On-site treatment plant that uses precipitation, clarifying, activated carbon, pH adjustment, ion exchange, and filtration to treat impacted groundwater and construction water.	Potentially applicable.

000409

TABLE 3-12
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Disposal	Discharge	Discharge to Great Miami River	Direct discharge of treated wastewater to the Great Miami River via the AWWT facility.	Potentially applicable.
		Discharge to Paddys Run	Discharge of treated wastewater to Paddys Run via the AWWT facility.	Not applicable. Paddys Run is periodically dry. This affords a direct pathway to the GMA.
		Injection	Injection of treated or untreated groundwater into the aquifer.	Not applicable because Great Miami Aquifer is a sole-source aquifer.

000410

TABLE 3-13

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR PERCHED GROUNDWATER/CONSTRUCTION WATER INACTIVE FLYASH PILE, SOUTH FIELD, AND ACTIVE FLYASH PILE

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions.	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Deed Restrictions	Deed restrictions to prevent the use of contaminated water within the area overlying the contaminated groundwater.	Not applicable under federal ownership. Potentially applicable under private ownership.
	Monitoring	Groundwater Monitoring Wells	Installation of monitoring wells and periodic sampling and analysis of groundwater to detect contaminant migration.	Potentially applicable as an indirect means of assessing the effectiveness of the cleanup of the soil/waste.
Containment/ Control	Subsurface Barriers/ Controls	Slurry Wall	Use of soil/bentonite low permeability material to restrict horizontal migration of groundwater.	Not applicable. Large volume of material directly overlays the GMA. Perched water cannot be contained without excavating a large percentage of the waste. After removal of the contaminated media, horizontal groundwater controls will not be required. Residual contamination in the perched aquifer is a subject of Operable Unit 5.
		Grout Curtain	Use of cements to restrict horizontal migration of groundwater.	Not applicable. Large volume of material directly overlays the GMA. Perched water cannot be contained without excavating a large percentage of the waste. After removal of the contaminated media, horizontal groundwater controls will not be required. Residual contamination in the perched aquifer is a subject of Operable Unit 5.
		Extraction/Injection Wells	Combine extraction and injection of groundwater by pumping and injecting this groundwater into wells to impose artificial hydraulic gradients to control groundwater flow.	Not applicable. Perched groundwater zone is a relatively thin layer; it would be difficult to impose a continuous artificial hydraulic gradient because the radius of influence would be minimal.

TABLE 3-13
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Removal	Extraction	Extraction Wells	Use of wells to extract groundwater.	Not applicable. Perched groundwater zone is a relatively thin layer; it would be difficult to impose a continuous artificial hydraulic gradient because the radius of influence would be minimal.
		Interceptor Systems	Use of excavated trenches backfilled with permeable fill to collect groundwater.	Potentially applicable.
		Wellpoint System	A series of small-diameter riser pipes connected to a common header to extract shallow groundwater.	Not applicable. Perched groundwater zone is a relatively thin layer; it would be difficult to impose a continuous artificial hydraulic gradient because the radius of influence would be minimal.
		Excavation Dewatering	Collecting and pumping storm water runoff and groundwater seepage (construction water) that collects in the base of excavations. Water is transferred using a suction pump and hose to eliminate need for personnel to enter excavation.	Potentially applicable.
Treatment	Physical Treatment	Sedimentation	Tanks and containers are used to hold groundwater/construction water and allow solids to settle to bottom for removal.	Potentially applicable as a pretreatment.
		Filtration	Groundwater/construction water is passed through a filter bed composed of granular material, typically sand. Process is used to remove particulates in groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
	Chemical Treatment	Air Stripping	Contact of contaminated water with air to promote removal of volatile compounds.	Not applicable because no volatile organics above the PRGs were found in the groundwater.

TABLE 3-13
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical Treatment (continued)	Adsorption	Removal of constituents by adsorption onto the surface of a medium such as activated carbon.	Not applicable. Not effective for removal of uranium without additional processes. Treatment to be provided at AWWT facility.
		Reverse Osmosis	Use of pressure and a semipermeable membrane to separate inorganic ions (salts) from water.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Ion Exchange	Contaminated water flows over resins to selectively adsorb contaminants.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Electrodialysis	Transfer/removal of contaminants by placing an electrically charged membrane in the contaminated groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5 and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Ozone Oxidation/ Ultra-violet	Use of ozone and UV light to oxidize organic contaminants in groundwater.	Not applicable based on the waste characteristics (i.e., primarily inorganics).

000413

TABLE 3-13
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (Continued)	Chemical Treatment (Continued)	Reduction	Use of strong reducing agents to chemically react constituents and promote their separation in groundwater.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Precipitation	Adding chemicals to groundwater that react with dissolved inorganic contaminants to make them insoluble so they can be separated.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
		Biosorption	A sorption process for removing toxic metal ions from water is based on the strong affinity of biological materials for heavy metal/radionuclides ions.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.

TABLE 3-13
(Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (continued)	Chemical Treatment (continued)	Solvent Extractions	Separate constituents of a liquid solution by transfer to a second liquid that is immiscible in the first liquid.	Not applicable. Although this process option is potentially implementable for the COCs, it is not being retained as a stand-alone process, because it is enveloped by the AWWT facility, where effective treatment would be conducted. The AWWT facility is operated by Operable Unit 5, and as per the Amended Consent Agreement, Operable Unit 5 is required to handle site groundwater.
	Biological	Biological (Aerobic)	Biodegradation of contaminants in an environment containing oxygen. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Anaerobic)	Biodegradation of contaminants in an oxygen-deficient environment. Requires the addition of suitable bacteria and nutrients. Selection of bacteria/nutrients requires completion of treatability studies.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Oxidation	Injection of oxidizing agents into the groundwater to oxidize contaminants to promote separation.	Not applicable based on the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
	Physical/ Chemical Treatment	FEMP Advanced Wastewater Treatment Facility (AWWT)	On-site treatment plant that uses precipitation, clarifying, activated carbon, pH adjustment, ion exchange, and filtration to treat impacted groundwater and construction water.	Potentially applicable.
Disposal	Discharge	Discharge to Great Miami River	Direct discharge of treated wastewater to the Great Miami River via the AWWT facility.	Potentially applicable.
		Discharge to Paddys Run	Discharge of treated wastewater to Paddys Run via the AWWT facility.	Not applicable. Paddys run is periodically dry. This affords a direct pathway to the GMA.
		Injection	Injection of treated or untreated groundwater into the aquifer.	Not applicable because Miami Aquifer is a sole-source aquifer.

TABLE 3-14

SUMMARY
TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES
SOLID WASTE LANDFILL SOIL/SEDIMENT/SOLID WASTE MEDIA

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No consideration	None
Institutional Actions	Access Restrictions	Physical Barriers	Effective for reducing potential direct human contact with COCs. Will not treat or stabilize waste, but will mitigate potential public exposure by restricting access.	Readily implementable. Requires long-term security and maintenance.	Moderate capital and O&M
		Deed Restrictions	Effective for placing legal restraints on land use and development. Will not treat or stabilize waste, but can mitigate potential public exposure by restricting activities that would disturb waste.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
Containment	Capping Systems	Composite Cap	Effectively isolates subunit from surficial erosion by wind or precipitation; minimizes exposure from direct human contact; minimizes infiltration; and limits release of radon and biogenic gases.	Readily implementable to construct.	High capital and O&M
	Surface Controls	Surface Water Controls	Reduces migration of COCs via surface water. May impact nearby wetlands.	Readily implementable.	Low capital and O&M
		Revegetation	Effective measure for controlling surficial erosion.	Readily implementable.	Moderate capital/ low O&M

000416

TABLE 3-14
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Removal	Excavation	Mechanical Excavation	Very effective for removing soil, solid wastes, and low-level radioactive wastes. Does not treat waste.	Readily implementable.	Moderate capital and O&M
		Sorting/ Separation	Effective for classifying/processing material in preparation for treatment or disposal. Does not treat waste. Increased handling can result in increased risk to workers.	Physical methods are readily implementable. Radiological sorting method is slow.	Moderate capital/high O&M
Ex Situ Treatment	Physical/ Chemical	Soil Washing	Effective for reducing the concentration of COCs from berm soil having relatively high concentrations of COCs	Requires extensive material processing. Difficult to implement with large volume of residue requiring further treatment.	High capital and O&M costs
		Stabilization/ Solidification	Proven effective process for improving waste stability and reducing leaching potential. May require the addition of soil/stone dust to form monolithic matrix. Dependent on completion of treatability studies.	Equipment is readily available. Moderate difficulty due to mixing/material handling.	Moderate capital and O&M
		Crushing/ Shredding	Effective for improving material handling characteristics and for size reduction. Requires fugitive emissions controls.	Readily implementable.	Moderate capital and O&M
		Drying	Effective for reducing water content. Does not treat COCs. Requires fugitive emissions controls	Readily implementable.	High Capital and O&M
	Thermal	Vitrification	Effective for treating fraction of contaminated waste having high concentrations of COCs.	Requires specialized equipment and trained personnel which have limited availability. Mobile equipment not available. Requires extensive material processing and pretreatment. Relatively difficult to implement.	High capital and O&M costs

000417

TABLE 3-14
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Disposal	On-site Disposal	On-Site Disposal Cell	Effective for containing the solid waste and minimizing migration of the contaminants. Reduces surface water infiltration and leachate generation. Minimizes exposure. Limits release of radon gas.	Readily implementable to construct. However, siting requirements may cause difficulty in implementation, because the FEMP is located over a sole-source aquifer.	High capital and O&M
	Off-site Disposal	Low-Level Radioactive Waste Disposal Facility	Effective disposal of radiologically contaminated wastes.	Readily implementable. Two potential disposal facilities identified. Must obtain approval from DOE headquarters and owner of off-site facility. Must prove that waste has not been contaminated with hazardous waste.	High capital/moderate O&M

000418

5857

TABLE 3-15

TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES LIME SLUDGE PONDS SOIL/LIME SLUDGE/WASTE MEDIA

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No consideration	None
Institutional Actions	Access Restrictions	Physical Barriers	Effective for reducing potential direct human contact with COCs. Will not treat or stabilize waste, but will mitigate potential public exposure on site by restricting access.	Readily implementable. Requires long-term security and maintenance.	Moderate capital and O&M
		Deed Restrictions	Effective for placing legal restraints on land use and development. Will not treat or stabilize waste, but can mitigate potential public exposure by restricting activities that would disturb waste.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
Containment	Capping Systems	Composite Cap	Effectively isolates subunit from surficial erosion by wind or precipitation; minimizes exposure from direct human contact; minimizes infiltration; and limits release of radon and biogenic gases.	Readily implementable to construct.	High capital and O&M
	Surface Controls	Surface Water Controls	Reduces migration of COCs via surface water.	Readily implementable.	Low capital and O&M
		Revegetation	Effective measure for controlling surficial erosion.	Readily implementable.	Moderate capital and low O&M

TABLE 3-15
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Removal	Excavation	Mechanical Excavation	Very effective for removing soil, lime sludge, and low-level radioactive wastes. Does not treat waste.	Readily implementable.	Moderate capital and O&M
		Sorting/ Separation	Effective for classifying/processing material in preparation for treatment or disposal. Does not treat waste. Increased handling can result in increased risk to workers.	Physical methods are readily implementable. Radiological sorting is slow.	Moderate capital/high O&M
In Situ Treatment	Physical/Chemical	Solidification/ Stabilization	Effective for improving structural stability of lime sludge and reducing mobility of COCs.	Low to moderately difficult to implement. Requires the use of specialized equipment to accomplish adequate mixing of waste and reagent/additives.	Moderate capital and O&M
Ex Situ Treatment	Physical/Chemical	Stabilization/ Solidification	Proven, effective process for improving waste stability and reducing leaching potential. Effective for creating a stabilized backfill by mixing lime sludge with flyash.	Equipment is readily available. Moderately difficult to implement for contaminated material. Readily implementable for lime sludge/flyash stabilization.	Moderate capital and O&M
		Crushing/ Shredding	Effective for improving material handling characteristics and for size reduction. Requires fugitive emissions controls.	Readily implementable.	Moderate capital and O&M

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TABLE 3-15
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Ex Situ Treatment (continued)	Physical/ Chemical (continued)	Drying	Effective for reducing water content. Does not treat COCs. Can result in improved handling characteristics and volume reduction. Requires fugitive emissions controls.	Readily implementable.	High capital and O&M
Disposal	On-Site Disposal	On-Site Disposal Cell	Effective for containing the contaminated materials and minimizing migration of the contaminants. Reduces surface water infiltration and leachate generation.	Readily implementable to construct.	High capital and O&M
	Off-Site Disposal	Low-Level Radioactive Waste Disposal Facility	Effective for disposing of dried low-level radioactive wastes.	Readily implementable. Two potential disposal facilities identified. Must obtain approval from DOE headquarters and owner of off-site facility. Must prove that waste has not been contaminated with hazardous waste.	High capital/low O&M

TABLE 3-16

SUMMARY
TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES
INACTIVE FLYASH PILE SOIL/SEDIMENT/FLYASH/WASTE MEDIA

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No consideration	None
Institutional Actions	Access Restrictions	Physical Barriers	Effective for reducing potential direct human contact with COCs. Will not treat or stabilize waste, but will mitigate potential public exposure on site by restricting access.	Readily implementable. Requires long-term security and maintenance.	Moderate capital and O&M
		Deed Restrictions	Effective for placing legal restrains on land use and development. Will not treat or stabilize waste, but can mitigate potential public exposure by restricting activities that would disturb waste.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
Containment	Capping Systems	Composite Cap	Effectively isolates subunit from surficial erosion by wind or precipitation; minimizes exposure from direct human contact; minimizes infiltration; and limits release of radon and biogenic gases.	Readily implementable to construct	High capital and O&M
	Surface Controls	Surface Water Controls	Reduces migration of COCs via surface water.	Readily implementable.	Low capital and O&M
		Revegetation	Effective measure for controlling surficial erosion.	Readily implementable.	Moderate capital/ low O&M

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TABLE 3-16
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Removal	Excavation	Mechanical Excavation	Very effective for removing soil, flyash, and solid wastes. Does not treat waste.	Readily implementable.	Moderate capital and O&M
		Sorting/Separation	Effective for classifying/processing material in preparation for treatment or disposal. Does not treat waste. Increased handling can result in increased risk to workers.	Physical methods are readily implementable. Radiological sorting is slow.	Moderate capital/ high O&M
Ex Situ Treatment	Physical/ Chemical	Soil Washing	Effective for reducing concentration of COCs from that fraction of soil/waste having relatively high concentrations of COCs.	Moderately difficult to implement. Waste streams are difficult to handle. Requires extensive material processing. Difficult to implement with large volume of residue requiring further treatment.	High capital and O&M
		Stabilization/ Solidification	Effective for creating a stabilized backfill by mixing the flyash with lime sludge. Proven, effective process for improving waste stability and reducing leaching potential.	Equipment is readily available. Readily implementable for lime sludge/flyash stabilization.	Moderate capital and O&M
		Crushing/ Shredding	Effective for improving material handling characteristics. Requires fugitive emissions controls.	Readily implementable.	Moderate capital and O&M
		Drying	Effective at reducing water content. Does not treat COCs. Can result in improved handling characteristics and volume reduction. Requires fugitive emissions controls.	Readily implementable.	High capital and O&M
	Thermal	Vitrification	Effective for treating fraction of contaminated waste having high concentrations of COCs.	Requires specialized equipment and trained personnel which have limited availability. Mobile equipment not available. Relatively difficult to implement. Requires treatability studies to verify application.	High capital and O&M

TABLE 3-16
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Disposal	On-Site Disposal	On-Site Disposal Cell	Effective for containing the contaminated waste and minimizing migration of the contaminants. Reduces surface water infiltration and leachate generation. Minimizes exposure. Limits release of radon gas.	Readily implementable to construct.	High capital and O&M
		Low-Level Radioactive Waste Disposal Facility	Effective disposal for radiologically contaminated wastes.	Readily implementable. Two potential disposal facilities identified. Must obtain approval from DOE headquarters and owner of off-site facility. Must prove that waste has not been contaminated with hazardous waste.	High capital/ moderate O&M

TABLE 3-17

SUMMARY
TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES
SOUTH FIELD SOIL/SEDIMENT/FLYASH/WASTE MEDIA

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No consideration	None
Institutional Actions	Access Restrictions	Physical Barriers	Effective for reducing potential direct human contact with COCs. Will not treat or stabilize waste, but will mitigate potential public exposure on site by restricting access.	Readily implementable. Requires long-term security and maintenance.	Moderate capital and O&M
		Deed Restrictions	Effective for placing legal restraints on land use and development. Will not treat or stabilize waste, but can mitigate potential public exposure by restricting activities that would disturb wastes.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
Containment	Capping System	Composite Cap	Effectively isolates subunit from surficial erosion by wind or precipitation; minimizes exposure from direct human contact; minimizes infiltration; and limits release of radon and biogenic gases.	Readily implementable to construct.	High capital and O&M
	Surface Controls	Surface Water Controls	Reduces migration of COCs via surface water.	Readily implementable.	Low capital and O&M
		Revegetation	Effective measure for controlling surficial erosion.	Readily implementable.	Moderate capital/low O&M

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TABLE 3-17
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Removal	Excavation	Mechanical Excavation	Very effective for removing soil, construction debris, and low-level radioactive wastes. Does not treat waste.	Readily implementable.	Moderate capital and O&M
		Sorting/ Separation	Effective for classifying/processing material in preparation for treatment or disposal. Does not treat waste. Increased handling can result in increased risk to workers.	Physical methods are readily implementable. Radiological sorting is slow.	Moderate capital/high O&M
Ex Situ Treatment	Physical/Chemical	Soil Washing	Effective for reducing concentration of COCs from that fraction of soil/waste having relatively high concentrations of COCs.	Moderately difficult to implement. Waste streams are difficult to handle. Requires extensive material processing. Difficult to implement with large volume of residue requiring further treatment.	High capital and O&M
		Stabilization/ Solidification	Proven effective process for improving waste stability and reducing leaching potential. Effective for creating a stabilized backfill by mixing the flyash with lime sludge.	Equipment is readily available. Moderately difficult to implement.	Moderate capital and O&M
		Crushing/ Shredding	Effective for improving material handling characteristics. Requires fugitive emission controls.	Readily implementable.	Moderate capital and O&M
		Drying	Effective for reducing water content. Does not treat COCs. Can result in improved handling characteristics and volume reduction. Requires fugitive emissions controls.	Readily implementable.	High capital and O&M

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TABLE 3-17
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Ex Situ Treatment (continued)	Thermal	Vitrification	Effective for treating fraction of contaminated waste having high concentrations of COCs.	Requires specialized equipment and trained personnel, which have limited availability. Mobile equipment not available. Requires extensive material processing and pretreatment. Relatively difficult to implement.	High capital and O&M
Disposal	On-Site Disposal	On-Site Disposal Cell	Effective for containing the contaminated material and minimizing migration of the contaminants. Reduces surface water infiltration and leachate generation. Minimizes exposure. Limits release of radon gas.	Readily implementable to construct.	High capital and O&M
	Off-Site Disposal	Mixed Waste Facility	Effective for containing the mixed wastes and minimizing migration of the lead contamination.	Requires permit to construct. Frequent local opposition to siting.	Moderate to high capital/moderate O&M
		Low-Level Radioactive Waste Disposal Facility	Effective disposal for radiologically contaminated wastes.	Readily implementable. Two potential disposal facilities identified. Must obtain approval DOE headquarters and owner of off-site facility. Must be proven that waste has not been contaminated with hazardous waste.	High capital/moderate O&M

TABLE 3-18

SUMMARY
TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES
ACTIVE FLYASH PILE SOIL/SEDIMENT/FLYASH MEDIA

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No consideration	None
Institutional Actions	Access Restrictions	Physical Barriers	Effective for reducing potential direct human contact with COCs. Will not treat or stabilize waste, but will mitigate potential public exposure by restricting access.	Readily implementable. Requires long-term security and maintenance.	Moderate capital and O&M
		Deed Restrictions	Effective for placing legal restrains on land use and development. Will not treat or stabilize waste, but can mitigate potential public exposure by restricting activities that would disturb waste.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
Containment	Capping Systems	Composite Cap	Effectively isolates subunit from surficial erosion by wind or precipitation; minimizes exposure from direct human contact; minimizes infiltration; and limits release of radon and biogenic gases.	Readily implementable to construct.	Moderate capital and O&M

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TABLE 3-18
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Containment (continued)	Surface Controls	Surface Water Controls	Reduces migration of COCs via surface water.	Readily implementable.	Low capital and O&M
		Revegetation	Effective measure for controlling surficial erosion.	Readily implementable.	Moderate capital/ low O&M
Removal	Excavation	Mechanical Excavation	Very effective for removing soil and flyash. Does not treat material.	Readily implementable.	Moderate capital and O&M
		Sorting/Separation	Effective for classifying/processing material in preparation for treatment or disposal. Increased handling can result in increased risk to workers.	Physical methods are readily implementable. Radiological sorting is slow.	Moderate capital/ high O&M
Ex Situ Treatment	Physical/Chemical	Stabilization/ Solidification	Proven, effective process for improving waste stability and reducing leaching potential. Effective for creating a stabilized backfill by mixing the flyash with lime sludge.	Readily implementable for lime sludge/flyash stabilization. Equipment is readily available.	Moderate capital and O&M
		Drying	Effective pretreatment, treatment, or posttreatment when used with other technologies. Requires fugitive emissions controls.	Readily implementable.	High capital and O&M

TABLE 3-18
(Continued)

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
Disposal	On-Site Disposal	On-Site Disposal Cell	Effective for containing the flyash and soil and minimizing migration of the contaminants. Reduces surface water infiltration and leachate generation. Minimizes exposure. Limits release of radon gas.	Readily implementable to construct.	High capital and O&M
	Off-Site Disposal	Low-Level Radioactive Waste Disposal Facility	Effective disposal of dried radiologically contaminated wastes.	Readily implementable. Two potential disposal facilities identified. Must obtain approval from DOE headquarters and owner of off-site facility. Must prove that waste has not been contaminated with hazardous waste.	High capital/ moderate O&M

TABLE 3-19

SUMMARY
TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES
PERCHED GROUNDWATER/CONSTRUCTION WATER MEDIA
SOLID WASTE LANDFILL

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No implementation considered	None
Institutional Actions	Access Restrictions	Deed Restrictions	Effective for placing legal restraints on groundwater use. Will not treat or stabilize waste, but will mitigate potential public exposure by prohibiting the installation of production wells for agriculture or consumption purposes.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
	Monitoring	Groundwater Monitoring Wells	Effective for determining underground contaminant migration and for evaluating the effectiveness of other remedial actions.	Readily implementable. A number of monitoring wells already exist near the solid waste landfill. Additional wells can be installed quickly.	Moderate capital and O&M
Removal	Extraction	Excavation Dewatering	Effective for safely removing stormwater runoff and groundwater seepage.	Readily implementable.	Low capital and O&M
Treatment	Physical Treatment	Sedimentation	Effective as a pretreatment for removing suspended particles from groundwater and construction water. Generates a concentrated sludge and clarified effluent that will require additional treatment.	Readily implementable. Generates secondary waste stream (sediment).	Moderate capital and O&M
	Physical/ Chemical Treatment	FEMP AWWT	Very effective for treating groundwater and construction water, provided suspended solids are reduced in a pretreatment step.	Can accept Operable Unit 2's groundwater/construction water beginning in June 1996.	Low capital and O&M (for Operable Unit 2)
Disposal	Discharge	Discharge to Great Miami River	Effective for disposal of treated waste water.	Implementable. Requires modification of NPDES permit.	Low capital and O&M (for Operable Unit 2)

TABLE 3-20

SUMMARY
TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES
PERCHED GROUNDWATER/CONSTRUCTION WATER MEDIA
LIME SLUDGE PONDS

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No implementation considered	None
Institutional Actions	Access Restrictions	Deed Restrictions	Effective for placing legal restraints on groundwater use. Will not treat or stabilize waste, but will mitigate potential public exposure by prohibiting the installation of production wells for agriculture or consumption purposes.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
	Monitoring	Groundwater Monitoring Wells	Effective for determining underground contaminant migration and for evaluating the effectiveness of other remedial actions.	Readily implementable. A number of monitoring wells already exist near the solid waste landfill. Additional wells can be installed quickly.	Moderate capital and O&M
Removal	Extraction	Excavation Dewatering	Effective for safely removing stormwater runoff and groundwater seepage.	Readily implementable.	Low capital and O&M
Treatment	Physical Treatment	Sedimentation	Effective as a pretreatment for removing suspended particles from groundwater and construction water. Generates a concentrated sludge and clarified effluent that will require additional treatment.	Readily implementable. Generates secondary waste stream (sediment).	Moderate capital and O&M
	Physical/ Chemical Treatment	FEMP AWWT	Very effective for treating groundwater and construction water, provided suspended solids are reduced in a pretreatment step.	Can accept Operable Unit 2's groundwater/construction water beginning in June 1996.	Low capital and O&M (for Operable Unit 2)
Disposal	Discharge	Discharge to Great Miami River	Effective disposal of treated waste water.	Implementable. Requires modification of NPDES permit.	Low capital/moderate O&M (for Operable Unit 2)

TABLE 3-21

SUMMARY
TECHNOLOGIES RETAINED FOR CONSIDERATION AS COMPONENT OF REMEDIAL ALTERNATIVES
PERCHED GROUNDWATER/CONSTRUCTION WATER MEDIA
INACTIVE FLYASH PILE, SOUTH FIELD, AND ACTIVE FLYASH PILE

General Response Action Component	Remedial Technology	Process Option	Evaluation Comments		
			Effectiveness	Implementability	Cost
No Action	None	Not applicable	Not effective	No implementation considered	None
Institutional Actions	Access Restrictions	Deed Restrictions	Effective for placing legal restraints on groundwater use. Will not treat or stabilize waste, but will mitigate potential public exposure by prohibiting the installation of production wells for agriculture or consumption purposes.	Readily implementable. Susceptible to changes in laws governing transference of property, and to deed adherence and enforcement.	Low capital and O&M
	Monitoring	Groundwater Monitoring Wells	Effective for determining underground contaminant migration and for evaluating the effectiveness of other remedial actions.	Readily implementable. A number of monitoring wells already exist near the solid waste landfill. Additional wells can be installed quickly.	Moderate capital and O&M
Removal	Extraction	Interceptor Systems	Effective for removing contaminated groundwater near surface and in shallow perched aquifers.	Readily implementable.	Moderate capital and O&M
		Excavation Dewatering	Effective for safely removing storm water runoff and groundwater seepage.	Readily implementable.	Low capital and O&M
Treatment	Physical Treatment	Sedimentation	Effective as a pretreatment in removing suspended particles from groundwater and construction water. Generates a concentrated sludge and clarified effluent that will require additional treatment.	Readily implementable. Generates secondary waste stream (sediment).	Moderate capital and O&M
	Physical/ Chemical Treatment	FEMP AWWT	Very effective for treating groundwater and construction water, provided suspended solids are reduced in a pretreatment step.	Can accept Operable Unit 2's groundwater/construction water beginning in June 1996.	Low capital and O&M (for Operable Unit 2)
Disposal	Discharge	Discharge to Great Miami River	Effective disposal of treated waste water.	Implementable. Requires modification of NPDES permit.	Low capital and O&M (for Operable Unit 2)

- how proven and reliable the process is with respect to the contaminants, media, and conditions at the site

- Implementability - The implementability evaluation encompassed both the technical and administrative feasibility of implementing a technology process option and focused on:
  - the availability of necessary equipment, skilled workers, vendors, mobile units, etc.
  - the ability to obtain necessary permits for either off-site or on-site actions
  - the availability of treatment, storage, and disposal services
- Cost - The cost evaluation considered only relative costs and focused on:
  - relative capital and operation and maintenance (O & M) costs
  - costs presented as high, medium or low relative to other process options in the same technology group.

All of the items listed under each criterion may not apply directly to each technology; therefore, each item will only be addressed where appropriate.

3.5.1 Description and Evaluation of Process Options for the Soil/Sediment/Waste Medium

This section provides description and evaluations of the remedial technologies and process options that are indicated in the initial screening process as being potentially applicable as components of remedial action alternatives addressing the soil/sediment/waste medium. The presentation is organized by process option and evaluates each process option for the Operable Unit 2 as a whole.

3.5.1.1 No Action

3.5.1.1.1 Description

The no action GRA does not include any remedial technologies. No action is considered in the FS as the baseline to which other remedial actions are compared and is retained throughout the FS process, as required by the NCP, regardless of its effectiveness in achieving the RAOs.

3.5.1.1.2 Evaluation

Effectiveness - The no action GRA would not achieve the RAOs. Exposure pathways are not addressed. The existing risk to human health associated with exposure to COCs would continue. The

no action GRA does not provide any protection of the environment. Contaminants would continue to migrate from impacted media to the environment.

Implementability - There are no measures to implement under the no action GRA.

Cost - There are no costs associated with the no action GRA.

Conclusion - The no action scenario is applicable for all subunits as a baseline to which other remedial actions can be compared.

3.5.1.2 Institutional Actions

3.5.1.2.1 Description

Institutional actions are used to control access and/or restrict land use through implementation of active and passive actions. Active actions include physical barriers to prevent access, while passive actions include legal controls such as deed restrictions.

Physical Barriers

Physical barriers consist of fences, structures, and controls implemented at a waste site to inhibit human contact with the contaminants. These barriers would discourage trespassing.

Deed Restrictions

Deed restrictions are a form of legal federal ownership that would restrict specified land-use activities. Land-use restrictions could include prohibiting earth excavation operations, as well as prohibiting the erection of structures.

3.5.1.2.2 Evaluation

Physical Barriers

Effectiveness - Physical barriers would be an effective method for isolating and defining the area required to handle, treat, or dispose of contaminated materials contained at the subunits or consolidated at a disposal facility. Physical barriers alone are not effective in meeting remediation goals, since physical barriers provide no reduction in the toxicity, mobility, or volume of contaminants. However, when used in conjunction with other technologies, physical barriers can

assist in meeting remediation goals. Physical barriers are effective in protecting human health by restricting public access to a waste site. Physical barriers are only minimally effective in protecting the environment, because contaminants could continue to migrate into the environment through groundwater, soil, surface water, and the atmosphere. Physical barriers would limit access of certain animals (i.e., deer, dogs, raccoons) to the waste site. The construction of physical barriers would have a negligible negative impact on human health and the environment. Physical barriers are a reliable and proven method of restricting access of the general public to a waste site; however, continuing maintenance would be required.

Implementability - Physical barriers are administratively feasible and require no special permits to implement. Physical barriers are currently in place; however, maintenance activities would be required for long-term effectiveness.

Cost - When compared to the deed restriction process option, physical barriers would have moderate capital and O&M costs. O&M costs include maintenance activities.

Conclusion - Physical barriers are applicable for all subunits.

Deed Restrictions

Effectiveness - Deed restrictions would be effective for placing legal restrictions on the future use or development of areas required to contain or dispose of contaminated material. Deed restrictions can be effective for protecting human health by restraining agriculture, construction, or other use or development activities that could increase personal or public exposure to the contaminated material. Deed restrictions alone would provide no protection to the environment, since the contaminated material would remain in place without treatment, and wildlife access to the site would not be restricted.

Implementability - Deed restrictions are administratively feasible; however, deed restrictions are susceptible to changes in laws governing the transfer of property, and to deed adherence and enforcement. Deed restrictions do not require any special resources to implement. Legal services would be required to implement deed restrictions.

Cost - Deed restrictions have low capital and O&M costs, as compared to physical barriers.

Conclusion - Deed restrictions are applicable for all subunits.

3.5.1.3 Containment

3.5.1.3.1 Description

Containment consists of technologies that confine contaminated media to their current locations. Containment is used to minimize infiltration, to reduce transport of waste materials, and to minimize the potential for direct contact with contaminants. Containment typically involves installation of capping systems or surface controls.

Composite Cap (multi-layered capping system with both synthetic and clay barrier)

A composite cap involves the installation of a low permeability multi-layered capping system, including a compound barrier (clay and synthetic membrane), over an area that contains contaminated material. The composite cap would be in general conformance with 40 CFR 192, DOE Order 5400.5 and OAC 3745-27. Details of a suggested composite cap are presented in Appendix E for reference.

Surface Water Controls

Surface water controls consist of installation of diversion swales/ditches, sedimentation basins and/or grading of the surface to divert/control stormwater runoff to control infiltration and erosion, and thus reduce potential for migration of contaminants.

Revegetation

Revegetation consists of reestablishing a vegetative cover over an area disturbed by grading/excavation operations. Revegetation decreases erosion by wind and water and contributes to the development of a naturally fertile and stable surface environment.

3.5.1.3.2 Evaluation

Composite Cap

Effectiveness - A composite cap would effectively isolate the surface of an area containing contaminated material and minimize infiltration of surface water. A composite cap would also be effective for limiting the release of radon and biogenic gases to the atmosphere. Construction of a composite cap would be effective for meeting the remediation goals, since it would reduce the migration of the contaminants (EPA 1988).

During construction, significant volumes of construction material for the cap would be hauled from off-site sources to the site. This activity would result in increased traffic on local highways and roads. The potential negative impact from this increased traffic could be mitigated by limiting truck traffic during rush hours and enforcing traffic laws.

Workers would be subjected to minimal exposure to COCs during installation of a cap, since the work would involve minimal disturbance of contaminated materials.

A composite cap would be designed to provide an effective life of 1,000 years with a minimum life of 200 years. The design life would be based on the use of natural materials as the key components in the capping system. The longevity of the geosynthetics within composite caps is not well proven, because all of the existing caps have been recently constructed; therefore, the effective life for the system as a whole is hypothetical.

Implementability - The construction of a composite cap is administratively feasible. Resources required to construct a composite cap are readily available. The placement of flexible membrane liners requires a skilled labor force to ensure proper installation and seaming of the liner. The required materials and equipment are commonly used in the construction industry.

Cost - When compared to other capping options, the composite cap has high capital and O&M costs.

Conclusion - A composite cap is applicable for all subunits.

Surface Water Controls

Effectiveness - Surface water controls are proven to be effective in managing and directing surface water runoff, and thus would be effective for meeting remediation goals by reducing the migration of contaminants via surface water. Surface water controls are effective for protecting human health and the environment by reducing the quantity of contaminants conveyed by surface water to areas outside the limits of waste. During implementation of surface water controls, risks to human health and the environment due to the possible disturbance of the contaminated material and the proliferation of airborne contaminants in construction dust can be mitigated by minimizing areas of barren soils and by using dust suppressants. Workers would utilize appropriate personal protection equipment (PPE). Both radioactivity and airborne emissions would be monitored.

Implementability - Surface water controls are administratively feasible, although some controls may require obtaining approval from the U.S. Army Corps Of Engineers (COE) and other government agencies/departments having relevant jurisdiction due to the nearby wetlands. Modification to the current NPDES permit may be required for discharge to off-site surface water. Resources required to construct the surface water controls are readily available.

Cost - Surface water controls have low capital and low O&M costs as compared to capping systems.

Conclusion - Surface water controls are applicable for all subunits.

Revegetation

Effectiveness - Revegetation would be used as final treatment of areas graded or excavated/backfilled in conjunction with remedial activities or as a component of multi-layered cap. Revegetation through stabilizing surface soils is effective for helping to achieve remediation goals by reducing the erosion/migration of surface soils. Revegetation is effective for controlling wind and surface water erosion. Potential worker exposure from contact or airborne emissions would be minimal.

Implementability - Revegetation is administratively feasible and requires no special permits to implement. Both the resources and services required to install a vegetative cover are readily available.

Cost - When compared to other surface control options, revegetation has moderate capital cost and low O&M costs.

Conclusion - Revegetation is applicable for all subunits.

3.5.1.4 Removal

3.5.1.4.1 Description

Removal consists of the extraction of buried contaminated material. The appropriate waste removal methodology depends on the physical properties and the volume of the medium to be handled, as well as the distances that the material must be moved and the condition of the haul roads.

Mechanical Excavation

Waste removal would be accomplished utilizing conventional earthwork equipment that could include backhoes, bulldozers, scrapers, loaders, and trucks.

Sorting/Separation

Sorting/separation would be used to separate excavated materials into one of the three following groups: (1) soil; (2) debris or solid waste; and (3) non-contaminated material.

Excavated materials would be visually screened/classified and sorted using mechanical excavating equipment to separate debris. Materials may also be sorted in the field using gamma detectors or photoionization detectors to detect low-level radioactive waste or volatile organics, respectively.

3.5.1.4.2 Evaluation

Mechanical Excavation

Effectiveness - Mechanical excavation is effective for excavating and handling large quantities of soil, rock, or debris and for excavating localized areas of elevated contaminant concentrations. Mechanical excavation alone would not be effective in meeting remediation goals, or in protecting human health and the environment. During implementation, risks to human health would be mitigated by worker use of PPE, by observing excavation safety procedures, and by using dust suppressants.

Implementability - Mechanical excavation is administratively feasible at the site. Both the resources and services required to provide excavation and earth moving operations are readily available.

Cost - When compared to other removal options, mechanical excavation has moderate capital and O&M costs.

Conclusion - Mechanical excavation is applicable for all subunits.

Sorting/Separation

Effectiveness - Sorting/separation would be an effective technology for classifying/processing the material at the subunits in preparation for treatment or disposal. Sorting/separation is reliable for visually identifying flyash, lime sludge, soil, debris, and solid waste and for sorting using mechanical excavators. During construction, risks to site workers using field screening techniques can be

mitigated by using safe work procedures. Solid waste can be effectively separated from soils by particle size using mechanical screening techniques. Increased handling could increase potential for worker exposure. Both radioactivity and airborne particulate emissions would be monitored. Dust suppressants and air filtering systems would be effective measures to mitigate risks to workers and the public.

The field identification process for separating radiologically contaminated materials from non-radiologically contaminated materials is relatively slow. Classification can be completed by modeling that identifies COC concentrations on a grid basis or in the field by using gama detectors. Separation by the COC modeling method would be confirmed by sampling/testing on designated grids following excavation. Sorting by the field monitoring method would require excavation by layers with labor intensive hand monitoring.

Implementability - Sorting/separation is administratively feasible if conservative sorting decisions are made in the field. The resources for sorting using mechanical excavators and mechanical screening are readily available.

The currently available resources for sorting radiologically contaminated material are slow. Devices that can identify large quantities of radiologically contaminated material relatively quickly are currently being developed.

Cost - When compared to other removal options, sorting/separation has moderate capital cost and high O&M costs.

Conclusion - Sorting/separation is applicable for all subunits, although the extent of utilization would vary. Minimal separation/sorting would be required at the Lime Sludge Ponds. The extent of sorting required would depend on the ultimate disposal of the medium being handled. Generally, the debris would be separated from the waste excavated at all of the subunits and subjected to further processing for size reduction.

3.5.1.5 In Situ Treatment

3.5.1.5.1 Description

Stabilization/Solidification

Impacted media are mixed with inert additives, cement or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid. Stabilizing/solidifying agents typically include pozzolanic-based materials such as portland cement, cement kiln dust, and flyash.

The performance of a stabilization/solidification system is highly waste specific; therefore, the process must be designed to accommodate the specific waste. A thorough physical and chemical characterization of a waste is essential to determining the most suitable solidification reagents and mixing ratios.

The equipment used in stabilization includes a mixing system, a feed system to inject the reagents/additives into the waste, and crane-mounted augers to mix the additives with the waste. Large-diameter augers have a treatment depth limitation of approximately 7.6 m (25 ft). Treatment at greater depths is achieved through use of ganged, small-diameter augers. The equipment is specialized, and there are few experienced personnel.

3.5.1.5.2 Evaluation

Stabilization/Solidification

Effectiveness - Stabilization/solidification is a proven method for treating soil and lime sludges to improve structural strength and reduce leachability of COCs. The reliability and effectiveness of these processes for treatment of materials containing heavy metals and radioactive material is well proven (EPA 1988).

During mobilization and operation of the stabilization/solidification equipment, impacts to human health and the environment can be mitigated through the use of sound construction safety practices when handling/mixing the contaminated materials. Since the media is treated in place, exposure to workers is minimal.

Implementability - Stabilization/solidification is administratively feasible when used in conjunction with other technologies such as containment. Implementation requires specialized equipment and

trained personnel. Construction debris would impede adequate mixing. Treatability studies would be required to determine effectiveness and optimum mixing ratios. EPA accepts stabilization/solidification as a proven technology for treating many hazardous wastes.

Cost - When compared to other physical/chemical in situ treatment options, stabilization/solidification has moderate capital and O&M costs.

Conclusion - Stabilization/solidification is potentially applicable at the Lime Sludge Ponds to improve structural stability and possibly provide support for a cap. However, the typically low concentration of COCs at all of the subunits minimizes any benefits attributable to reduced leaching of contaminants. In those areas of the Inactive Flyash Pile, South Field, and Solid Waste Landfill where concentrations of COCs are highest, implementation would be difficult because debris would impede the mixing process. Applicability is limited to the Lime Sludge Ponds.

3.5.1.6 Ex Situ Treatment

3.5.1.6.1 Description

Ex situ treatment consists of physical, chemical, or combinations of treatment processes in engineered reactors in a controlled environment.

Soil Washing (ex situ)

The soil washing process utilizes physical separation and chemical extraction for the removal of contaminants from soil. Reagents are mixed as a water-based solution with the soil/waste in a reaction vessel to solubilize COCs. The resultant solution (reagent/COC/water) is removed from the vessel and treated to remove or reduce the COCs to a less toxic or less mobile form. After treatment for removal of COCs, the water can be injected into the reaction vessel, creating a closed loop extraction/recovery system.

Stabilization/Solidification (ex situ)

Wastes are mixed with inert additives, cement or other reagents to increase the structural integrity of the waste mass, reduce potential for leaching of COCs from the waste, or transform the waste into a monolithic solid. Stabilizing/solidifying agents typically include pozzolanic-based materials such as portland cement, cement kiln dust, and flyash. Additives such as lime or proprietary reagents are

often added to the stabilization/solidification formula to increase the effectiveness of the treatment. Specifically, lime can be added to reduce the solubility of metals, or organophilic clays can be added to adsorb organic contaminants.

The performance of a stabilization/solidification system is highly waste specific; therefore, the process must be designed to accommodate the specific waste. A thorough physical and chemical characterization of a waste is essential to determine the most suitable solidification reagents and mixing ratios, as well as any special pretreatment or material handling methods that may be required.

The equipment used in stabilization includes a feed system (conveyor or hopper), mixing vessels (pug mill or containers with excavating equipment), and bulk storage bins. After the waste is mixed with the stabilizing/solidifying agents, the material is allowed to cure for a specified time period which depends on the strength required prior to handling or disposal. The solidified waste can be in the form of a treated block or a modified soil which can be compacted in a disposal area using standard construction equipment.

Vitrification (ex situ)

Ex situ vitrification is a thermal treatment process which binds waste in a glassy, solid matrix. Vitrification is achieved in a reaction chamber in which a high temperature is used to reduce toxic organic compounds to elemental gas and carbon. The inorganic contaminants are either entrained in glass-like matrix or volatilized and recovered with the off-gases.

The reaction chamber melter is divided into an upper and a lower section, both of which are refractory-lined and have separate electric heating systems. During operation, the upper section accepts the waste feed via gravity and contains gases and other products of pyrolysis. The lower section contains the molten glass and inorganics of the waste. The off-gases and particulates are drawn off by an induction fan and treated through a cyclone, a baghouse, and an acid gas scrubber. The molten material containing the inorganics is withdrawn from the lower section of the chamber. The process operates on a continuous cycle. The waste enters the reactor mixed with frit (glass-making material) while molten glass is withdrawn . The off-gases and vapors are treated in a gas scrubber system and released to the atmosphere. The water in the scrubber system is recycled.

Crushing/Shredding

Solid waste and debris would be crushed using a standard mechanical crusher or a ball mill to make gravel-sized particles, and then passed through a mechanical shredder for size reduction/homogenization in preparation for treatment or disposal.

Drying

Drying includes physical and/or thermal processes. Physical drying processes include filter presses or spreading out in drying beds. The thermal process being considered for the FEMP site is an indirect rotary dryer consisting of an outer concentric cylinder around an inner rotating cylinder containing the wet solids. Hot gases or steam are circulated through the interstitial space between the outer and inner cylinders, and thus do not contact the waste.

3.5.1.6.2 Evaluation

Soil Washing (ex situ)

Effectiveness - Soil washing has been used effectively in both ore mining and for remediation. The soil would be sorted prior to treatment to screen out debris and flyash, and also to sort out non-radiologically contaminated materials. Soil washing would be effective in reducing the amount of radioactive material in the soil (Lockheed Environmental Systems and Technologies Company 1993); however, a residual waste stream consisting of concentrated contaminants would have to be addressed. The residual waste stream would require further treatment prior to disposal. On-going treatability studies indicate that this technology has limited application for Operable Unit 2 waste. The data indicates that, for waste with concentrations of COCs typical at the Operable Unit 2 subunits, the residual waste stream would be in the order of 40 percent of the initial volume treated. Hence, soil washing would be suitable for only a small portion of Operable Unit 2 material that has significant concentrations of radionuclides.

During construction and operation of the soil washing facility, there would be moderate risk to human health and the environment, with the most significant concern being accidents or spills of the extraction solution or the waste streams of concentrated contaminants. Appropriate safe work procedures would be followed to minimize this risk. The ongoing treatability study indicates that the extraction solution most effective at achieving low radionuclide concentrations would be sulfuric acid.

This is a hazardous chemical requiring special handling. Further, hazardous fumes are generated during the soil washing process.

Implementability - Soil washing is administratively feasible when used in conjunction with other technologies. Soil washing uses mining and earthwork equipment that has been used in large-scale operations at other facilities. Trained FERMCO employees are available to operate the soil washing facility. The concentrated waste stream generated from soil washing would have high concentrations of contaminants and require further treatment prior to disposal. Off-site disposal facilities will not accept the concentrated contaminant waste stream without additional treatment steps such as residue drying, vitrification, or stabilization.

Cost - When compared to other ex situ physical/chemical treatment options, soil washing has high capital and O&M costs.

Conclusion - Potentially applicable for treatment of soil with high concentrations of COCs; therefore, this process option would be appropriate for only a small percentage of the media residing at each subunit. It is potentially applicable for that small fraction of waste from isolated areas within the Solid Waste Landfill, Inactive Flyash Pile and the South Field subunits having high concentrations of COCs.

Stabilization/Solidification

Effectiveness - Stabilization/solidification is a proven method for treating material to improve structural strength and reduce leachability of COCs. The reliability and effectiveness of these processes for treatment of materials containing heavy metals and radioactive material is well proven (EPA 1988).

Most of the wastes at Operable Unit 2 have very low levels of COCs and comprise a relatively large volume. Treatment of these materials would reduce leachability of COCs, but would probably not be required to meet remediation goals.

During construction and operation of the stabilization/solidification facility, impacts to human health and the environment can be mitigated through the use of sound construction safety practices when handling the contaminated materials.

Implementability - Stabilization/solidification is administratively feasible when used in conjunction with other technologies such as on-site disposal. Implementation of cement/pozzolanic-based processes involves traditional cement mixing equipment that is widely available and supplied by many vendors. Some sorting/separation of the soil/flyash would be required to produce an acceptable feedstock to the stabilization/solidification process. EPA accepts stabilization/solidification as a proven technology for treating many hazardous wastes. The final stabilized material could be disposed on site or off site and would be in a stable form that is easy to handle and transport. The final product would meet requirements for disposal at an on-site or off-site facility.

Cost - When compared to other physical/chemical treatment options, stabilization/solidification has moderate capital and O&M costs.

Conclusion - Stabilization/solidification is potentially applicable for all subunits; however, the process would be appropriate for only a small percentage of the media residing at each subunit. It is potentially applicable for that small fraction of waste from isolated areas within the Solid Waste Landfill, Inactive Flyash Pile and the South Field subunits having high concentrations of COCs. It is also appropriate for stabilizing the lime sludge to improve handling characteristics and structural integrity.

Vitrification (ex situ)

Effectiveness - Successful large-scale applications are limited. The process is most successful when used on small volumes with relatively high concentrations of COCs. Most of the wastes at Operable Unit 2 have low levels of COCs and comprise a relatively large volume. Treatment of these materials would reduce leachability of COCs, but would probably not be required to meet the remediation goals. Vitrification would only be effective for treating that fraction of contaminated material from identified isolated areas having high concentrations of COCs after they have been excavated and sorted from the low level contaminated materials. Vitrification would be effective for treating organics via thermal oxidation and immobilizing inorganics and radionuclides in a glass matrix. The molten glass process can potentially achieve high removal efficiencies (over 99 percent) for hazardous organic contaminants. The glass matrix has been demonstrated to be resistant to leaching. Volume reduction of the contaminated material is dependent on the material and its ability to vitrify; however, if sand (silica) is added to induce vitrification, there would be an increase in volume.

The throughput of the vitrification system would be limited by the capacity of the "off-gas" system which can be overloaded by the volatilization of organics or steam generation. To control the generation of these gases, the waste would be pretreated to reduce the organic and moisture contents.

Excavation and processing of waste materials would potentially increase airborne concentrations of COCs. Air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures would be implemented. Potential impacts to workers operating the vitrification equipment can be mitigated by using safe work practices during the material handling and vitrification processes.

Implementability - Vitrification is administratively feasible. A treatability study on site would be used to evaluate this technology's ability to treat the contaminated material at the FEMP. Contractors, skilled workers, and proven mobile equipment are limited.

Cost - When compared to other ex situ thermal treatment options, ex situ vitrification has high capital and O&M costs.

Conclusion - Ex situ vitrification has limited applicability for Operable Unit 2. It is not warranted for the large fraction of waste having low concentrations of COCs. It is potentially applicable for a small fraction of waste from isolated areas within the Solid Waste Landfill, Inactive Flyash Pile , and the South Field subunits having high concentrations of COCs.

Crushing/Shredding

Effectiveness - Crushing/shredding is a proven method for size reduction of large pieces of contaminated debris, construction debris and solid waste. Further, crushers and shredders are effective for texturizing soil/waste to improve handling characteristics.

During construction, potential impacts to workers can be mitigated through the use of sound construction safety practices when operating the crushing and shredding equipment. Fugitive dust control/suppression (controlled environment) would be required to prevent worker exposure to COCs.

Implementability - Crushing/shredding is administratively feasible as a pretreatment step. The equipment and labor to operate this equipment are readily available.

Cost - When compared to other methods for size reduction, crushing/shredding has moderate capital and O&M costs.

Conclusion - Crushing/shredding is applicable for all subunits.

Drying (ex situ)

Effectiveness - Rotary kiln dryers are proven to be effective for drying soils, sediments, and debris. The use of indirect rotary dryers minimizes the potential for volatilizing COCs. Dust suppression/controls (e.g., high-efficiency air filters, controlled environment) would prevent potential exposure from fugitive dust.

Implementability - Drying is administratively feasible as a pretreatment, primary treatment, or post-treatment step. The equipment and labor to operate this equipment are readily available.

Cost - Compared to other methods for moisture control, rotary dryers have high capital and O&M costs.

Conclusion - Drying is potentially applicable for all subunits.

3.5.1.7 Disposal

3.5.1.7.1 Description

Disposal technologies are classified in two ways, on-site disposal and off-site disposal, either of which would require transportation by rail, truck, or a combination of both. On-site disposal consists of technologies that confine contaminated/treated materials at an engineered facility located on site. On-site disposal would be designed in accordance with applicable regulations to minimize infiltration and to minimize the potential for direct contact with contaminated/treated material.

Off-site disposal consists of technologies that confine contaminated/treated material in engineered disposal facilities located off site. Off-site disposal effects a removal of COCs from the site, and thus remediates the site; however, contaminant toxicity, mobility, and volume are not addressed unless treatment is provided at the disposal facility.

On-Site Disposal Facility

The general requirements for an on-site disposal facility are regulated under OAC 3745-27, 40 CFR 192, and DOE Order 5400.5. The on-site disposal facility would contain waste in an aboveground earthen structure. Operational methods that reduce the volume of contaminated media, ease the handling of waste, and reduce human exposure to radiation and other contaminants would be rigidly followed. Contaminated media received at the disposal facility would have to meet acceptance criteria which would restrict moisture content; concentration and quantities of radioactivity; and toxic and hazardous chemical concentrations. The disposal facility would be designed for a 200-year design life and an effective life of 1,000 years, in accordance with 40 CFR 192 and DOE 5400.5. Typical details of the on-site disposal facility are provided in Appendix E.

Off-Site Low-Level Radioactive Waste Disposal Facility (LLWDF)

The construction, operation, monitoring, and closure requirements of an off-site LLWDF are similar to the requirements for the on-site disposal cell. DOT and DOE Order 5820.2A regulates the transportation of contaminated material. Rail transportation could be used to ship large quantities of contaminated material off site. Railroad sidings currently exist at the FEMP; however, they would have to be extended to allow operation of a waste loading facility. Material from the Operable Unit 2 subunits would be subjected to the off-site disposal facility's waste acceptance criteria (WAC). Some material may require pretreatment to comply with the WAC. Refer to Appendix E for a discussion of potentially acceptable off-site disposal facilities and their WACs.

Off-Site Mixed Waste Disposal Facility

The construction, operation, and maintenance of an off-site mixed waste disposal facility would be performed in accordance with RCRA requirements (40 CFR 264) and applicable DOE Orders (5820.2A) or NRC regulation (10CFR61). A mixed waste disposal facility would be required for disposal of lead-containing soils from the Firing Range located in the South Field subunit.

3.5.1.7.2 Evaluation

On-Site Disposal Facility

Effectiveness - An on-site disposal facility would be effective in containing the volumes of contaminated material from all of the subunits. Engineered disposal is effective in reducing migration of the contaminants, preventing direct contact with the waste and reducing the release of radon gas; thus, the disposal facility would be protective of human health and the environment. A disposal

facility would be reliable for minimizing the exposure of contaminated material to surface water, groundwater, wind, and other environmental forces; however, the 1,000-year effective life has not been proven on any disposal facility (EPA 1988).

During construction and filling of a disposal facility, potential impacts to workers can be mitigated through the use of sound construction safety practices. Monitoring would be required for airborne contamination. Dust suppression would be implemented to control fugitive emissions.

Implementability - Implementation of an on-site disposal facility would involve meeting stringent siting requirements. Siting of the facility would require approval from DOE, EPA, and OEPA. The facility would be an earthen structure that could be readily constructed by experienced civil contractors and skilled workers. Resources required to construct the disposal facility are readily available. The placement of geomembrane liners requires a skilled labor force to ensure proper installation and seaming of the liner. The required materials and equipment are commonly used in the construction industry.

Cost - When compared to other on-site disposal options, an on-site disposal facility has high capital and O&M costs.

Conclusion - An on-site disposal facility is applicable for all subunits.

Off-Site Low-level Radioactive Waste Disposal Facility

Effectiveness - An off-site LLWDF would be effective in containing all of contaminated material from the subunits. All of the contaminants at the subunits would be removed, thus eliminating further migration of COCs; however, the toxicity, mobility, and volume of the contaminants would not be reduced. The public would be subjected to potential exposure during transport of waste to the off-site facility. Once implemented, disposal at the off-site facility would be effective in protecting human health and the environment.

During excavation and transportation of the contaminated material, potential impacts to workers can be mitigated through the use of sound construction safety practices and adherence to the site-specific health and safety plan. An increase in truck traffic, required to haul the waste material off-site, can be mitigated by using rail transportation.

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Implementability - Using an off-site LLWDF is administratively feasible; however, it must be proven that the material has not been contaminated with hazardous constituents which are not accepted at the LLWDF. Waste material would have to meet all acceptance criteria for the off-site LLWDF. A small percentage of the waste may require pretreatment prior to shipment. Public acceptance of transporting the waste across state lines to the existing facilities may be difficult. Resources required to excavate and transport the waste material are readily available. Options for disposing low level radioactive media at off-site facilities are limited to the Nevada Test Site (NTS) (currently accepting FEMP low-level waste), and Envirocare (not yet authorized to accept FEMP low-level waste). Approval must be gained from DOE headquarters (Washington - EM1) and the off-site facility prior to off-site disposal of contaminated material.

Cost - When compared to other disposal options, utilizing an off-site LLWDF has high capital costs and moderate O&M costs.

Conclusion - An off-site LLWDF is applicable for all subunits, conditional on meeting WACs.

Off-Site Mixed Waste Disposal Facility

Effectiveness - An off-site mixed waste disposal facility would be effective in containing the 230 cu m (300 cu yd) of lead-containing soil from the firing range. The facility would be designed for containment/treatment of materials containing both hazardous constituents, as defined by RCRA, and radionuclides. Disposal of the lead-containing soil from the South Field would meet remedial objectives since the material is removed from the site. Prior to disposal, the soil would be treated to reduce the mobility of the lead. Once implemented, disposal at the off-site mixed waste disposal facility would be protective of human health and environment.

During excavation and transportation of the mixed waste, potential impacts to workers can be mitigated through the use of sound construction safety practices. A minor increase in truck traffic required to haul the waste material off site can be mitigated by transporting material during off-peak times. The public would be subjected to a small potential for exposure during shipment. This risk can be mitigated through proper packaging/containerization and planning of shipping routes to avoid heavily populated areas.

Implementability - Approvals must be obtained from OEPA, EPA, and DOE headquarters (Washington - EM1), as well as from the owner of the off-site facility, prior to off-site disposal of any waste material. Facilities that provide off-site treatment and disposal services for lead-containing soil are limited. Resources required to excavate the lead-contaminated soil are readily available.

Cost - When compared to other disposal options, an off-site mixed waste disposal facility has a moderate capital cost and a low O&M cost.

Conclusion - Disposal of waste materials at a mixed waste disposal facility is applicable only for the small volume of lead-containing soil at the South Field. No other potential sources of mixed waste have been identified at the subunits.

3.5.2 Description and Evaluation of Technologies and Process Options for Perched Groundwater/Construction Water Medium

3.5.2.1 No Action

This subsection provides descriptions and evaluations of the remedial technologies and process options as being potentially applicable as components of remedial action alternatives addressing the perched groundwater/construction water medium. The presentation is organized on an Operable Unit 2 wide basis.

3.5.2.1.1 Description

The no action GRA does not include any remedial technologies. The no action scenario is considered in the FS as the baseline to which other remedial actions are compared and is retained throughout the FS process, as required by the NCP, regardless of its effectiveness in achieving the RAOs.

3.5.2.1.1 Evaluation

Effectiveness - Effectiveness of this response action depends on the ability of the construction water/perched groundwater to be discharged directly to surface water in an uncontrolled manner. The current COC levels in the soil and perched groundwater indicate that an uncontrolled discharge would not be effective.

Implementability - There are no measures to implement under the no action GRA.

Cost - There are no costs associated with the no action GRA.

Conclusion - The no action scenario is applicable for all subunits as a baseline to which other remedial actions can be compared.

3.5.2.2 Institutional Actions

3.5.2.2.1 Description

Institutional actions, both active and passive, are used to regulate intentional or unintentional use or contact with contaminated groundwater/construction water. Active actions include groundwater monitoring to detect contaminant migration, while passive actions include legal controls such as deed restrictions.

Groundwater Monitoring Wells

Groundwater monitoring, sampling, and analysis of selected wells are used to assess the concentration levels, to detect movement of the COCs, and to verify that remedial action clean-up concentrations are achieved. Groundwater monitoring would be appropriate as either compliance monitoring or response action monitoring.

Deed Restrictions

Deed restrictions would restrict specified groundwater usage activities. Groundwater usage restrictions could include prohibiting domestic water supply wells as well as prohibiting water usage for farming.

3.5.2.7.2 Evaluation

Groundwater Monitoring Wells

Effectiveness - Groundwater monitoring wells are effective for determining underground contaminant migration and for evaluating the effectiveness of other remedial actions. When used in conjunction with other technologies, monitoring wells are effective for meeting the remediation goals.

Implementability - The use of monitoring wells is administratively feasible. A large number of monitoring wells currently exist at and near the FEMP site, and additional wells can be installed quickly. The resources and services required to implement groundwater monitoring are readily available.

Cost - When compared to other institutional actions, monitoring wells have moderate capital and O&M costs.

Conclusion - Monitoring wells are applicable for all subunits.

Deed Restrictions

Effectiveness - Deed restrictions would be effective for placing legal restrictions on use of the perched groundwater. Deed restrictions can be effective in protecting human health by restricting agricultural, construction, or other use or development activities that could increase public exposure to the groundwater.

Deed restrictions by themselves would not be effective for meeting remediation goals nor would deed restrictions alone provide protection to the environment. Deed restrictions could prevent the drilling of production wells that could be used for consumption or agriculture. Deed restrictions are a reliable method for placing legal restrictions on the use or development of property.

Implementability - Deed restrictions are administratively feasible; however, deed restrictions are susceptible to changes in laws governing the transfer of property, and to deed adherence and enforcement. Deed restrictions do not require any special resources to implement. Legal services would be required to implement deed restrictions, but are commonly available.

Cost - When compared to other institutional actions, deed restrictions have low capital and O&M costs.

Conclusion - Deed restrictions are applicable for all subunits.

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3.5.2.3 Removal Technologies

3.5.2.3.1 Description

Interceptor Systems

Interceptor systems are effective for collecting contaminated groundwater from shallow aquifers in the FEMP. The perched groundwater is typically less than 6.1 m (20 ft) below grade and could be collected through trenches or horizontal perforated pipes which drain to a collection sump. The depths of trenches/drains would depend on the local thickness of the glacial till and the perched groundwater layers beneath each Operable Unit 2 subunit. The collected perched groundwater would be pumped to the AWWT facility for treatment.

Subsurface drains or trenches are typically installed perpendicular to the direction of groundwater flow, although other orientations may be applicable in certain cases. Subsurface drains are generally constructed by excavating a trench and installing perforated pipe on gravel bedding on the bottom of the trench. The trench is then backfilled with gravel or other highly permeable material, followed by backfilling the remainder of the trench with soil. The gravel or the perforated pipe may be enveloped in a geotextile fabric to prevent fine soil particles from clogging the drain. If the surrounding soils have a moderate to high hydraulic conductivity and there is some question as to whether the drain will be a complete barrier, an impermeable synthetic membrane may be installed on the downgradient side of the drain to prevent passage of water.

Bio-polymer trenches are collection trenches that use the same installation principle as a slurry (barrier) wall, except that the backfill for bio-polymer trenches has a very high hydraulic conductivity. The bio-polymer slurry degrades biologically leaving a gravel cutoff/collection trench. Bio-polymer walls can be installed to greater depths than conventional trenches without shoring.

Excavation Dewatering

This process option includes the removal/collection of construction water that accumulates in excavations during the remedial action. Construction water includes storm water runoff and groundwater seepage that collects in the base of excavations. This accumulated water would be pumped out and transferred to a holding tank for gravity removal of suspended solids.

During excavation activities at any of the Operable Unit 2 subunits, berms and diversion ditches would be installed to keep surface water runoff out of the excavations.

3.5.2.3.2 Evaluation

Interceptor Systems

Effectiveness - The use of interceptor systems would be effective for removing the predicted volumes of groundwater located close to the surface and in the shallow perched aquifer at the Inactive Flyash Pile/South Field/Active Flyash Pile area. The use of interceptor systems is effective for meeting remediation goals by reducing the lateral migration of the contaminants and by removing contaminants from the impacted areas for treatment and disposal. However, long-term effectiveness depends on the long-term presence of a treatment facility which can receive the collected water.

Impacts to human health during installation of interceptor systems can be mitigated by using sound construction safety practices. OSHA trenching safety standards will have to be utilized to maintain worker safety.

Implementability - Interceptor systems are administratively feasible when used in conjunction with other treatment and disposal technologies. Both the resources and services required to install interceptor systems are readily available.

Cost - When compared to other removal options, interceptor systems have moderate capital and O&M costs.

Conclusion - Interceptor systems are applicable for the Inactive Flyash Pile/South Field/Active Flyash Pile area.

Excavation Dewatering

Effectiveness - Excavation dewatering would be an effective method for pumping out the volumes of construction water that can accumulate in the excavation envisioned for the subunits. This process is effective for meeting the remediation goals by reducing the potential for migration of the contaminants in the construction water. The use of excavation dewatering is effective in protecting human health and the environment by reducing lateral or downward migration of contaminants, and by removing contaminants for treatment and disposal.

During excavation activities, impacts to human health would be mitigated by using surface diversions to minimize storm water runoff flowing into the excavation, thereby minimizing the quantities that need to be pumped. Pumping would be performed using a suction pump on the original grade with enough hose to reach the base of the excavation. Excavation dewatering using suction pumps is a well-proven and reliable technology widely used in the construction industry.

Implementability - Excavation dewatering is administratively feasible when used in conjunction with other treatment and disposal technologies. Both the equipment and personnel required to perform the dewatering are readily available.

Cost - Excavation dewatering has low capital and O&M costs.

Conclusion - Excavation dewatering is applicable for all subunits.

3.5.2.4 Treatment

3.5.2.4.1 Description

Sedimentation

Sedimentation is the process of separating particles that are heavier than water from water by gravitational settling. Settling tanks (also known as sedimentation tanks, sedimentation basins, settling basins, or clarifiers) are normally employed in this process, and vary in size depending on the flow rate of water to be treated. In determining the tank volume, the water must be allowed to stay in the sedimentation tanks for a sufficient period of time, typically 1.5 to 2.5 hours, to allow the solids to settle. The tanks are also designed to provide storage capacity if the wastewater collection rate is greater than what can be sent to the AWWT facility. Chemicals can be added to the settling tanks to help promote the settling of the solids.

The objective of pre-treatment by sedimentation is to remove the readily settleable solids, and thus reduce the suspended solids content prior to treatment at the AWWT facility. Sedimentation produces a concentrated sludge.

Advanced Wastewater Treatment Facility

The AWWT facility is being built on the FEMP site and will be available for treating wastewater, including groundwater and construction water generated during remediation of all of the Operable Unit 2 subunits. The AWWT facility is currently scheduled to begin accepting groundwater and construction water in June 1996. This system will utilize metals precipitation, ion exchange, and other treatment techniques to treat influent so that the effluent will meet all discharge criteria. The AWWT facility is designed to reduce uranium in FEMP's wastewater discharges to less than the proposed Safe Drinking Water Standard of 20 parts per billion (ppb).

The treatment system will consist of two parallel treatment systems. Phase I will treat 700 gallons per minute (gpm) of contaminated storm water runoff from the FEMP Storm Water Retention Basin. Starting in March 1994, an interim treatment system will also treat uranium-contaminated groundwater to be extracted from the South Groundwater Contamination Plume (South Plume) prior to its discharge to the Great Miami River. The South Plume is located just south of the FEMP in a portion of the Great Miami Aquifer. During periods of low flow from other sources, the AWWT facility will also treat water from the South Plume. Phase II will treat 400 gpm of wastewater from cleanup and other activities at the site. This consists of approximately 200 gpm from existing wastewater flows and 200 gpm from future remediation flows.

3.5.2.4.2 Evaluation

Sedimentation

Effectiveness - Sedimentation is an effective way to remove particulates from construction water. Settling tanks can be sized to handle the volumes of construction water anticipated from the subunits. The tanks also would be effective for providing temporary storage capacity in order to eliminate surges at the AWWT facility. Contaminated suspended solids can be partially removed by sedimentation, reducing the sediment loading to the AWWT facility.

Implementability - The use of sedimentation is administratively feasible when used in conjunction with other treatment and disposal technologies. Both the resources and services required to install and operate settling tanks are readily available.

Cost - When compared to other treatment options for removal of suspended solids, gravity sedimentation has moderate capital and O&M costs.

Conclusion - Sedimentation as a pretreatment to other water treatment technologies is applicable for all subunits.

Advanced Wastewater Treatment

Effectiveness - The AWWT facility was designed to treat the liquid waste to be generated during the implementation of remedial measures. The design is based on similar documented application and site-specific treatability studies.

Implementability - Using the AWWT facility is administratively feasible. Modification to the current NPDES permits may be required. The facility is currently under construction and is scheduled to begin accepting Operable Unit 2's construction water in late 1996.

Cost - When compared to other treatment options, using the AWWT facility would have low capital and O&M costs for Operable Unit 2, because the facility will have already been constructed under Operable Unit 5.

Conclusions - The AWWT facility is applicable for treating the groundwater and construction water from all subunits.

3.5.2.5 Disposal

3.5.2.5.1 Description

Discharge to Great Miami River

This process option consists of discharging treated site groundwater and construction water via the existing pipeline from the AWWT facility. This is applicable to all water from the Operable Unit 2 subunits.

3.5.2.5.2 Evaluation

Discharge to Great Miami River

Effectiveness - Direct discharge of treated groundwater and construction water to the Great Miami River via the existing pipeline and manhole number 175 would be an effective way of disposing the volume of treated construction water/perched groundwater. Discharge of treated effluent to the Great Miami River meets the remediation goals by removing the treated water from the site. Discharge of

treated wastewater to the Great Miami River is the current disposal method at the FEMP. It has proven to be a reliable means of discharging at the FEMP.

Implementability - This discharge option is administratively feasible to implement. The FEMP currently holds a NPDES permit to discharge treated water to the Great Miami River. The uranium content of the existing discharge is not regulated by the NPDES permit program; however, it is regulated by internal DOE DCGs and agreements with the EPA. This option will require modification of the existing NPDES permit for the added flow.

Cost - When compared to other disposal options, this option has low capital and O&M costs.

Conclusion - Discharge of treated wastewater to the Great Miami River via the existing pipeline is applicable for the treated wastewater from all subunits.

3.6 Summary

The process options deemed potentially applicable to remediation of the Operable Unit 2 subunits are presented in Table 3-22 by subunit and by medium. These process options will be assembled into potential remedial alternatives and screened in Section 4.0. Alternatives that pass the screening process will be evaluated in detail in Section 5.0.

TABLE 3-22

PROCESS OPTIONS RETAINED FOR CONSIDERATION AS COMPONENTS OF REMEDIAL ALTERNATIVES

General Response Action / Technology/Process Option	Subunit				
	Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
SOIL/WASTE MEDIA					
No Action	●	●	●	●	●
Institutional Controls					
Physical Barriers	●	●	●	●	●
Deed Restrictions	●	●	●	●	●
Containment					
Composite Cap	●	●	●	●	●
Surface Water Controls	●	●	●	●	●
Revegetation	●	●	●	●	●
Removal					
Mechanical Excavation	●	●	●	●	●
Sorting/Separation	●	●	●	●	●
In Situ Treatment					
Stabilization/Solidification		●			
Ex Situ Treatment					
Soil Washing	●		●	●	
Stabilization/Solidification	●	●	●	●	●
Crushing/Shredding	●	●	●	●	
Drying	●	●	●	●	●
Vitrification	●		●	●	
Disposal					
On-Site Disposal Cell	●	●	●	●	●
Off-Site Low Level Radioactive Waste Disposal Facility	●	●	●	●	●
Off-Site Mixed Waste Disposal Facility				●	
PERCHED GROUNDWATER/CONSTRUCTION WATER MEDIA					
No Action	●	●	●	●	●
Institutional Actions					
Deed Restrictions	●	●	●	●	●
Groundwater Monitoring Wells	●	●	●	●	●
Removal					
Interceptor System			●	●	●
Excavation Dewatering	●	●	●	●	●
Physical/Chemical Treatment					
Sedimentation	●	●	●	●	●
FEMP AWWT[a] Facility	●	●	●	●	●
Disposal					
Discharge to Great Miami River	●	●	●	●	●

[a]AWWT = advanced wastewater treatment.

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