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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 2 VOLUME 1 OF 6 TABLE OF CONTENTS AND SECTIONS 1-3 DRAFT APRIL 1994 REF: 5500, 5502, 5503, 5504, 5505, 5506, 5507

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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 2

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 1 OF 6
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SECTIONS 1-3

APRIL 1994

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 1 OF 6
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LIST OF ACRONYMS AND ABBREVIATIONS

ADM	Actin Description Memorandum
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	centimeter/second
CMSA	consolidated metropolitan statistical area
COA	certificate of analysis
COE	U.S. Army Corps of Engineers
COC	contaminant of concern
CRARE	Comprehensive Remedial Action Response Evaluation
CSM	conceptual site model
CT	central tendency
CWA	Clean Water Act
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

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

EWDF	exempted waste disposal facility
°F	degrees Fahrenheit
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
FMPC	Feed Materials Production Center
FR	Federal Register
FS	feasibility study
ft/yr	feet/year
GC/MS	gas chromatograph/mass spectrometry
GIS	Geographic Information System
GMA	Great Miami Aquifer
GMR	Great Miami River
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
ISO	International Shipping Organization
IT	IT Corporation
lbs/hr	pounds per hour
km	kilometer
LD/LC	leak detection/leachate collection
LLW	low-level radioactive waste
LLWDF	low-level radioactive waste disposal facility
μg/g	microgram/gram
μg/L	microgram/liter
μg/kg	microgram/kilogram

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

μm	micrometer
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/kg	milligram/kilogram
mg/L	milligram/liter
mi	mile
MSL	mean sea level
MUSLE	Modified Universal Soil Loss Equation
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	operation and maintenance
OAC	Ohio Administrative Code
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
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyls
pCi/g	picoCuries/gram
pCi/L	picoCuries/liter
pH	negative log of the hydrogen ion concentration
PIC	products of incomplete combustion
PID	photoionization detector
PP	proposed plan

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

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
ROD	record of decision
RSE	Removal Site Evaluation
SAP	Sampling and Analysis Plan
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
SWDA	Solid Waste Disposal Act (state of Ohio)
SWDF	solid waste disposal facility
SWIFT III	Sandia Waste Isolation Flow and Transport (computer model)

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

SWMU	solid waste management unit (RCRA)
TAL	target analyte list
TBC	to be considered
TCA	trichloroethane
TCLP	toxicity characteristic leaching procedure
TLD	thermoluminescence dosimeters
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	United States 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

DISTRIBUTION LIST

DRAFT OPERABLE UNIT 2 FS REPORT SUBMITTAL TO EPA

April 29, 1994

EPA and OEPA
J. Saric, EPA
G. Jablonowski, EPA
P. VanLeeuwan, EPA
G. Mitchell, OEPA
J. Kwasniewski, OEPA
P. Harris, OEPA
M. Proffitt, OEPA
T. Schneider, OEPA
S. Lloyd, PRC
F. Bell, ATSDR
R. Cohen, Geotrans

Ohio Department of Health
L. Gilham

DOE Fernald
J. Craig
J. Reising
R. Warner
B. Shroff
R. Janke
R. Mendelsohn
DOE Files
E. Skintik
G. Becker, MTC
Steve Gibson, MTC

DOE Headquarters
J. Fiore
M. McCune
D. Kozlowski
S. Frush
W. Black
S. Woodbury
S. Pearce, Booze Allen & Hamilton

DOE NTS
Wendy Griffin

EXECUTIVE SUMMARY

This report documents the Feasibility Study (FS) phase of the Fernald Environmental Management Project (FEMP) Operable Unit 2 Remedial Investigation/Feasibility Study (RI/FS). The FEMP is a U.S. Department of Energy (DOE) facility located near Fernald, Ohio, which operated from 1952 to 1989 providing high purity uranium metal products to support United States defense programs. In 1989, uranium processing operations ceased and the mission of the facility was changed to environmental restoration. Also in 1989, the facility was placed on the National Priorities List (NPL) or the "Superfund List" by the U.S. Environmental Protection Agency (EPA). The RI/FS for the FEMP is being conducted pursuant to the 1986 Federal Facility Compliance Agreement (FFCA) between the EPA and DOE, which has been superseded by the 1990 Consent Agreement, which was amended in 1992. The Consent Agreement and the amendment, collectively referred to as the "Amended Consent Agreement" or ACA, is under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Ohio Environmental Protection Agency (OEPA) is also 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 through which nature and extent of contamination is documented and appropriate remedial alternatives are evaluated to be protective of human health and the environment. The Operable Unit 2 RI Report provides a detailed understanding of the nature and extent of the waste materials, their present and future impacts on the surrounding environment, and the present and future risks to human health if the Operable Unit 2 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 (PP) is submitted in conjunction with the FS and identifies the preferred comprehensive alternative for remediation of Operable Unit 2. The PP summarizes the alternatives considered, identifies the preferred alternative, and summarizes the information relied upon in the selection of the preferred alternative. Public participation is encouraged; a summary of the plan is prepared to facilitate public review. A public comment meeting will be held to obtain public comment and a responsive summary to public comment will be prepared. Consistent with the ACA, selection of the preferred cleanup alternative will be documented in a Record of Decision (ROD). The ROD is issued by the EPA after consideration of comments received from the public and other interested parties.

EPA approved the FEMP RI/FS Work Plan in May 1988. The work plan provided the overall technical approach, identified the areas to be investigated, and presented the objectives and data evaluation critical for the planned investigations. The work plan 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 (see Figure ES-1). The operable units are:

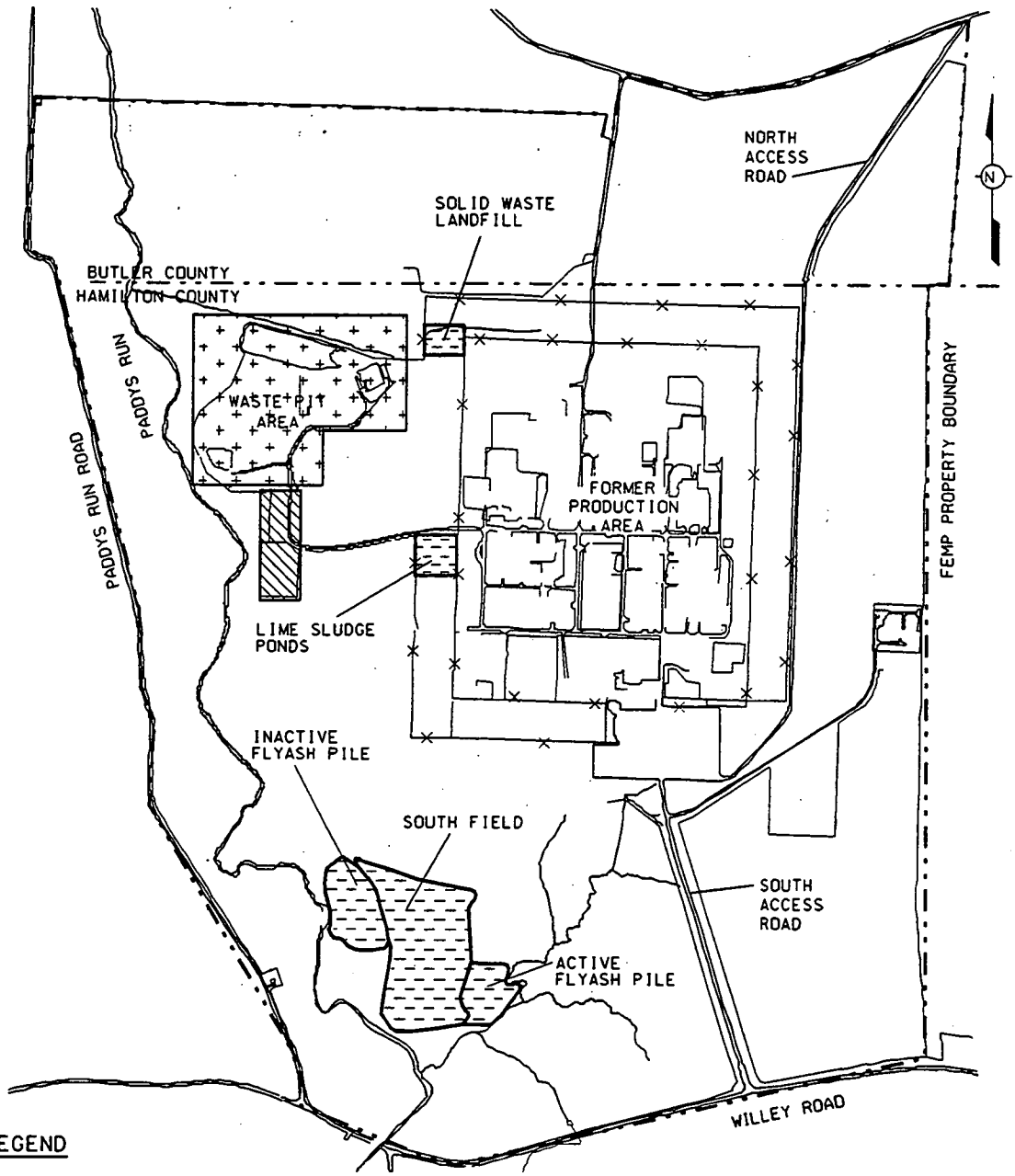
- Operable Unit 1 - Waste Pit Area
- Operable Unit 2 - Other Waste Areas
- Operable Unit 3 - Former Production Area
- Operable Unit 4 - Silos 1 through 4
- Operable Unit 5 - Environmental Media

Operable Unit 2 is comprised of five subunits: the Solid Waste Landfill, the Lime Sludge Ponds, the Inactive Flyash Pile, the South Field, and the Active Flyash Pile. The contaminated material addressed in the Operable Unit 2 FS include berms, liners, and soil within the operable unit boundary. The treatment and disposal of storm water and perched groundwater will be coordinated with remedial actions for Operable Unit 5.

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. 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 (NOI) was published in the Federal Register (FR), which outlined the NEPA/CERCLA integration approach to evaluate the environmental impacts associated with planned cleanup activities at the site. As identified in the NOI, the FS for the lead FEMP operable unit, Operable Unit 4, was issued as a Feasibility Study/Proposed Plan - Draft Environmental Impact Statement (FS/PP-DEIS) and has been written to incorporate NEPA values at the level of an EIS. Furthermore, the RI/FS documents for the remaining operable units will also be written to include NEPA values. An Action Description Memorandum (ADM) documenting the decision to prepare Environmental Assessments (EAs) for Operable Units 1, 2, and 5 was prepared



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.

fs0810.dgn

FIGURE ES-1
RI/FS OPERABLE UNITS

000058

(Letter, DOE-1015-94, J.P. Hamric to J.J. Fiore, "Action Description Memorandum for Operable Units 1, 2, and 5 -- Fernald Environmental Management Project," March 14, 1994).

In addition, the Operable Unit 2 FS/PP-EA 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). This discussion of the NEPA cumulative impacts will be updated, as appropriate, with 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 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.

SOURCE DESCRIPTION

Operable Unit 2 subunits are defined as follows:

Solid Waste Landfill

The Solid Waste Landfill is a flat rectangular area of about 0.4 hectare (one acre), located in the northeast corner of the Waste Storage Area. The Solid Waste Landfill received a variety of waste materials including cafeteria waste, medical waste, rubbish, and construction demolition wastes. Disposal activities began as early as 1954 and ceased during 1986. The nominal depth of the landfill is 3 meters (m) [10 feet (ft)] with a dish-shaped depression of 4.6 m (15 ft) in the south central portion of the landfill. There is one localized area in the southeast corner of the landfill with a waste depth of 6.7 m (22 ft). There is an estimated 11,636 cubic (cu) m [15,220 cu yards (yd)] of waste in the landfill.

Seventeen contaminants of concern (COCs) have been identified for all media of the Solid Waste Landfill. These COCs consist of ten radionuclides, three metals, and four organic compounds. The extent of the COCs in the Solid Waste Landfill is distributed throughout the surface and subsurface fill materials, with the maximum levels located in the south central area of the landfill. The COCs were also detected in the glacial till beneath this area and in the perched groundwater near the southeast corner of the subunit. No impact has been observed on the Great Miami Aquifer.

Lime Sludge Ponds

The North and South Lime Sludge Ponds are two unlined, rectangular ponds, each measuring approximately 38 by 69 m (125 by 225 ft); they are located in the southeast corner of the Waste Storage Area. Small earthen dikes of unknown origin provide freeboard and additional confinement of the sludge. The operational history of the ponds is well understood. Wastes disposed in the ponds originated from water plant operations, coal pile storm water runoff, and boiler plant blowdown. The South Pond is full and has been inactive since the mid-1960s, and is now overgrown with grasses and shrubs. The North Pond is partially full and currently remains in use. The west side of the North Pond is usually covered with 0.3 to 0.6 m (1 to 2 ft) of water, depending on precipitation. The remainder of the pond is dry and sparsely covered with vegetation.

The waste from the water plant operations is generated from a water softening process. About 0.76 cu m (one cu yd) of waste sludge is generated each day and is pumped to Tanks 6 and 7 of the General Sump. Coal pile runoff is treated in a retention basin to settle out the solids, then pumped to Tanks 6 and 7 of the General Sump. The boiler plant blowdown consists of backflushed water, generated when the boiler is backflushed to prevent scale buildup. This water is also pumped to Tanks 6 and 7 of the General Sump. Tanks 6 and 7 contain only sludges from these three sources.

Sludge is allowed to accumulate in the tanks for about two weeks. It is then pumped as a slurry to the North Lime Sludge Pond. The bulk of the material comprising the slurry is sludge from the water softening operations. The Lime Sludge Ponds have been operated in this manner since the early 1950s. Based on this process knowledge as well as the resulting analysis of the sludge, it appears that the lime sludge is relatively homogeneous (uniform in composition). Use of the North Lime Sludge Pond is planned to cease during the summer of 1995, once an electrolysis system to produce potable water becomes operational, or when the proposed public water system is connected to the FEMP.

The nominal depth of the North and South Lime Sludge Ponds are 2.1 m and 3.4 m (7 ft and 11 ft), respectively, with side slopes of two horizontal to one vertical. The ponds are estimated to contain 12,610 cu m (16,490 cu yd) of lime sludge material. The berms are estimated to contain approximately 4,890 cu m (6,400 cu yd) of soil.

The Lime Sludge Ponds are presently classified as Solid Waste Management Units by OEPA. However, evaluation of RI data indicates that the lime sludge could be classified as an exempted waste in accordance with Chapter 3734 of the Ohio Administrative Code (OAC).

Seventeen COCs have been identified for all media of the Lime Sludge Ponds. These COCs consist of nine radionuclides, two metals, and six organic compounds. The extent of COCs in the Lime Sludge Ponds is limited mostly to the earthen berms surrounding the ponds. Beryllium is the only COC that is believed to have originated in the lime sludge. Radionuclides and organics appear to have originated in the surface and berm soils. The COCs were also detected in the perched groundwater downgradient of the subunit, but the source of these contaminants is believed to be the K-65 slurry line, which is located immediately to the south of the Lime Sludge Pond area. No impact has been observed on the Great Miami Aquifer.

Inactive Flyash Pile

The Inactive Flyash Pile is located about 610 m (2,000 ft) southwest of the former Production Area and covers approximately 0.8 ha (2 acres). Paddys Run forms the western boundary; the South Field lies to the east. The Inactive Flyash Pile and South Field are contiguous and lack a defined physical boundary. In appearance, this subunit resembles a relatively steep hill covered with shrubs and trees. The soil covering the Inactive Flyash Pile is of unknown origin. Approximately 70 percent of the ash material is bottom ash from the facility's boiler plant operations; the remainder is flyash.

The operating history of the Inactive Flyash Pile is complex and not well understood. Both ash and fill (a mixture of soil, ash, and other waste) was taken by truck to a natural terrace (erosional slope) along Paddys Run and dumped. The fill generally underlies the ash. Various other wastes including rubble, gravel, asphalt, and process waste were also deposited and are primarily associated with the fill. There is some construction debris associated with the soil cover. Disposal operations at this subunit ceased during the mid-1960s.

It is estimated that there are 890 cu m (1,160 cu yd) of material in the soil cover, 33,360 cu m (43,635 cu yd) of ash material, and 39,070 cu m (51,100 cu yd) of fill material in the Inactive Flyash Pile area. Based on an evaluation of the RI data, the flyash could be classified as an exempted waste in accordance with Chapter 3734 of the ORC.

Eleven COCs have been identified for all media of the Inactive Flyash Pile. The COCs consist of eight radionuclides, two metals, and one organic compound. The extent of COCs in the Inactive Flyash Pile covers most of the surface and subsurface soils, surface water, sediment, and perched groundwater sampled within the subunit. Radionuclides and organics appear to be primarily associated with the fill, although at lesser concentrations, the organics are associated with the flyash, possibly from dust control spraying. The COCs were also detected in the perched groundwater beneath the subunit. Uranium is the only COC detected in the Great Miami Aquifer downgradient of the subunit; the source is believed to be the fill area beneath the central part of the Inactive Flyash Pile.

South Field

The South Field is an 4.4 ha (11 acre) area that lies between the Inactive Flyash Pile and the Active Flyash Pile. A physical boundary with the Inactive Flyash Pile is not distinguishable. Currently, the South Field is relatively flat and is covered with grasses, shrubs, and trees.

The operational history of the South Field is not well documented. It was not an engineered disposal site; disposal is believed to have been initiated in 1954 and continued randomly until the mid-1960s. A number of wastes were disposed in the South Field including construction and demolition materials, flyash, soils that have been contaminated with low levels of radioactive materials, and possibly process wastes. The South Field is estimated to contain 91,750 cu m (120,100 cu yd) of fill material.

Twenty-two COCs have been identified for all media of the South Field. These COCs consist of ten radionuclides, three metals, and nine organic compounds. The extent of COCs in the South Field covers most of the surface and subsurface soils, surface water, sediment, perched groundwater, and groundwater sampled within the subunit. Radionuclides and organics were detected in higher concentrations in the northern portion of the South Field relative to other areas of this subunit. Several of the COCs were also detected in the perched groundwater beneath of the subunit and in the Great Miami Aquifer downgradient of the subunit.

Active Flyash Pile

The Active Flyash Pile is bounded to the east and north by the Storm Sewer Outfall Ditch and is separated from the South Field to the west by an unpaved road. The Active Flyash Pile appears as a large, steep pile of black flyash and covers about 1.2 ha (three acres). Wind screens and silt fences have been installed to prevent wind and water erosion, and a crusting agent has been applied to harden the surface and minimize erosion and resuspension of dust. The operational history of the subunit is well documented.

Flyash from the site's coal-fired boiler plant was disposed at the Active Flyash Pile from the mid-1960s until December 1992. Flyash presently being generated at the FEMP is disposed at an approved, off-site facility. The waste at the Active Flyash Pile is comprised of about 70 percent bottom ash and 30 percent flyash. Small quantities of unburned coal and rock are present, as is typical of boiler ashes. There are approximately 49,730 cu m (65,050 cu yd) of flyash material disposed in the Active Flyash Pile. Based on an evaluation of the RI data, the flyash qualifies for classification as an exempted waste in accordance with Chapter 3734 of the ORC.

Nine COCs have been identified for all media of the Active Flyash Pile. These COCs consist of seven radionuclides and two metals. The extent of COCs in the Active Flyash Pile covers most of the surface and subsurface soils and sediment within the subunit. The COCs uranium-234, uranium-234, uranium-235/236, and uranium-238 were detected in the Great Miami Aquifer downgradient of the subunit.

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 current and future 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 occurs beyond that which has already taken place.

The postulated human receptors of incremental risk for the current land use scenario were trespassing youths, groundkeepers, off-property residents, and the consumer of meat and milk products. For the future land use scenario assuming federal ownership, the receptors were expanded trespassers and off-property resident farmers. For the future land use scenario assuming private ownership, the receptors were on-property resident farmers, homebuilders, users of perched groundwater (isolated bodies of groundwater within the glacial till), and users of Great Miami Aquifer groundwater. To ensure that the most sensitive or most exposed individuals in the population are protected, a calculation for the Reasonable Maximum Exposure (RME) was effected, which is the maximum exposure a person reasonably could receive from the waste site being evaluated. For all subunits, future risks to off-property receptors (with the exception of the expanded trespasser, whose exposures primarily occur on site) were the same for federal or private ownership.

The results of the baseline risk assessment for each subunit are summarized in Table ES-1 and in the following sections. For carcinogens, EPA has identified, in the NCP, a target range for incremental risks of 10^{-6} to 10^{-4}, or one in 1,000,000 to one in 10,000, respectively, to limit the possibility that an individual will develop cancer due to exposures to residual contaminants. For noncarcinogens, EPA guidance provides protection to individuals from health effects other than cancer by proposing that potential intakes or dermal exposures to a toxic chemical are maintained below the reference dose. The ratio of actual or potential dose to the reference dose is maintained at less than 1.0 to provide protection.

Solid Waste Landfill

For the current land use scenario, a combined total carcinogenic risk to a trespassing youth is 1.6×10^{-5} due to external radiation from radium-226 and thorium-228 and dermal contact with beryllium. Hazard Indices (HIs) are less than unity (one). Off-property resident farmers have carcinogenic risks on the order of 10^{-8} and a HI of less than 1.0.

For the future land use scenario assuming private ownership, combined carcinogenic risks from all media to the RME farmer are 1.2×10^{-3}. The RME farmer at the landfill has a noncarcinogenic HI of 1.5. The largest contributions to risk to on-property resident farmers are from external radiation from radium-226, uranium-238, and thorium-228 in surface soils and from ingestion of produce and livestock products contaminated with polynuclear aromatic hydrocarbons (PAHs).

TABLE ES-1

BASELINE RISK ASSESSMENT SUMMARY
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	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child
Solid Waste Landfill	Carcinogenic	$1.6x10^{-5}$	$2.4x10^{-5}$	$4.6x10^{-8}$	$6.2x10^{-9}$	$3.9x10^{-7}$	$4.4x10^{-5}$	$1.3x10^{-6}$	$1.5x10^{-7}$
	Noncarcinogenic	$3.9x10^{-1}$	$1.4x10^{-1}$	$5.5x10^{-6}$	$2.6x10^{-5}$	$6.1x10^{-5}$	$7.4x10^{-1}$	$1.3x10^{-4}$	$6.1x10^{-4}$
Lime Sludge Ponds	Carcinogenic	$2.8x10^{-5}$	$4.7x10^{-5}$	$2.3x10^{-7}$	$4.9x10^{-8}$	$5.5x10^{-6}$	$9.8x10^{-5}$	$2.4x10^{-7}$	$5.0x10^{-8}$
	Noncarcinogenic	$2.1x10^{-1}$	$1.4x10^{-1}$	$1.1x10^{-4}$	$2.0x10^{-4}$	$1.8x10^{-3}$	$6.3x10^{-1}$	$1.1x10^{-4}$	$2.0x10^{-4}$
Inactive Flyash Pile	Carcinogenic	$3.3x10^{-5}$	$5.0x10^{-5}$	$8.6x10^{-8}$	$8.3x10^{-9}$	$3.2x10^{-8}$	$1.2x10^{-4}$	$6.6x10^{-5}$	$3.2x10^{-6}$
	Noncarcinogenic	$1.2x1^{-1}$	$4.5x10^{-2}$	$3.1x10^{-5}$	$1.3x10^{-4}$	$7.2x10^{-5}$	$4.0x10^{-1}$	1.3	3.4
South Field	Carcinogenic	$8.0x10^{-5}$	$6.5x10^{-4}$	$7.0x10^{-7}$	$3.0x10^{-7}$	$4.2x10^{-6}$	$2.2x10^{-4}$	$8.1x10^{-5}$	$1.2x10^{-5}$
	Noncarcinogenic	$3.6x10^{-1}$	$4.1x10^{-2}$	$1.2x10^{-5}$	$4.9x10^{-5}$	$1.7x10^{-5}$	$3.8x10^{-1}$	1.1	2.7
Active Flyash Pile	Carcinogenic	$6.5x10^{-5}$	$9.2x10^{-5}$	$1.7x10^{-6}$	$5.0x10^{-7}$	$6.5x10^{-6}$	$2.4x10^{-4}$	$9.2x10^{-6}$	$8.7x10^{-7}$
	Noncarcinogenic	$1.1x10^{-1}$	$9.9x10^{-2}$	$4.2x10^{-3}$	$1.6x10^{-2}$	$4.7x10^{-2}$	$2.8x10^{-1}$	$1.9x10^{-1}$	$7.1x10^{-1}$

See footnotes at end of table

TABLE ES-1
(Continued)

Waste Subunit	Risk Type[a]	Future Land Use Assuming Private Ownership							
		On-Property Resident Farmer (RME)[b]	On-Property Resident Farmer (CT)[c]	On-Property Resident Child	Home Builder	Perched Groundwater User	Perched Groundwater Child	Great Miami River User (Adult)	Great Miami River User (Youth)
Solid Waste Landfill	Carcinogenic	$1.2x10^{-3}$	$8.8x10^{-5}$	$1.2x10^{-4}$	$5.1x10^{-6}$	$5.3x10^{-3}$	$1.1x10^{-3}$	$1.0x10^{-5}$	$4.2x10^{-6}$
	Noncarcinogenic	1.5	$3.0x10^{-1}$	3.3	1.9	NA	NA	$1.4x10^{-1}$	$1.7x10^{-1}$
Lime Sludge Ponds	Carcinogenic	$1.9x10^{-3}$	$1.7x10^{-4}$	$2.1x10^{-4}$	NA	$7.7x10^{-7}$	$1.4x10^{-7}$	N/A	N/A
	Noncarcinogenic	$2.6x10^{-1}$	$1.4x10^{-1}$	1.3	NA	$6.0x10^{-3}$	$1.2x10^{-2}$	N/A	N/A
Inactive Flyash Pile	Carcinogenic	$3.2x10^{-3}$	$2.7x10^{-4}$	$3.3x10^{-4}$	NA	NA	NA	$2.5x10^{-5}$	$8.2x10^{-6}$
	Noncarcinogenic	2.3	1.3	5.8	NA	NA	NA	$3.8x10^{-1}$	$2.4x10^{-2}$
South Field	Carcinogenic	$3.8x10^{-3}$	$3.1x10^{-4}$	$4.5x10^{-4}$	$2.7x10^{-7}$	NA	NA	$1.1x10^{-4}$	$6.3x10^{-5}$
	Noncarcinogenic	2.2	1.3	5.7	0.1	NA	NA	$4.4x10^{-2}$	$6.3x10^{-2}$
Active Flyash Pile	Carcinogenic	$1.9x10^{-3}$	$1.7x10^{-4}$	$6.0x10^{-4}$	NA	NA	NA	$1.3x10^{-4}$	$6.5x10^{-5}$
	Noncarcinogenic	2.1	1.1	8.0	NA	NA	NA	0.2	0.2

[a]The carcinogenic risk value is the Incremental Lifetime Cancer Risk (ILCR) and the noncarcinogenic hazard value is the Hazard Index (HI).

[b]RME = Reasonable Maximum Exposure

[c]CT = Central Tendency

[d]NA = The indicated land use is not applicable to the waste subunit

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For the future scenario having federal ownership, the expanded trespasser has a combined carcinogenic risk of 4.4 x 10^{-5} due mostly to external radiation by radium-228, thorium-228, and uranium-238 and dermal contact with beryllium in soil. Total HI is less than 1.0. Combined carcinogenic risks for off-property resident farmers range from 10^{-5} to 10^{-8}.

The exposure pathways with the most significant risk from COCs are related to ingestion, inhalation, and dermal contact of soils and consumption of produce, milk, and beef from cattle grazing on contaminated soil. Two COCs, carbazole and technetium-99, contribute risk to the on-property resident farmer if perched groundwater is used as a household drinking water source. Approximately 86 percent of the total risk to the on-property farmer is derived from four COCs: radium-228, thorium-228, uranium-238, and beryllium in the soil. Ninety-nine percent of the risk from use of perched groundwater is from carbazole.

Lime Sludge Ponds

For the current land use scenario, a combined total carcinogenic risk to a trespassing youth is 2.8 x 10^{-5} due to exposure to surface soil containing radium-228, thorium-228 (via external radiation), and to dermal contact with beryllium and Aroclor-1254. Total HI is less than 1.0. Carcinogenic risks to off-property residents are on the order of 10^{-7}, and the combined HI is much less than 1.0.

For the future land use scenario assuming private ownership, the RME farmer has total risks of 1.9 x 10^{-3}, due almost entirely to the presence of radium-228, thorium-228, uranium-238, beryllium, and Aroclor-1254 in soil. The HI was less than 1.0.

For the future land use scenario with federal ownership, the expanded trespasser has a total risk of less than 9.8 x 10^{-5} and a HI of less than 1.0. Off-property resident farmers have carcinogenic risks on the order of 10^{-7}. The off-property resident farmer has a HI of less than 1.0.

The exposure pathways with the most significant risk from COCs are related to ingestion, inhalation, and dermal contact of soils and consumption of produce, milk, and beef from cattle grazing on contaminated soil. No COCs were determined for perched groundwater, even if perched groundwater is used for a household drinking water source. Approximately 88 percent of the total risk resulted from inhalation, ingestion, and dermal contact from radium-228, thorium-228, beryllium and Aroclor-1254.

Inactive Flyash Pile

Because of the contiguous nature of the Inactive Flyash Pile and South Field, the complexity of the geology and lithology, and the patterns of groundwater flow in the area, it was not possible to completely separate these potential groundwater contaminant sources on other than an arbitrary basis. Therefore, the groundwater modeling for these subunits included simultaneous inputs from the entire area of these combined subunits. Hence, the risk contribution of the groundwater pathway is based on the combined effects of these subunits.

For the current land use scenario, total carcinogenic risks range from slightly greater than 10^{-5} for the trespassing youth to about 10^{-8} for off-property receptors. Risks to the trespassing youth were mostly due to the presence of radium-228, thorium-228, and beryllium in soil. HIs for the trespassing youth and off-property resident farmers are less than 1.0.

For the future land use scenario assuming private ownership, the RME farmer has a total risk of 3.2×10^{-3}. The RME have HIs far greater than 1.0. The largest component of risk to the on-property resident farmers is from thorium-228 and beryllium in soil and uranium-234 and uranium-238 in groundwater and consequently in produce and milk and beef from livestock that drink the contaminated groundwater from the combined Inactive Flyash Pile/South Field source area. The most significant components of the elevated HI are uranium in groundwater and consequently in homegrown produce.

For future land use assuming federal ownership, the expanded trespasser has a total carcinogenic risk of about 1.2×10^{-4} and a HI of less than 1.0. Off-property resident farmer has a total risk of 6.6×10^{-5} carcinogenic risks and an HI of 3.4. The largest component of risk to the off-property farmer is uranium-234 and uranium-238 in groundwater contaminated from the combined Inactive Flyash Pile/South Field source area.

The exposure pathways with the most significant risk from the COCs are related to ingestion, inhalation, and dermal contact of soils, ingestion of soil and groundwater, dermal contact with soil, and consumption of produce, milk, and beef from livestock that drink the contaminated groundwater. Approximately 85 percent of the risk from all media to the on-property resident farmer is derived from five COCs: radium- 228, thorium-228, uranium-234, uranium-238, and beryllium.

South Field

For the current land use scenario, total carcinogenic risks range from slightly greater than 10^{-5} for the trespassing youth to about 10^{-7} for off-property receptors. Risks to the trespassing youth were mostly due to external radiation of radium-228 and thorium-228 and dermal contact with beryllium. HIs for all receptors are less than 1.0.

For the future land use scenario assuming private ownership, the RME farmer has a total carcinogenic risk of 3.8×10^{-3} and the resident child has a risk of 4.5×10^{-4}. The RME farmer and resident child have HIs of more than 1.0. The largest component of risk to the on-property resident farmer is thorium-228, radium-228, beryllium, and benzo(a)pyrene in soil, and uranium-234 and uranium-238 in groundwater and consequently in irrigated produce and milk and beef from livestock that are watered with groundwater contaminated from the combined Inactive Flyash Pile/South Field source area. Risks for the RME farmer at the South Field are somewhat higher than for the Inactive and Active Flyash Piles because it is feasible to build a house on the South Field. Therefore, the South Field RME farmer has higher direct radiation exposures as well as exposure to indoor radon.

For future land use assuming federal ownership, the expanded trespasser has a total carcinogenic risk of about 2.2×10^{-4} and a HI of less than 1.0. Off-property resident farmers have carcinogenic risks as great as 10^{-5} and HIs greater than 1.0. The largest component of risk to the off-property farmer is uranium-234, uranium-238, and total uranium in groundwater and consequently in irrigated produce and milk and beef from livestock that are watered with groundwater contaminated from the combined Inactive Flyash Pile/South Field source area.

The exposure pathways with the most significant risk from the COCs are ingestion, inhalation, and dermal contact of soils, ingestion of groundwater, and ingestion of produce, milk, and beef contaminated by contact with soil or by drinking contaminated groundwater. Over 80 percent of the risk to the on-property resident farmer is derived from five COCs: radium-228, thorium-228, uranium-234, uranium-238, and beryllium.

Active Flyash Pile

For the current land use scenario, total carcinogenic risk to a trespassing youth is 6.8×10^{-5} due to external radiation from radium-226, radium-228, and thorium-228. Total HI is less than 1.0.

Carcinogenic risks to off-property residents are on the order of 10^{-6}, and the total HI is much less than 1.0.

For the future land use scenario assuming private ownership, the RME farmer has combined carcinogenic risks of 1.9×10^{-3} due mostly to the presence of neptunium-237, radium-228, and thorium-228 and arsenic in surface flyash material. The RME farmer has a HI of less than 1.0.

For the future land use assuming federal ownership, the expanded trespasser has a total carcinogenic risk of 2.4×10^{-4} and a HI of less than 1.0. Exposures to the expanded trespasser are due to beryllium in flyash material. Off-property farmers have carcinogenic risks as great as 10^{-6} and a HI of less than one. The largest component of risk to the off-property resident farmers is uranium-234 and uranium-238 in groundwater contaminated from the Active Flyash Pile source area.

The exposure pathways which poses the most significant risk to the Active Flyash Pile receptor is ingestion, inhalation, and dermal contact of soils (surface flyash material). Over 85 percent of the risk to the on-property resident farmer is derived from three COCs in soil: radium-228, thorium-228, and arsenic.

FEASIBILITY PROCESS AND CONCLUSIONS

This FS presents information to support the selection of the most appropriate remedial alternative for each of the five subunits in Operable Unit 2. 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 (RAOs), 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 (GRAs).
- Identification and screening of remedial technologies and process options.
- Evaluation and screening of process options within each technology.
- Assemblage of a wide range of remedial alternatives using the selected process options within each remedial technology.

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Remedial Action Objectives

Remedial action objectives (RAOs) have been developed for Operable Unit 2. The RAOs, which are common to all subunits, are given below:

- Prevent exposure to the COCs that are carcinogens at concentrations that would exceed a risk of 10^{-6} for all potential exposure pathways.
- Prevent exposure to the COCs that are non-carcinogens at concentrations that would result in the HI exceeding 0.20 for each individual COC in all potential exposure pathways.
- Prevent exposure to COCs that are at concentrations which exceed applicable or relevant and appropriate requirements (i.e., ARAR based levels for radiation, maximum contaminant levels, etc.) for all potential exposure pathways.
- Prevent further degradation of the environment and resources in the Operable Unit 2 waste areas.
- Provide a degree of remediation and a design that are suitable for the designated future land use.
- Achieve remediation goals for as low as reasonably achievable (ALARA) considerations when practicable.

Preliminary Remedial Levels

Proposed remediation levels for contaminated media are established in Section 2.0 of the FS using the following process:

- Preliminary Remedial Goals (PRGs) were established for each COC for incremental risks of 10^{-4}, 10^{-5}, and 10^{-6} assuming no institutional or source controls.
- Modified-PRGs were developed from risk-based PRGs based on various combinations of institutional, cross media impacts, and source controls. Source controls consist of barriers to potential horizontal flow pathways in the perched groundwater zone and infiltration controls with and without the groundwater barriers.
- Preliminary Remedial Levels (PRLs) were then established by adding background concentrations of each COC to the respective PRGs.

The PRLs developed for the land use scenarios assuming private ownership (no institutional controls) and federal ownership (institutional controls) without source controls are at background concentrations for uranium-238 for three of the five Operable Unit 2 subunits.

Remedial Alternatives Development

Given the wide range of potential remedial technologies and process options capable of meeting the PRLs, it was necessary to develop alternatives which are representative of the myriad of potential technological combinations. Those technologies carried through for detailed analysis include consolidation and containment (capping), on-site and off-site disposal cells, soil washing, vitrification, stabilization, and solidification. Ancillary technologies/processes include settling tanks to control solids in wastewater and storm water and vertical barriers and subsurface drains to control potential horizontal flow in the perched groundwater zone.

The geologic setting, the nature and extent of contamination below the source, and the overall conservatism in the risk assessment methodology are critical to the understanding of the alternatives carried through for detailed analysis. The Baseline Risk Assessment performed in the Operable Unit 2 RI shows a carcinogenic risk for the RME on-property farmer of greater than 10^{-4} and dictates removal and off-site disposal of essentially all contaminated Operable Unit 2 material. Accordingly, all subunits have a common off-site disposal alternative (i.e., Alternative 2) carried through for detailed analysis.

For future land use assuming continued federal ownership, the following are the major considerations affecting the detailed analysis for each of the subunits.

- Solid Waste Landfill

  There are greater than 9.1 m (30 ft) of glacial till beneath the Solid Waste Landfill, with the exception of one area near the southeast corner where deeper fill exists. This area is a potential direct pathway to the perched groundwater zone within the till. An evaluation of current conditions indicates that impacts to the glacial till soils are limited to a zone 0.6 to 1.2 m (2 to 4 ft) thick immediately below the fill. The remainder of the glacial till contains COC concentrations at or near their respective background concentrations. According to the Baseline Risk Assessment in the Operable Unit 2 RI, the glacial till is functioning as a natural barrier and there are no anticipated future impacts to the Great Miami Aquifer.

Physical conditions that are important are the wetlands associated with the drainage course that forms the northern extent of the Solid Waste Landfill and the railroad which forms the southern boundary.

- Lime Sludge Ponds

There are greater than 9.1 m (30 ft) of glacial till between the Lime Sludge Ponds and the Great Miami Aquifer and approximately 1.5 to 3.0 m (5 to 10 ft) between the Lime Sludge Ponds and the perched groundwater zone. The glacial till underlying the Lime Sludge Ponds has had little impact from contaminant migration, with COC concentrations at or near background. According to the Operable Unit 2 RI, the glacial till underlying the Lime Sludge Ponds is functioning as a natural barrier and no future impacts to the perched groundwater or the Great Miami Aquifer are anticipated.

Physical conditions that are important are the K-65 trench located to the south of the South Lime Sludge Pond and the railroad which forms the western boundary.

- Inactive Flyash Pile

The Inactive Flyash Pile is founded on a pre-existing terrace (valley slope) along Paddys Run (see Figure ES-2). To the northeast, approximately 3.7 m (12 ft) of glacial till underlies the flyash pile. To the west and south, the glacial till thickness decreases to 0 m at the toe of the terrace. The remainder of the Inactive Flyash Pile (approximately 70 percent) is founded directly on the unsaturated sand and gravel material of the Great Miami Aquifer.

Currently, the leachate from the ash has a direct pathway to the Great Miami Aquifer, either from the ash that directly overlies the Great Miami Aquifer or down the surface of the old terrace face into the Great Miami Aquifer. Additionally, the glacial till which underlies the Inactive Flyash Pile and adjacent South Field has an interbedded sand and gravel layer less than to 1.0 m (3.2 ft) thick which provides a source of horizontal migration from the South Field. This pathway exits along the terrace face as intermittent seeps.

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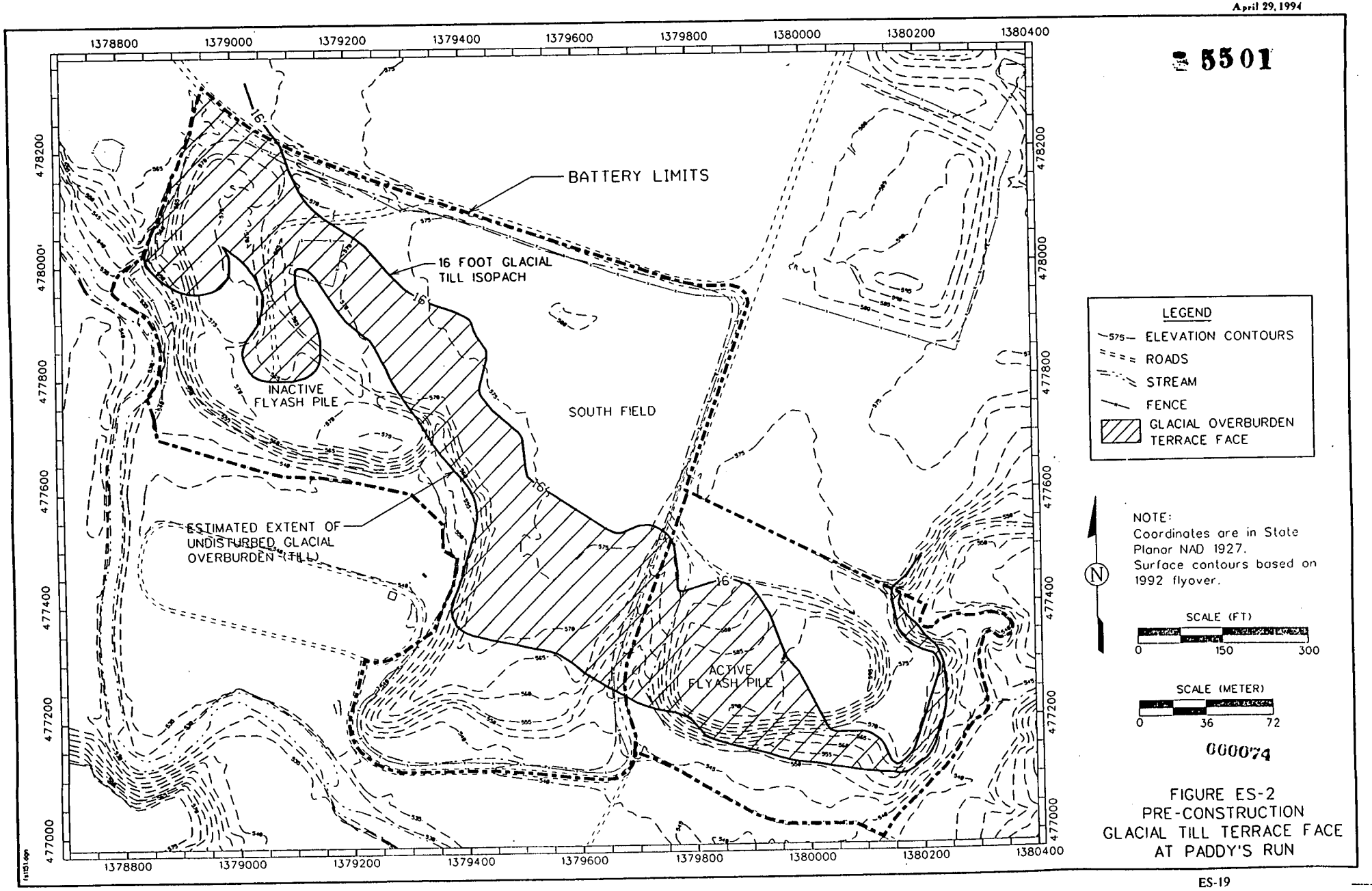

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FIGURE ES-2
PRE-CONSTRUCTION
GLACIAL TILL TERRACE FACE
AT PADDY'S RUN

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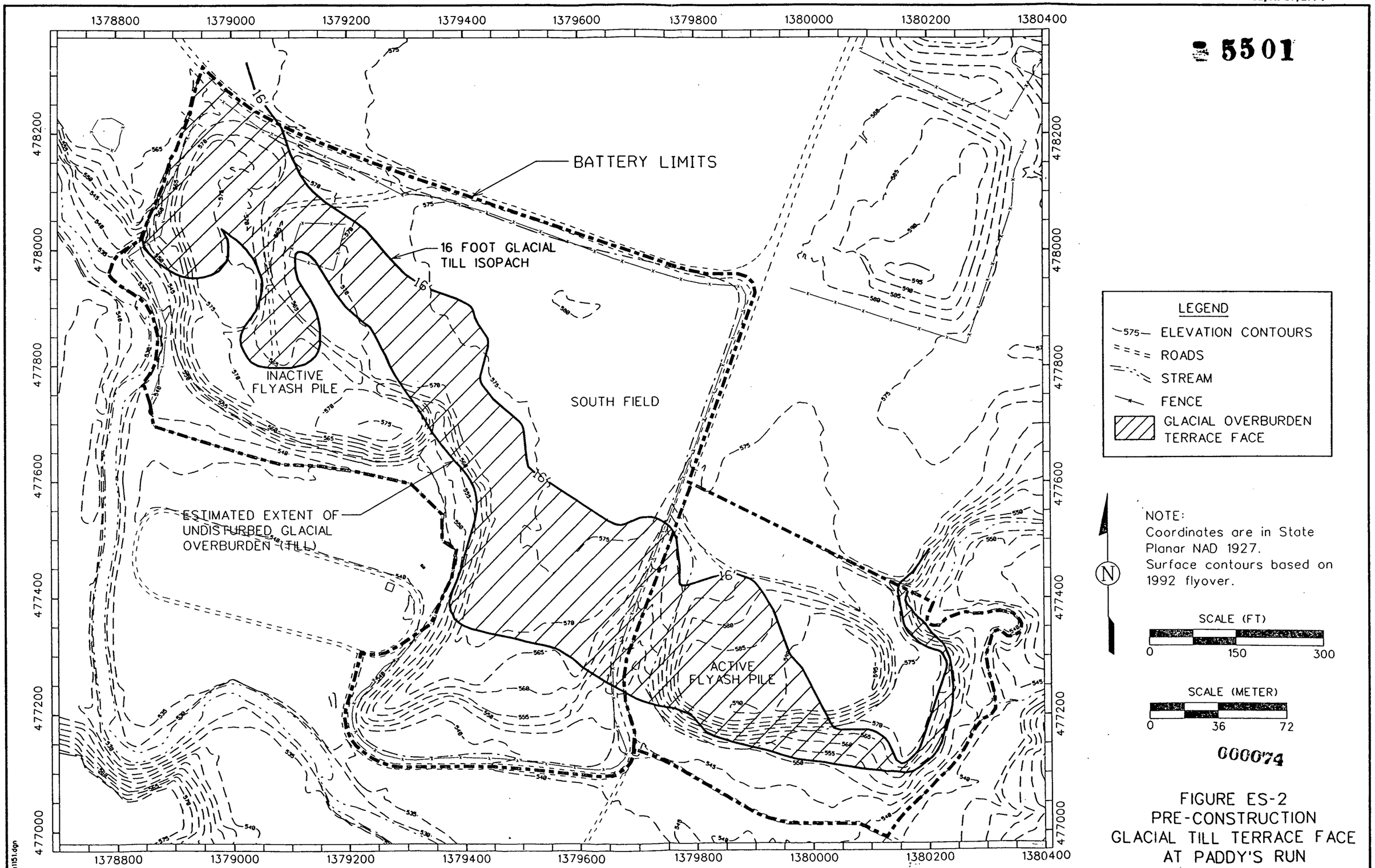

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FIGURE ES-2
PRE-CONSTRUCTION
GLACIAL TILL TERRACE FACE
AT PADDY'S RUN

An evaluation of current conditions indicates that the glacial till and unsaturated sand and gravel material of the Great Miami Aquifer are impacted by contaminants. Additionally, perched groundwater and the Great Miami Aquifer are also impacted by contaminants derived from the Inactive Flyash Pile subunit.

Source controls, in the form of vertical barriers and/or interceptor trench systems, are required to cut-off the potential horizontal pathways in the perched groundwater zone. Without these systems, the PRLs would be at or near background concentrations and the remedy would be the same as that required for private ownership.

- A physical condition that is important is the location of Paddys Run on the western edge of the Inactive Flyash Pile. Additionally, a significant portion of the Inactive Flyash Pile is located within the 100-year floodplain.

- <u>South Field</u>

  The geology of the South Field is dominated by a pre-existing terrace (valley slope) which generally parallels Paddys Run (see Figure ES-2). The upland portion of the South Field is underlain by glacial till with a maximum thickness of 6.7 m (22 ft) in the northeastern portion of the subunit. The thickness of the glacial till decreases towards the western edge of the South Field to approximately 2.4 to 3.0 m (8 to 10 ft) thick. To the south, the glacial till thickness decreases to 0 m in thickness at the toe of the terrace. Thereafter, fill material is deposited directly on the unsaturated sand and gravel of the Great Miami Aquifer.

  The glacial till has generally been impacted by uranium-238 to depths of 0.6 meter (2 ft) to 1.2 m (4 ft). The uranium-238 concentration in the remainder of the till is at or near the background concentration. Additionally, the unsaturated sand and gravel material of the Great Miami Aquifer have been adversely impacted in the southern part of the subunit.

  A direct vertical pathway exists for constituents to migrate to the Great Miami Aquifer from overlying fill. Additionally, due to the occurrence of an interbedded sand and gravel layer in the glacial till which is less than 1.0 m (3.2 ft) thick, there is a horizontal

pathway which exits along the Paddys Run terrace face. Upon exit, the constituents travel down the terrace face and vertically into the Great Miami Aquifer. This perched groundwater zone is also impacted by constituents from the South Field.

Source controls, in the form of vertical barriers and subsurface drains are required to cutoff the potential horizontal pathways in the perched groundwater zone. Without these systems, the PRLs would be at or near background concentrations and the remedy would be the same as that required for private ownership.

The primary physical condition that impacts remediation is the 100-year floodplain in which the southern portion of the South Field is located.

- Active Flyash Pile

The Active Flyash Pile is founded on a pre-existing terrace (valley slope) formed by stream erosion from Paddys Run and its eastern distributary (see Figure ES-2). The upland portion is underlain by 4.9 to 5.5 m (16 to 18 ft) of glacial till, with the southernmost portion founded on the unsaturated sand and gravel material of the Great Miami Aquifer. The subsoil beneath the flyash has been COC-impacted 0.3 to 0.6 m (1 to 2 ft). The COC-concentrations in the remainder of the glacial till are at or near background.

Currently, most of the leachate from the flyash has a direct pathway down the surface of the old terrace directly into the Great Miami Aquifer. Similar to the Inactive Flyash Pile and South Field, there is a permeable zone within the glacial till which is a potential horizontal pathway which exits along the old terrace face.

Source controls, in the form of vertical barriers and/or interceptor trench systems, are required to cut-off the potential horizontal pathways in the perched groundwater zone. Without these systems, the PRLs would be at or near background concentrations and the remedy would be the same as that required for private ownership.

Physical conditions that are important include the pre-existing terrace and the drainage course near the eastern boundary of the Active Flyash Pile.

Detailed and Comparative Analysis

The objectives of the detailed/comparative analysis are: (1) to further define the reasonable alternatives that have been carried forward from the alterative screening phase of the CERCLA process; (2) to individually assess each alternative against the evaluation criteria as specified in the NCP (40 CFR 300.430); and (3) to 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.

Alternatives identified for detailed analysis are listed below:

Solid Waste Landfill

- Alternative 1 -- No Action

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

- Alternative 2 -- Off-Site Disposal

  - Under this alternative, all waste and contaminated soil would be removed and disposed off-site. The Nevada Test Site was selected as a representative disposal site.

- Alternative 3 -- On-Site Disposal

  - Under this alternative, waste and contaminated soil would be removed and placed in an engineered disposal cell at the Fernald Site.

- Alternative 4 -- Consolidation/Containment

  - Under this alternative, waste and contaminated soil would be consolidated within the battery limits and isolated by an infiltration-limiting multimedia cap over the landfill area.

Lime Sludge Ponds

- Alternative 1 -- No-Action

  - Under this alternative, no further action would be taken. The No-Action Alternative was retained to provide a baseline for comparison in accordance with the NCP.

- Alternative 2 -- Off-Site Disposal

  - Under this alternative, all waste and contaminated soil would be removed and disposed off-site. The Nevada Test Site was selected as a representative disposal site.

- Alternative 3 -- On-Site Disposal

  - Under this alternative, waste and contaminated soil would be removed and placed in an engineered disposal cell at the Fernald Site.

- Alternative 4 -- In-Situ Containment

  - Under this alternative, waste would be isolated by an infiltration-limiting multimedia cap over the lime sludge ponds.

- Alternative 5 -- On-Site Disposal with Lime Sludge Stabilization

  - Under this alternative, all waste and contaminated soil would be removed and placed in an engineered disposal cell at the Fernald Site. The lime-sludge would be mixed with flyash from other Operable Unit 2 subunits prior to final disposal.

Inactive Flyash Pile

- Alternative 1 -- No Action

  - Under this alternative, no further action would be taken. The No-Action Alternative was retained to provide a baseline for comparison in accordance with the NCP.

- Alternative 2 -- Off-Site Disposal

  - Under this alternative, all waste and contaminated soil would be removed and disposed off-site. The Nevada Test Site was selected as a representative disposal site.

- Alternative 3 -- On-Site Disposal

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the Inactive Flyash Pile area. Waste and contaminated soil would be removed and placed in an engineered disposal cell at the Fernald Site.

- Alternative 4 -- Vitrification and On-Site Disposal with Flyash Stabilization

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the Inactive Flyash Pile area. Flyash would be removed and stabilized by mixing with lime sludge. The stabilized waste and contaminated soil would be placed in an engineered disposal cell at the Fernald Site. Prior to disposal, the portion of contaminated soil above a uranium-238 concentration of 57 pCi/g would be vitrified.

- Alternative 5 -- Solidification and On-Site Disposal with Flyash Stabilization

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the Inactive Flyash Pile area. Flyash would be removed and stabilized by mixing with lime sludge. The stabilized waste and contaminated soil would be placed in an engineered disposal cell at the Fernald Site. Prior to disposal, the portion of contaminated soil above a uranium-238 concentration of 57 pCi/g would be solidified with cement.

- Alternative 6 -- Soil Washing and On-Site Disposal with Flyash Stabilization

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the Inactive Flyash Pile area. Flyash would be removed and stabilized by mixing with lime sludge. The stabilized waste and contaminated soil would be placed in an engineered disposal cell at the Fernald Site. The portion of contaminated soil above a uranium-238 concentration of 57 pCi/g would be treated with soil washing and disposed on site.

- Alternative 7 -- Consolidation/Containment

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the Inactive Flyash area. Waste and contaminated soil

would be consolidated over an area of thick glacial till (greater than 16 ft) and isolated by an infiltration-limiting multimedia cap.

- Alternative 8 -- On-Site Disposal with Flyash Stabilization

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the Inactive Flyash Pile area. Flyash would be removed and stabilized by mixing with lime sludge. Waste and contaminated soil would be placed, along with the treated flyash, in an engineered disposal cell at the Fernald Site.

South Field

- Alternative 1 -- No-Action

  - Under this alternative, no further action would be taken. The No-Action Alternative was retained to provide a baseline for comparison in accordance with the NCP.

- Alternative 2 -- Off-Site Disposal

  - Under this alternative, all waste and contaminated soil would be removed and disposed off-site. The Nevada Test Site was selected as a representative disposal site.

- Alternative 3 -- On-Site Disposal

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the South Field area. Waste and contaminated soil would be removed and placed in an engineered disposal cell at the Fernald Site.

- Alternative 4 -- Vitrification and On-Site Disposal

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the South Field area. Waste and contaminated soil would be placed in an engineered disposal cell at the Fernald Site. Prior to disposal, the portion of contaminated soil above a uranium-238 concentration of 57 pCi/g would be vitrified.

- Alternative 5 -- Solidification and On-Site Disposal

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the South Field area. Waste and contaminated soil would be placed in an engineered disposal cell at the Fernald Site. Prior to disposal, the portion of contaminated soil above a uranium-238 concentration of 57 pCi/g would be solidified.

- Alternative 6 -- Soil Washing and On-Site Disposal

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater. Contaminated soil with concentrations would be placed in

an engineered disposal cell at the Fernald Site. Prior to disposal, the portion of contaminated soil above a uranium-238 concentration of 57 pCi/g would be vitrified.

- Alternative 7 -- Consolidation/Containment

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the South Field area. Waste and contaminated soil would be consolidated over an area of thick glacial till (greater than 16 ft) and isolated by an infiltration-limiting multimedia cap.

Active Flyash Pile

- Alternative 1 -- No-Action

  - Under this alternative, no further action would be taken. The No-Action Alternative was retained to provide a baseline for comparison in accordance with the NCP.

- Alternative 2 -- Off-Site Disposal

  - Under this alternative, all flyash and contaminated soil would be removed and disposed off-site. The Nevada Test Site was selected as a representative disposal site.

- Alternative 3 -- On-Site Disposal

  - Under this alternative, all flyash and contaminated soil would be removed and placed in an engineered disposal cell at the Fernald Site.

- Alternative 4 -- On-Site Disposal with Flyash Stabilization

  - Under this alternative, flyash and contaminated soil would be removed and placed in an engineered disposal cell at the Fernald Site. The flyash would be stabilized by mixing with lime sludge prior to final disposal.

- Alternative 5 -- Consolidation/Containment

  - Under this alternative, vertical barriers with subsurface drains would be employed to control perched groundwater in the Active Flyash Pile area. Flyash and contaminated soil would be consolidated over an area of thick glacial till (greater than 16 ft) and isolated by an infiltration-limiting multimedia cap.

Results of Detailed and Comparative Analysis

For each subunit, the no-action alterative was carried forward into the detailed analysis as a baseline for comparison as required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The objectives of the detailed/comparative analysis are: (1) to further define the reasonable alternatives that have been carried forward from the alternative screening phase of the CERCLA

process; (2) to individually evaluate each alternative against the evaluation criteria as specified under NCP and the EPA "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988a); and (3) to compare alternatives with each other to assess the relative performance of each alternative with respect to each evaluation criterion.

Except for the no-action alternatives, all remedial alternatives for Operable Unit 2 would provide a permanent solution to the current or potential environmental impact from Operable Unit 2 subunits. Alternative 2, in all cases, assumes a future land use with private ownership and farming by on-property residents. These alternatives are the most protective. The remainder of the alternatives assume continued federal ownership with active institutional controls. Each of these alternatives attain a health-based action level set at a 10^{-6} risk and reduce exposures and risks to humans by treating the waste or isolating contaminated or treated materials from the environment at the Fernald Site. Results of the comparative analysis are summarized for each of the Operable Unit 2 subunits in Tables ES-2 through ES-6.

The cost estimates developed in the feasibility study process are order-of-magnitude estimates with an intended accuracy range of -30 to +50 percent. Estimates are considered to be order of magnitude because of the uncertainties in the information used to develop the estimates. The estimated present value costs for all alternatives are summarized in Table ES-7.

The results of the comparative analysis distinguish the relative advantages and disadvantages of each alternative so that the preferred remedial action for each subunit can be identified in the PP. Ideally, the preferred remedial alternatives will consist of those alternatives, one from each subunit, which performed best overall when evaluated against the two threshold criteria and the five balancing criteria.

In the PP, the discrete preferred remedial alternatives for each subunit may be combined into one comprehensive remedial action strategy that will effectively address the complex nature of Operable Unit 2 cleanup activities. The PP will be issued for public review and comment. The final preferred remedies for the Operable Unit 2 subunits will be determined after the public comment period for the PP and any significant new information that may become available subsequent to submittal of the FS/PP-EA to EPA. The alternatives selected for implementation will be documented in the Operable Unit 2 ROD.

TABLE ES-2

COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE SOLID WASTE LANDFILL

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment[a]	Short-Term Effectiveness[b]	Implementability	Present Worth Cost ($1,000s)
Alternative 1 - No Action	Not protective	Not applicable	Not effective -- no action taken.	No treatment	No effect -- no action taken	No implementability -- no action taken	0
Alternative 2 - Off-Site Disposal	Protective under the private ownership scenario	Complies with ARARs	Highly effective -- off-site disposal; more stringent cleanup levels are used	No treatment	Less effective -- off-site disposal would increase public risk during transport; workers and public exposed to largest volume of material	Less implementable -- subject to state and federal regulations; administratively difficult to implement due to increased coordination	146,047
Alternative 3 - On-Site Disposal	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- on-site disposal; on-site facility would provide more effectiveness than cap	No treatment	Effective -- on-site disposal, but must excavate and transport; workers exposed to more material; public exposure minimal	Implementable -- construction of on-site disposal facility; concerns with siting criteria/use of CAMU	8,172
Alternative 4 - Consolidation/ Containment	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- contaminated material contained under a cap	No treatment	Highly effective -- on-site disposal; worker and public exposure minimal	Highly implementable -- construction of cap; technically and administratively feasible	7,142

[a]Treatment of groundwater and construction water are not compared, since alternatives that treat groundwater and construction water (Alternatives 2 through 4) use the same treatment process (sedimentation and transport to the AWWT facility).

[b]Total duration of remediation.

TABLE ES-3

COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE LIME SLUDGE PONDS

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment[a]	Short-Term Effectiveness[b]	Implementability	Present Worth Cost ($1,000s)
Alternative 1 - No Action	Not protective	Not applicable	Not effective -- no action taken	No treatment	No effect -- no action taken	No implementation -- no action taken	0
Alternative 2 - Off-Site Disposal	Protective under the private ownership scenario	Complies with ARARs	Highly effective -- off-site disposal; more stringent cleanup levels are used	No treatment	Least effective -- off-site disposal would increase public risk during transport; workers and public exposed to largest volume of material	Less implementable -- subject to state and federal regulations; administratively difficult to implement due to increased coordination	55,150
Alternative 3 - On-Site Disposal	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- on-site disposal; on-site facility would provide more effectiveness than cap	No treatment	Effective -- on-site disposal, but must excavate and transport; workers exposed to more material; public exposure minimal	Implementable -- construction of on-site disposal facility; concerns with siting criteria/use of CAMU	7,785
Alternative 4 - In Situ Containment	Protective under the Federal ownership scenario	Complies with ARARs	Less effective -- contaminated material contained under a cap	No treatment	Highly effective -- waste remains in area; worker and public exposure minimal	Highly implementable -- construction of cap; technically and administratively feasible	11,445
Alternative 5 - On-Site Disposal With Lime Sludge Stabilization	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- on-site disposal; lime sludge stabilized	Stabilization -- reduces mobility of contaminants in lime sludge	Less effective -- on-site disposal, but must excavate and transport; workers exposed to more material	Implementable -- construction of on-site disposal facility; concerns with siting criteria/use of CAMU	9,235

[a]Treatment of construction water is not compared, since all alternatives that treat construction water (Alternatives 2 through 5) use the same treatment process (sedimentation and transport to the AWWT facility).

[b]Total duration of remediation

TABLE ES-4

COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE INACTIVE FLYASH PILE

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment[a]	Short-Term Effectiveness[b]	Implementability	Present Worth Cost ($1,000s)
Alternative 1 - No Action	Not protective	Not applicable	Not effective -- no action taken	No treatment	No effect -- no action taken	No implementation -- No action taken	0
Alternative 2 - Off-Site Disposal	Protective under the private ownership scenario	Complies with ARARs	Most effective -- off-site disposal; more stringent cleanup levels are used	No treatment	Effective -- off-site disposal would increase public risk during transport; workers and public exposed to largest volume of material	Implementable -- subject to state and federal regulations; administratively difficult to implement due to increased coordination	136,688
Alternative 3 - On-Site Disposal	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- on-site disposal; less effective than stabilized flyash	No treatment of contaminated material; long-term treatment of perched groundwater	More effective -- on-site disposal, but must excavate and transport; workers exposed to more material; public exposure minimal	More implementable -- construction of liner and cap; concerns with siting criteria/use of CAMU	30,102
Alternative 4 - Vitrification and On-Site Disposal with Flyash Stabilization	Protective under the Federal ownership scenario	Complies with ARARs	More effective -- on-site disposal; treatment of some contaminated material and flyash stabilization	Better treatment -- mobility and volume of contaminants reduced; long-term treatment of perched groundwater	Effective -- reduced risk to public through treatment and on-site disposal; workers exposed to more material	Implementable -- construction of on-site disposal facility; vitrification may be difficult to implement; concerns with siting criteria/use of CAMU	417,943
Alternative 5 - Solidification and On-Site Disposal with Flyash Stabilization	Protective under the Federal ownership scenario	Complies with ARARs	More effective -- on-site disposal; treatment of some contaminated material and flyash stabilization	Treatment reduces mobility of contaminants, but volume increases; long-term treatment of perched groundwater	Effective -- reduced risk to public through treatment and on-site disposal; workers exposed to more material	Implementable -- construction of on-site disposal facility; solidification most implementable treatment; concerns with siting criteria/use of CAMU	35,492

See footnotes at end of table

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TABLE ES-4
(Continued)

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment[a]	Short-Term Effectiveness[b]	Implementability	Present Worth Cost ($1,000s)
Alternative 6 - Soil Washing and On-Site Disposal with Flyash Stabilization	Protective under the Federal ownership scenario	Complies with ARARs	More effective -- on-site disposal; treatment of some contaminated material and flyash stabilization	Best treatment -- Reduces volume of contaminated material requiring disposal; long-term treatment of perched groundwater	Effective -- reduced risk to public through treatment and on-site disposal; workers exposed to more material	Least implementable -- construction of on-site disposal facility; soil washing most difficult treatment; concerns with siting criteria/use of CAMU	38,737
Alternative 7 - Consolidation/ Containment	Protective under the Federal ownership scenario	Complies with ARARs	Least effective -- in situ containment less effective than disposal facility; groundwater extraction required for longest duration	No treatment of contaminated material; long-term treatment of perched groundwater	Most effective -- waste excavated and consolidated in area; public exposure minimal	Most implementable -- construction of cap; technically and administratively feasible	20,420
Alternative 8 - On-Site Disposal with Flyash Stabilization	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- on-site disposal; flyash stabilization	Treatment reduces mobility of contaminants; long-term treatment of perched groundwater	More effective -- on-site disposal, but must excavate and transport; workers exposed to more material; public exposure minimal	More implementable -- construction of on-site disposal facility; would be more implementable without treatment; concerns with siting criteria/use of CAMU	35,693

[a]Treatment of construction water is not compared, since all alternatives that treat construction water (Alternatives 2 through 8) use the same treatment process (sedimentation and transport to the AWWT facility).

[b]Total duration of remediation

TABLE ES-5

COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE SOUTH FIELD

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment[a,b]	Short-Term Effectiveness[c]	Implementability	Present Worth Cost ($1,000s)
Alternative 1 - No Action	Not Protective	Not applicable	Not effective - no action taken	No treatment	No effect -- no action taken	No implementation --no action taken	0
Alternative 2 - Off-Site Disposal	Protective under the private ownership scenario	Complies with ARARs	Most effective -- off-site disposal; more stringent cleanup levels are used	No treatment	Effective -- off-site disposal would increase public risk during transport; workers and public exposed to largest volume of material	Implementable -- subject to state and federal regulations; administratively difficult to implement due to increased coordination	288,190
Alternative 3 - On-Site Disposal	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- on-site disposal; less effective than treatment prior to disposal	No treatment of contaminated material; long-term treatment of perched groundwater	More effective -- on-site disposal, but must excavate and transport; workers exposed to more material; public exposure minimal	More implementable -- construction of liner and cap; concerns with siting criteria/use of CAMU	23,900
Alternative 4 - Vitrification and On-Site Disposal	Protective under the Federal ownership scenario	Complies with ARARs	More effective -- on-site disposal; treatment of some contaminated material	Better treatment -- mobility and volume of contaminants reduced; long-term treatment of perched groundwater	Effective -- reduced risk to public through treatment and on-site disposal; workers exposed to more material	Implementable -- construction of on-site disposal facility; vitrification may be difficult to implement; concerns with siting criteria/use of CAMU	212,956

See footnotes at end of table

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TABLE ES-5
(Continued)

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment[a,b]	Short-Term Effectiveness[c]	Implementability	Present Worth Cost ($1,000s)
Alternative 5 - Solidification and On-Site Disposal	Protective under the Federal ownership scenario	Complies with ARARs	More effective -- on-site disposal; treatment of some contaminated material	Treatment reduces mobility of contaminants, but volume increases; long-term treatment of perched groundwater	Effective -- reduced risk to public through treatment and on-site disposal; workers exposed to more material	Implementable -- construction of on-site disposal facility; solidification most implementable treatment; concerns with siting criteria/use of CAMU	24,487
Alternative 6 - Soil Washing and On-Site Disposal	Protective under the Federal ownership scenario	Complies with ARARs	Effective -- on-site disposal; treatment of some contaminated material; soil washing potentially more effective than other treatment	Best treatment -- Reduces volume of contaminated material requiring disposal; long-term treatment of perched groundwater	Effective -- reduced risk to public through treatment and on-site disposal; workers exposed to more material	Least implementable -- construction of on-site disposal facility; soil washing most difficult treatment; concerns with siting criteria/use of CAMU	25,506
Alternative 7 - Consolidation/ Containment	Protective under the Federal ownership scenario	Compiles with ARARs	Least effective -- in situ containment less effective than disposal facility; groundwater extraction required for longest duration	No treatment of contaminated material; long-term treatment of perched groundwater	Most effective -- waste excavated and consolidated in area; public exposure minimal	Most implementable -- construction of cap; technically and administratively feasible	11,271

[a]Treatment of groundwater is not compared, since all alternatives that treat groundwater (Alternatives 3, 4, 5, 6, and 7) use the same treatment process (sedimentation and transport to the AWWT facility).

[b]Treatment of construction water is not compared, since all alternatives that treat construction water (alternatives 2 through 7) use the same treatment process (sedimentation and transport to the AWWT facility).

[c]Total duration of remediation.

TABLE ES-6

COMPARATIVE ANALYSIS OF ALTERNATIVES FOR THE ACTIVE FLYASH PILE

Alternatives	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment[a]	Short-Term Effectiveness[b]	Implementability	Present Worth Cost ($1,000s)
Alternative 1 - No Action	Not protective	Not applicable	Not effective -- no action taken	No treatment	No effect -- no action taken	No implementation --no action required	0
Alternative 2 - Off-Site Disposal	Protective under private ownership scenario	Complies with ARARs	Highly effective -- off-site disposal; more stringent cleanup levels are used	No treatment	Less effective -- off-site disposal would increase public risk during transport; workers and public exposed to largest volume of material	Less implementable -- subject to state and federal regulations; administratively difficult to implement due to increased coordination	76,218
Alternative 3 - On-Site Disposal	Protective under Federal ownership scenario	Complies with ARARs	Effective -- on-site excavation and disposal	No treatment	Effective -- on-site disposal, but must excavate and transport; workers exposed to more material; public exposure minimal	More implementable -- construction of on-site disposal facility; concerns with siting criteria/use of CAMU	17,464
Alternative 4 - On-Site Disposal with Flyash Stabilization	Protective under Federal ownership scenario	Complies with ARARs	Highly effective -- on-site disposal; flyash stabilized	Stabilization -- reduces mobility of contaminants in flyash	Effective -- reduced risk to public through treatment and on-site disposal; workers exposed to more material	Implementable -- construction of on-site disposal facility; stabilization of flyash; concerns with siting criteria/use of CAMU	21,142
Alternative 5 - Consolidation/ Containment	Protective under Federal ownership scenario	Complies with ARARs	Effective -- contaminated material contained under a cap	No treatment of contaminated material; long-term treatment of perched groundwater	Highly effective -- waste remains in area; worker and public exposure minimal	Most implementable -- construction of cap; technically and administratively feasible	14,152

[a]Treatment of construction water is not compared, since all alternatives that treat construction water use the same treatment process (sedimentation and transport to the AWWT facility).

[b]Total duration of remediation.

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TABLE ES-7

OPERABLE UNIT 2 SUBUNITS
SUMMARY OF PRESENT WORTH COSTS

ALTERNATIVE	PRESENT WORTH COSTS		NET	YEAR	YEARS	YEARS	5-YEAR
	CAPITAL	O&M		1	2-5	6-30	REVIEW
SOLID WASTE LANDFILL							
Alternative 1	$0	$0	$0	$0	$0	$0	$0
Alternative 2	$146,046,600	$0	$146,046,600	$0	$0	$0	$0
Alternative 3	$6,768,800	$1,403,600	$8,172,200	$138,939	$117,510	$69,110	$5,924
Alternative 4	$4,982,700	$2,159,600	$7,141,700	$189,937	$189,937	$101,937	$24,400
LIME SLUDGE PONDS							
Alternative 1	$0	$0	$0	$0	$0	$0	$0
Alternative 2	$55,149,900	$0	$55,149,900	$0	$0	$0	$0
Alternative 3	$6,302,300	$1,483,400	$7,785,400	$138,939	$117,510	$69,110	$5,924
Alternative 4	$9,054,900	$2,389,800	$11,444,500	$195,905	$195,905	$107,905	$24,400
Alternative 5	$7,751,600	$1,483,400	$9,234,600	$138,939	$117,510	$69,110	$5,924
INACTIVE FLYASH PILE							
Alternative 1	$0	$0	$0	$0	$0	$0	$0
Alternative 2	$136,687,600	$0	$136,687,600	$0	$0	$0	$0
Alternative 3	$28,698,600	$1,403,600	$30,102,100	$138,939	$117,510	$69,110	$5,924
Alternative 4	$416,539,400	$1,403,600	$417,942,800	$138,939	$117,510	$69,110	$5,924
Alternative 5	$34,044,300	$1,447,800	$35,491,500	$172,119	$118,545	$70,145	$5,924
Alternative 6	$37,333,100	$1,403,600	$38,736,500	$138,939	$117,510	$69,110	$5,924
Alternative 7	$17,896,500	$2,522,500	$20,419,700	$253,728	$200,154	$123,154	$24,400
Alternative 8	$34,289,700	$1,403,600	$35,693,000	$138,939	$117,510	$69,110	$5,924

TABLE ES-7
(Continued)

ALTERNATIVE	PRESENT WORTH COSTS		NET	YEAR	YEARS	YEARS	5-YEAR
	CAPITAL	O&M		1	2-5	6-30	REVIEW
SOUTH FIELD							
Alternative 1	$0	$0	$0	$0	$0	$0	$0
Alternative 2	$288,190,400	$0	$288,190,400	$0	$0	$0	$0
Alternative 3	$20,769,000	$3,130,400	$23,899,700	$264,300	$242,871	$150,471	$5,924
Alternative 4	$209,824,700	$3,130,400	$212,955,500	$264,300	$242,871	$150,471	$5,924
Alternative 5	$21,356,300	$3,130,400	$24,487,200	$264,300	$242,871	$150,471	$5,924
Alternative 6	$22,375,400	$3,130,400	$25,506,200	$264,300	$242,871	$150,471	$5,924
Alternative 7	$10,008,900	$1,262,400	$11,270,500	$133,414	$79,841	$57,841	$24,400
ACTIVE FLYASH PILE							
Alternative 1	$0	$0	$0	$0	$0	$0	$0
Alternative 2	$76,217,800	$0	$76,217,800	$0	$0	$0	$0
Alternative 3	$16,021,200	$1,443,000	$17,464,000	$138,939	$117,510	$69,110	$5,924
Alternative 4	$19,699,500	$1,443,000	$21,142,200	$138,939	$117,510	$69,110	$5,924
Alternative 5	$11,763,000	$2,388,700	$14,151,700	$182,593	$182,593	$116,593	$24,400

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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 both 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.

On the basis of 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 the expedient completion of cleanup actions at the FEMP site.

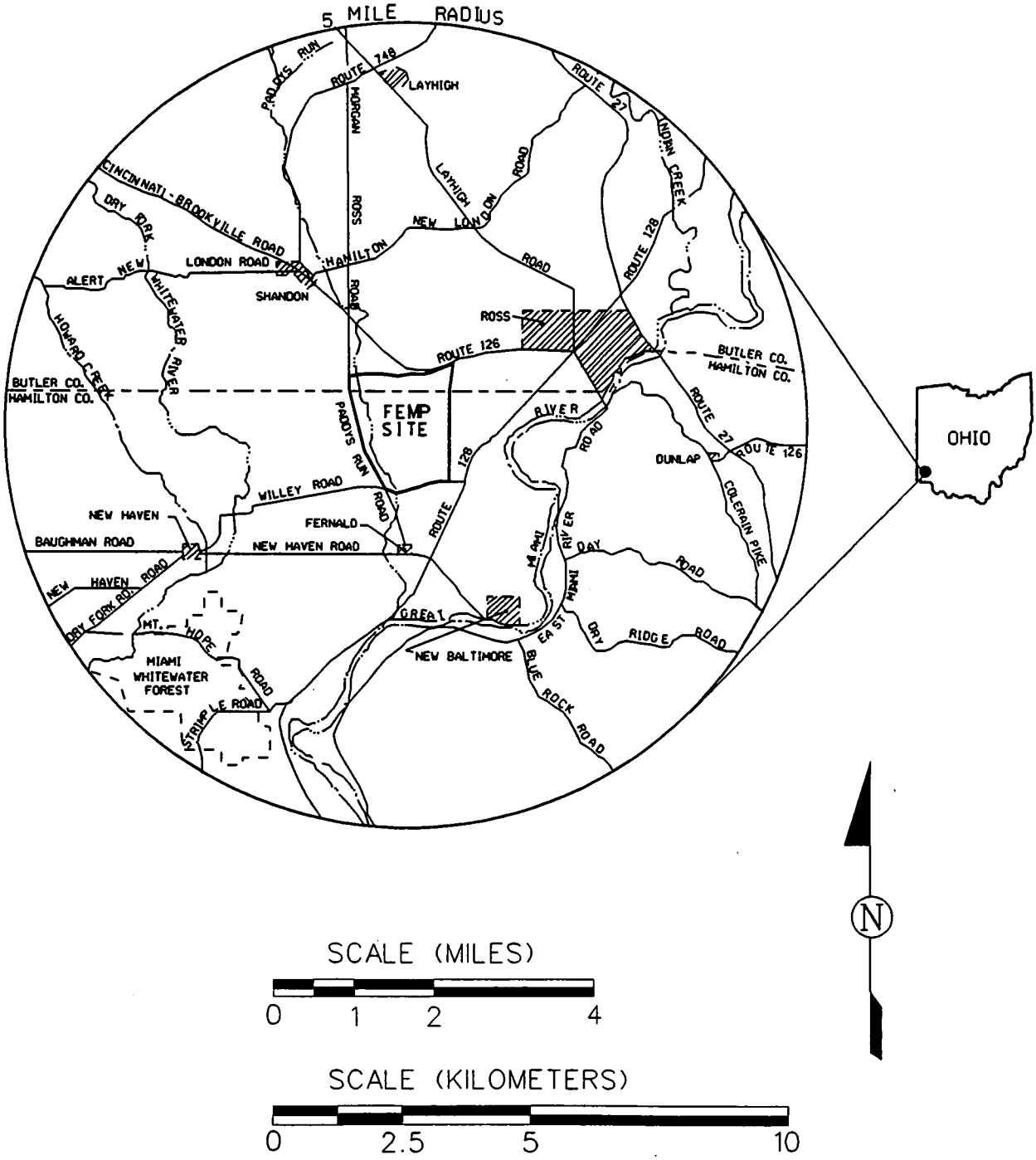

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FIGURE 1-1
FEMP FACILITY LOCATION MAP

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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 can be used to divide up the cleanup of a site and may be geographical specific site programs, initial phases of an action or concurrent actions at different locations of the site. Separate RI/FS documentation is being issued for each operable unit 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 are protective of human health and the environment.

Operable Unit 2 is one of six operable units at the FEMP and consists of waste subunits with relatively large volumes of conventional industrial wastes that were assumed to have small amounts of radionuclides. Operable Unit 2, referred to as Other Waste Units, consists of five subunits located in several locations at the FEMP. The subunits consist of:

- Solid Waste Landfill
- Lime Sludge Ponds

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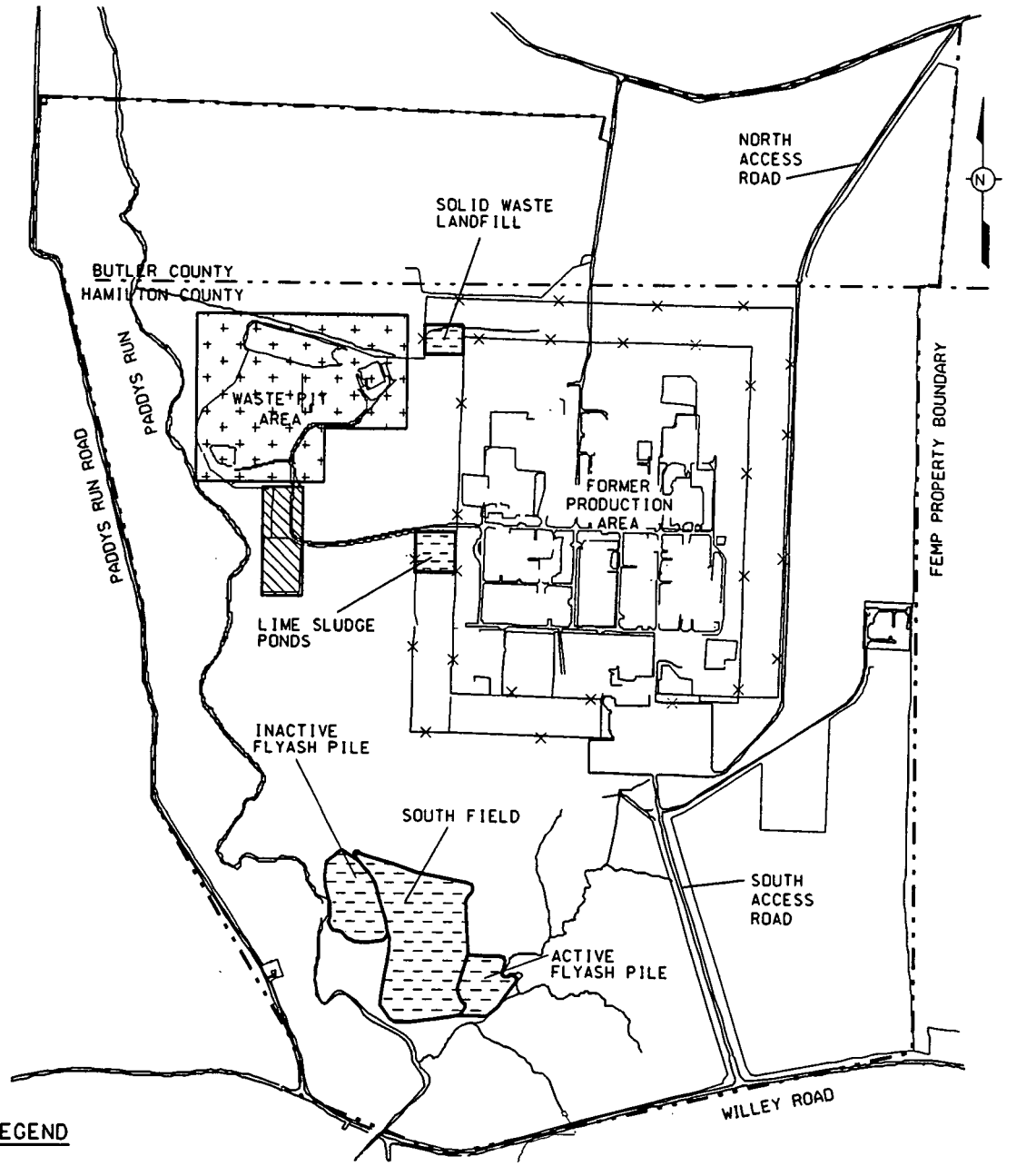

LEGEND

- 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

- Inactive Flyash Pile
- South Field
- Active Flyash Pile

The locations of these subunits are also shown on Figure 1-2.

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 October 1988a). The NCP states in part that:

- The primary objective of the Feasibility Study (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.

An evaluation of residual risks at the FEMP is mandated by the 1991 Amended Consent Agreement, which requires that each operable unit's FS include a Comprehensive Response Action Risk Evaluation (CRARE). The CRARE for each operable unit must include consideration of the following:

- Anticipated use of the FEMP property immediately after implementation of the response actions

- Future use scenarios

An additional purpose of the FS is to provide National Environmental Policy Act (NEPA) analyses of environmental impacts of the remedial alternatives. Summarized information on the affected environment at Operable Unit 2 is provided in Section 1.5 of this FS. This approach is in accordance with DOE's intent to integrate the requirements of NEPA and CERCLA 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.

1.1.2 Objectives of Feasibility Study

The FS/PP-Environmental Assessment (EA) report for Operable Unit 2 will contain characterization data for the specific subunit and nearby environmental media and will support the description of the affected environment for NEPA purposes. The NEPA evaluation will be contained within the detailed analysis of remedial alternatives for each particular 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; as well as 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.

In addition, the Operable Unit 2 FS/PP-EA has been written to incorporate evaluation of the cumulative environmental consequences, consistent with NEPA guidelines, of implementing the Operable Unit 2 Representative Alternative, or leading remedial alternative with the other leading remedial alternatives (or preferred alternatives) for each of the other FEMP operable units (Appendix G). 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-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. 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 and other remaining operable units for CERCLA purposes. At the completion of the EA process for Operable Unit 2, a determination will be made as to whether an EIS is necessary or that the proposed action would have no significant impacts resulting 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 nation-wide programmatic EIS for environmental restoration and waste management. The document is expected to be issued as a draft for public comment. All proposed remedial actions at the FEMP site are considered to qualify as interim actions for the programmatic EIS 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 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 the 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 has established a formalized risk assessment process. Under this process, several hypothetical scenarios are examined that could expose members of the public to site contamination. One of these scenarios assumes that site access is not controlled, and a member of the public could be exposed to site contaminants. Results of the risk assessment performed for this hypothetical scenario, which assumes a loss of access controls, indicate that if an individual were to enter the site and establish a residence within Operable Unit 2 under existing conditions, that individual could incur adverse health effects.

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 FS 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. The

FS Report 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 FS Report is organized as follows:

- 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 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 on available cost information, regulatory requirements, and the CRARE. The appendices are listed 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 EPA 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 performs 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 applicable or relevant and appropriate requirements (ARARs). The following paragraphs describe 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 (DOE 1987a), a RCRA Assessment Monitoring Plan for groundwater (DOE 1987b), and RCRA Part A (DOE 1984) and B (DOE 1985) 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 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 and 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 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.

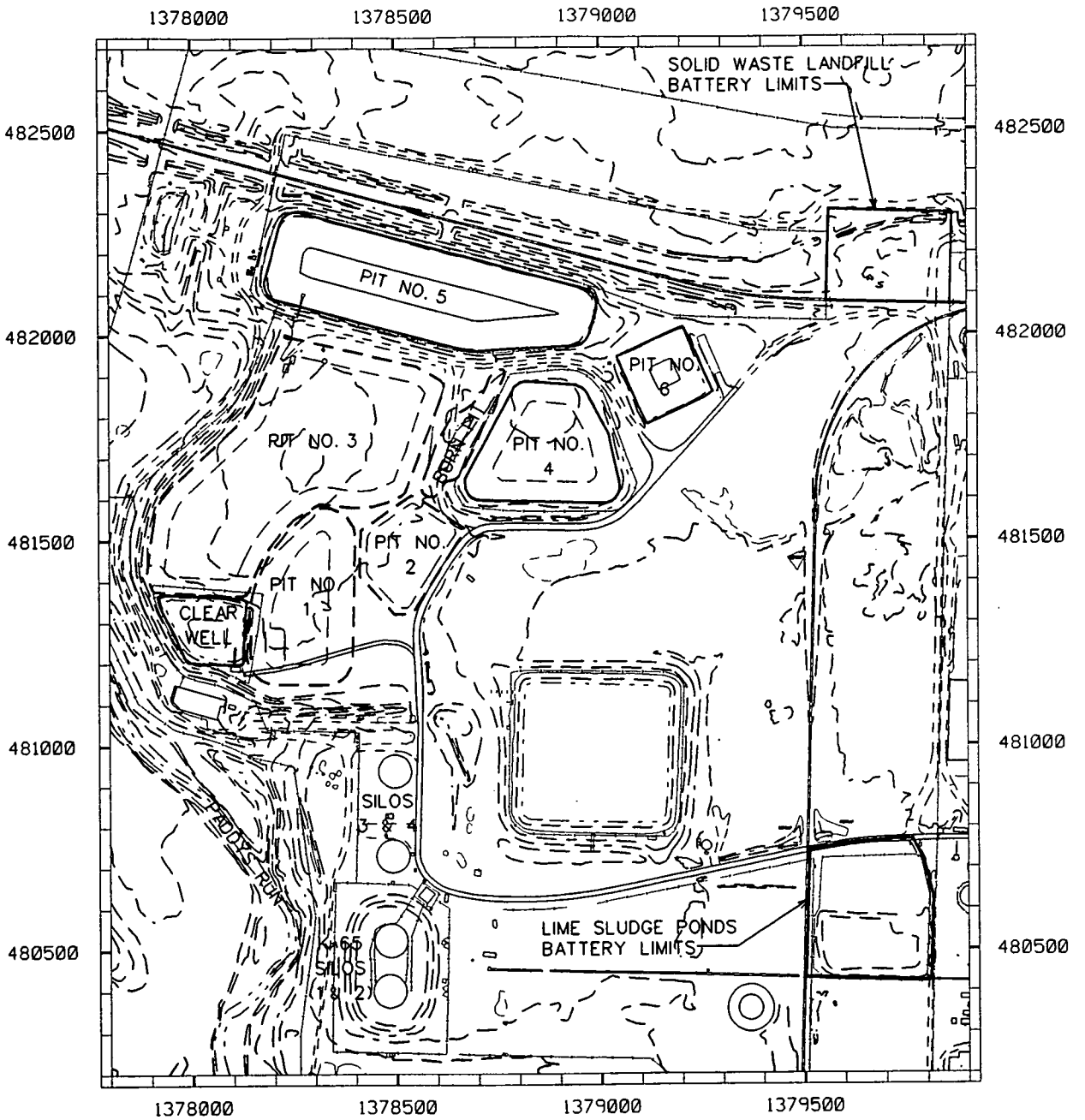
In December 1990, amendments were proposed to update the Consent Decree with regard to new agreements between the EPA and the DOE and to resolve compliance issues raised by the OEPA. The Stipulated Amended Consent Decree was signed on January 22, 1993.

1.4 DESCRIPTION AND HISTORY OF THE FEMP

The Atomic Energy Commission (AEC), predecessor to the U.S. Energy Research and Development Administration (ERDA) and now 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.



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

000104

FIGURE 1-3
WASTE STORAGE AREA

fs0103.dgn

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 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 defined as 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 illustrated 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

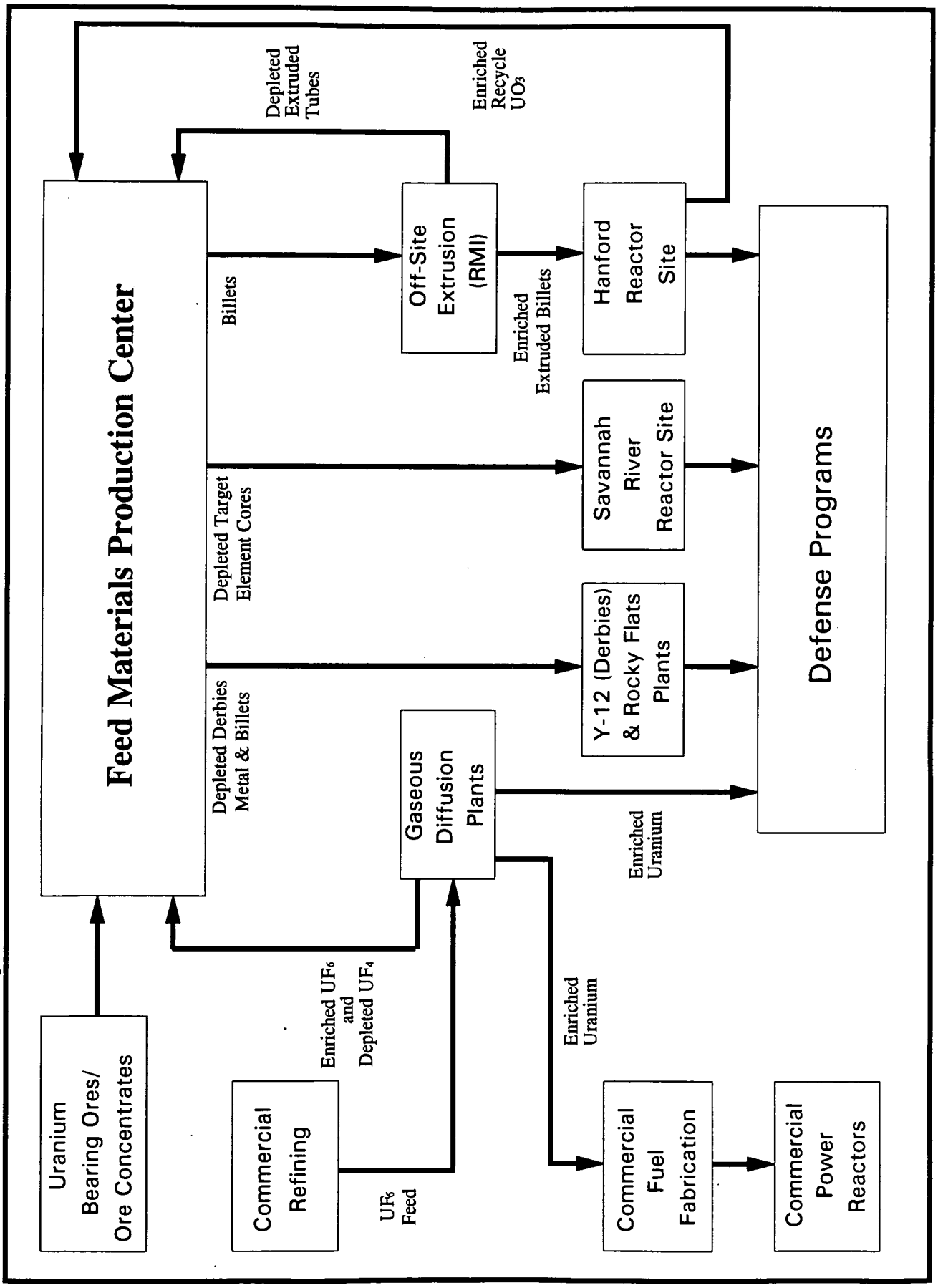
a closed refractory-lined steel pot. The resulting product was a 300 to 375 pound piece of pure uranium metal and a by-product, magnesium fluoride slag. The uranium metal had the shape of a gentleman's top hat, or derby.

Some of the derbies were shipped directly to the Y-12 and Rocky Flats Plant. 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, then shipped to Rocky Flats.

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.

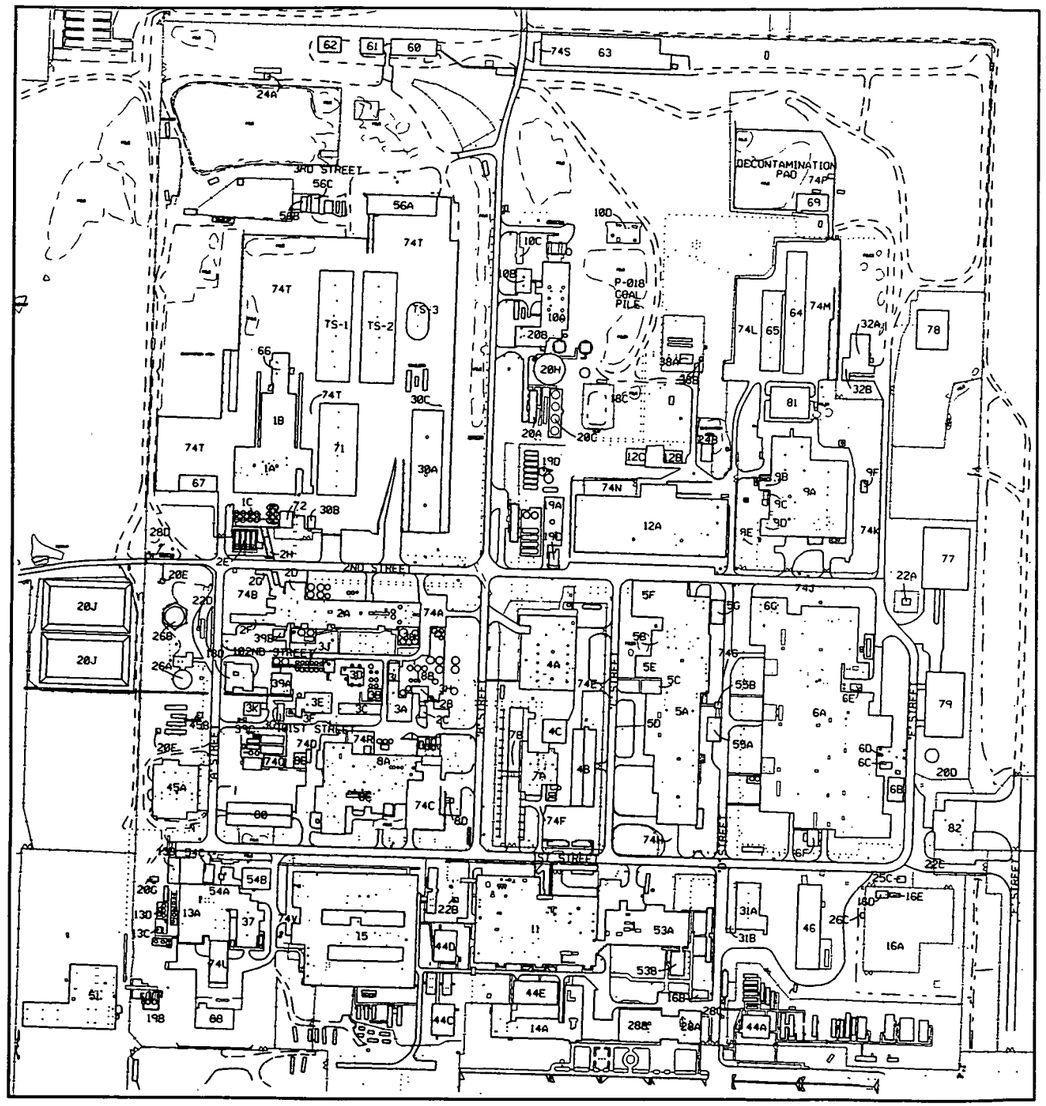
Production at the FMPC peaked in 1960 at approximately 12,000 metric tons of uranium per year. A product decline began in 1964 and reached a low in 1975 of about 1,230 metric tons. During the 1970s, consideration was given to closing the FMPC. Thus, capital improvements and staffing were reduced. The 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.



FER\CRU2FS\SECTION1\FIG1-4\April 15, 1994

FIGURE 1-4. FMPC RELATIONSHIP TO DEFENSE PROGRAMS

5501



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
18A BDN SURGE LAGOON
18B GENERAL SUMP
18C COAL PILE RUNOFF BASIN
18D BIODENITRIFICATION TOWERS
18E STORM WATER RETENTION BASINS
18F PIT #5 SLUICE GATE
18G CLEARWELL PUMP HOUSE
18H BDN EFFLUENT TREATMENT FACILITY
18J METHANOL TANK
18K LOW NITRATE TANK
18L HIGH NITRATE TANK
18M HIGH NITRATE STORAGE TANK
18N WASTE PIT AREA STORM WATER RUNOFF CONTROL
18P DISSOLVED OXYGEN BLDG.
18Q IAWWT VALVE HOUSE
19A MAIN TANK FARM
19B PILOT PLANT AMMONIA TANK FARM
19C TANK FARM CONTROL HOUSE
19D OLD NORTH TANK FARM
19E TANK FARM LIME SLITTER BLDG.
20A PUMP STATION & POWER CENTER
20B WATER PLANT
20C COOLING TOWERS
20D ELEVATED POTABLE STORAGE TANK
20E WELL HOUSE #1
20F WELL HOUSE #2
20G WELL HOUSE #3
20H PROCESS WATER STORAGE TANK
20J LIME SLURRY PITS
22A GAS METER BLDG.
22B STORM SEWER LIFT STATION
22C TRUCK SCALE
22D SCALE HOUSE & WEIGH SCALE
22E UTILITY TRENCH TO PIT AREA
23 METEOROLOGICAL TOWER
24A RAILROAD SCALE HOUSE
24B RAILROAD ENGINE HOUSE
25A CHLORINATION BLDG.
25B M.H. #173/EFF. LIME/SAMPLING BLDG.
25C SEWAGE LIFT STATION BLDG.
25D U.V. DISINFECTION BLDG.
25E DIGESTER & CONTROL BLDG.
25F SLUDGE DRYING BEDS
25G PRIMARY SETTLING BASINS
25H TRICKLING FILTERS
25J 10 PLEXS SEWAGE LIFT STATION
26A PUMP HOUSE-HP FIRE PROTECTION
26B ELEVATED WATER STORAGE TANK
26C MAIN ELECTRICAL STRAINER HOUSE
28A SECURITY BLDG.
28B HUMAN RESOURCES BLDG.
28C GUARD POST ON SOUTH END OF "D" STR.
28D GUARD POST ON WEST END OF "2ND" STR.
30A CHEMICAL WAREHOUSE
30B DRUM STORAGE WAREHOUSE
30C OLD TEN TON SCALE
31A ENGINE HOUSE/GARAGE
31B OLD TRUCK SCALE
32A MAGNESIUM STORAGE BLDG.
32B BLDG. 32 COVERED LOADING DOCK
34A K-65 STORAGE TANK (NORTH)
34B K-65 STORAGE TANK (SOUTH)
34C RTS BLDG.
35A METAL OXIDE STORAGE TANK (NORTH)
35B METAL OXIDE STORAGE TANK (SOUTH)
37 PILOT PLANT ANNEX
38A PROPANE STORAGE
38B CYLINDER FILLING STATION
39A INCINERATOR BLDG.
39B WASTE OIL DECANT SHELTER
39C INCINERATOR SPRINKLER RISER HOUSE
39D SEWAGE TREATMENT PLANT INCINERATOR
44A TRAILER COMPLEX (6-PLEX)
44C TRAILER COMPLEX (7-PLEX S.)
44D TRAILER COMPLEX (7-PLEX N.)
44E TRAILER COMPLEX (10 PLEX)
45A RUST ENGINEERING BLDG.
45B UTILITY SHED EAST OF RUST TRAILERS
46 HEAVY EQUIPMENT BLDG.
51 SIX TO FOUR REDUCTION FACILITY #2
53A HEALTH & SAFETY BLDG.
53B IN-VIVO BLDG.
54A SIX TO FOUR REDUCTION FACILITY #1
54B PILOT PLANT SHELTER
54C PILOT PLANT DISSOCIATOR SHELTER
55A SLAG RECYCLING BLDG.
55B SLAG RECYCLING PIT/ELEVATOR
56A CP STORAGE WAREHOUSE
56B STORAGE SHED (WEST)
56C STORAGE SHED (EAST)
60 QUONSET HUT #1
61 QUONSET HUT #2
62 QUONSET HUT #3
63 KC-2 WAREHOUSE
64 THORIUM WAREHOUSE
65 (OLD) PLANT 3 WAREHOUSE
66 DRUM RECONDITIONING BLDG.
67 PLANT 1 THORIUM WAREHOUSE
68 PILOT PLANT WAREHOUSE
69 DECONTAMINATION BLDG.
71 GENERAL IN-PROCESS WAREHOUSE
72 DRUM STORAGE BUILDING
73A FIRE BRIGADE TRAINING CENTER BLDG.
73B FIRE TRAINING POND
73C FIRE TRAINING TANK
73D FIRE TRAINING BURN TROUGH
73E CONFINED SPACE BURN TANK
74A PLANT 2 EAST PAD
74B PLANT 2 WEST PAD
74C PLANT 8 EAST PAD
74D PLANT 8 WEST PAD
74E PLANT 4 PAD
74F PLANT 7 PAD
74G PLANT 5 EAST PAD
74H PLANT 5 SOUTH PAD
74J PLANT 6 PADS
74K PLANT 9 PAD
74L BUILDING 65 WEST PAD
74M BUILDING 64 EAST PAD & R.R. DOCK
74N BUILDING 12 NORTH PAD
74P DECONTAMINATION PAD
74Q PLANT 8 OLD METAL DISSOLVER PAD
74R PLANT 8 NORTH PAD
74S BUILDING 63 WEST PAD
74T PLANT 1 STORAGE PAD
74U PILOT PLANT PAD
74V LABORATORY PAD
74W INCINERATOR BLDG. PAD
77 FINISHED PRODUCTS WAREHOUSE (4A)
78 D & D BUILDING
79 PLANT 6 WAREHOUSE
80 PLANT 8 WAREHOUSE
81 PLANT 9 WAREHOUSE
82 RECEIVING/INCOMING MAT'LS. INSP.
88 CLEARWELL LINE
89 PARKING LOTS
T76 INTERIM OFFICE SPACE
T77 INTERIM OFFICE SPACE
T80 INTERIM OFFICE SPACE
T81 INTERIM OFFICE SPACE

LEGEND

==== ROADS

N

SCALE (FEET)
0 200 400 800

SCALE (METER)
0 48 96 192

FIGURE 1-5
FORMER PRODUCTION AREA LAYOUT

fa0105.dgn

000108

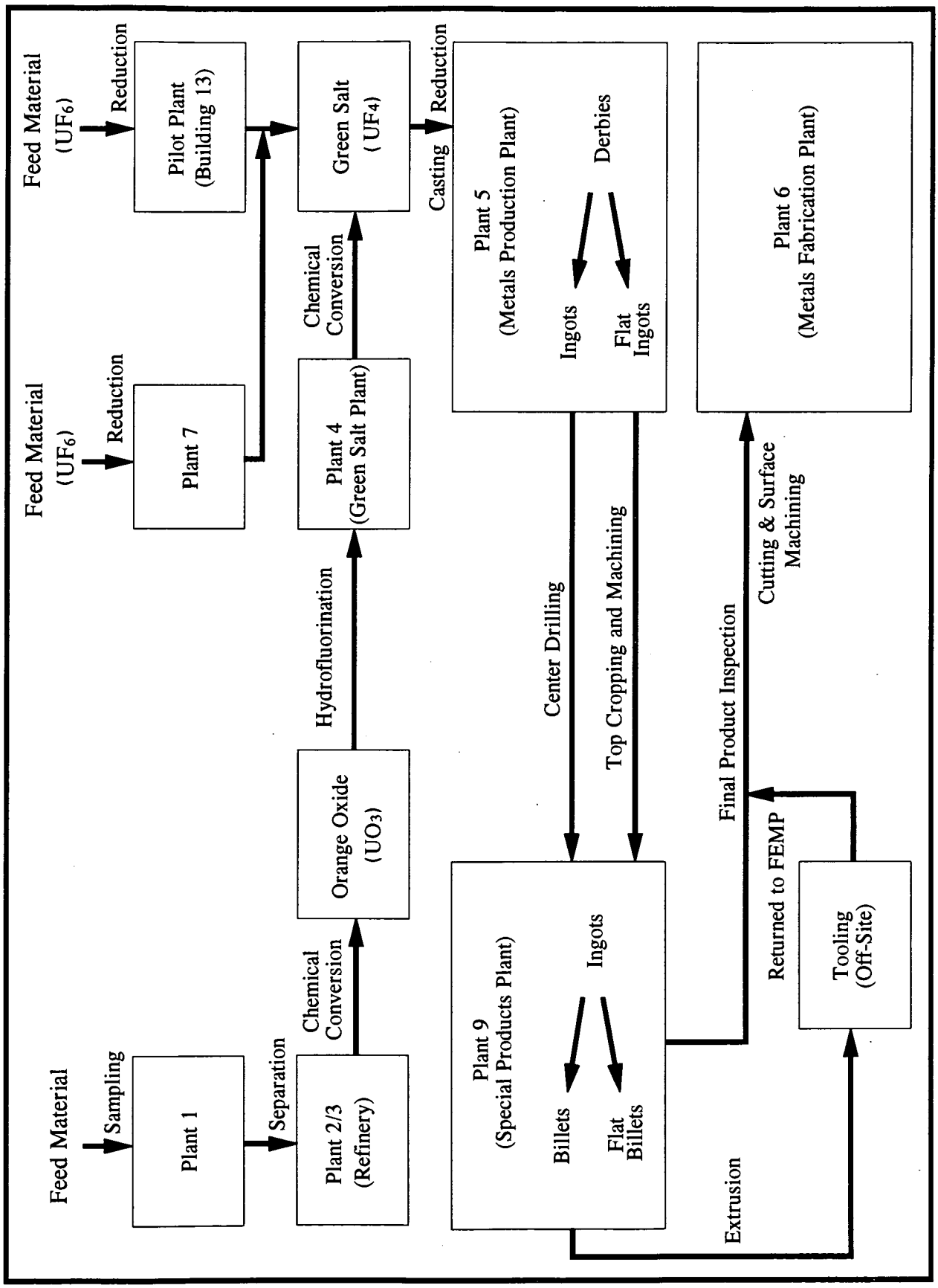


FIGURE 1-6 FEMP URANIUM METAL PRODUCTION PROCESS FLOW DIAGRAM

FER\CRU2FS\Section1\FIG1-6\April 15, 1994

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 to the 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 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 (SWCR) (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.

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 but 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, 1982] 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).

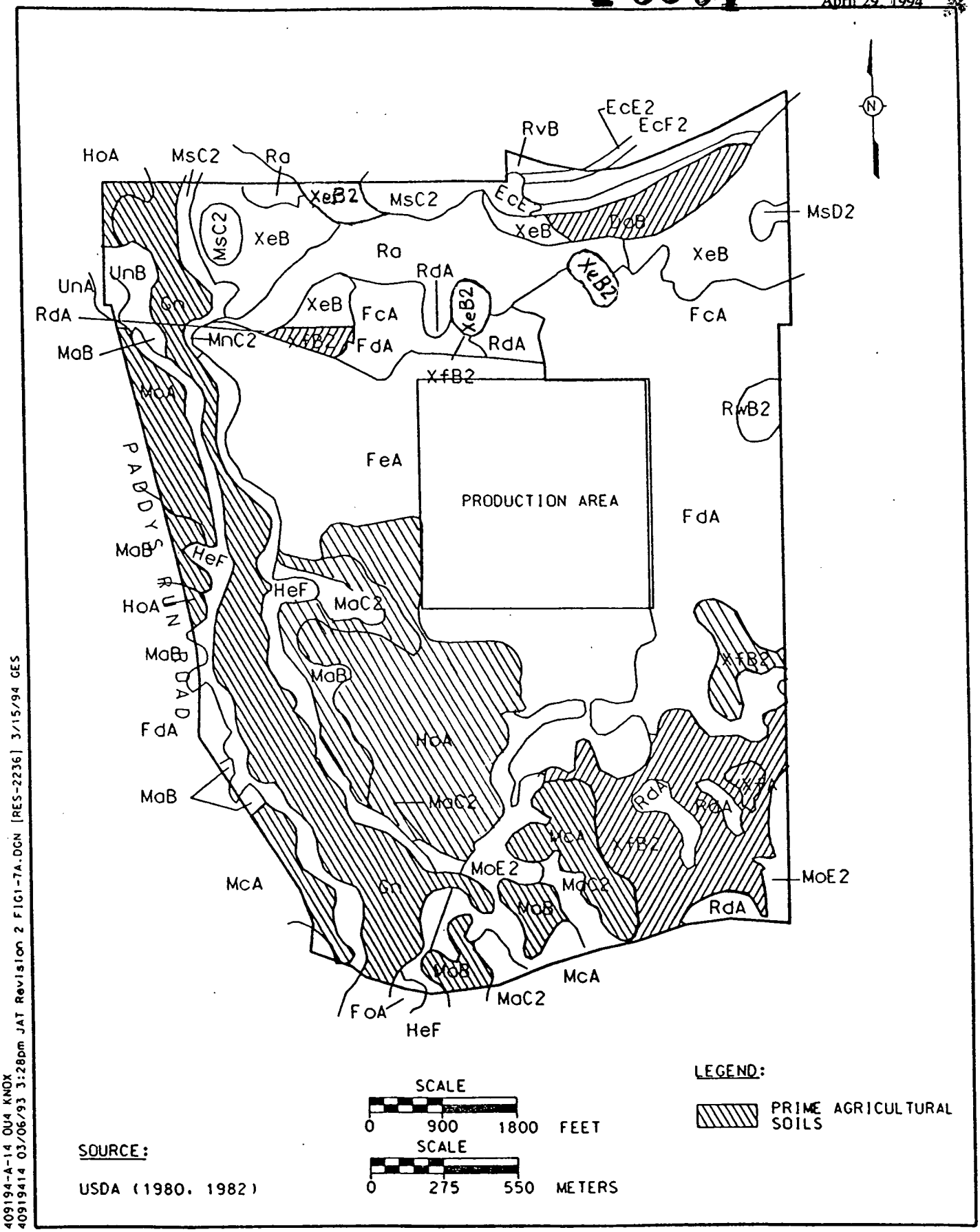


FIGURE 1-7 PRIME AGRICULTURAL SOILS WITHIN THE FEMP

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

Sources: SWCR (1993)

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 14.6 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.

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

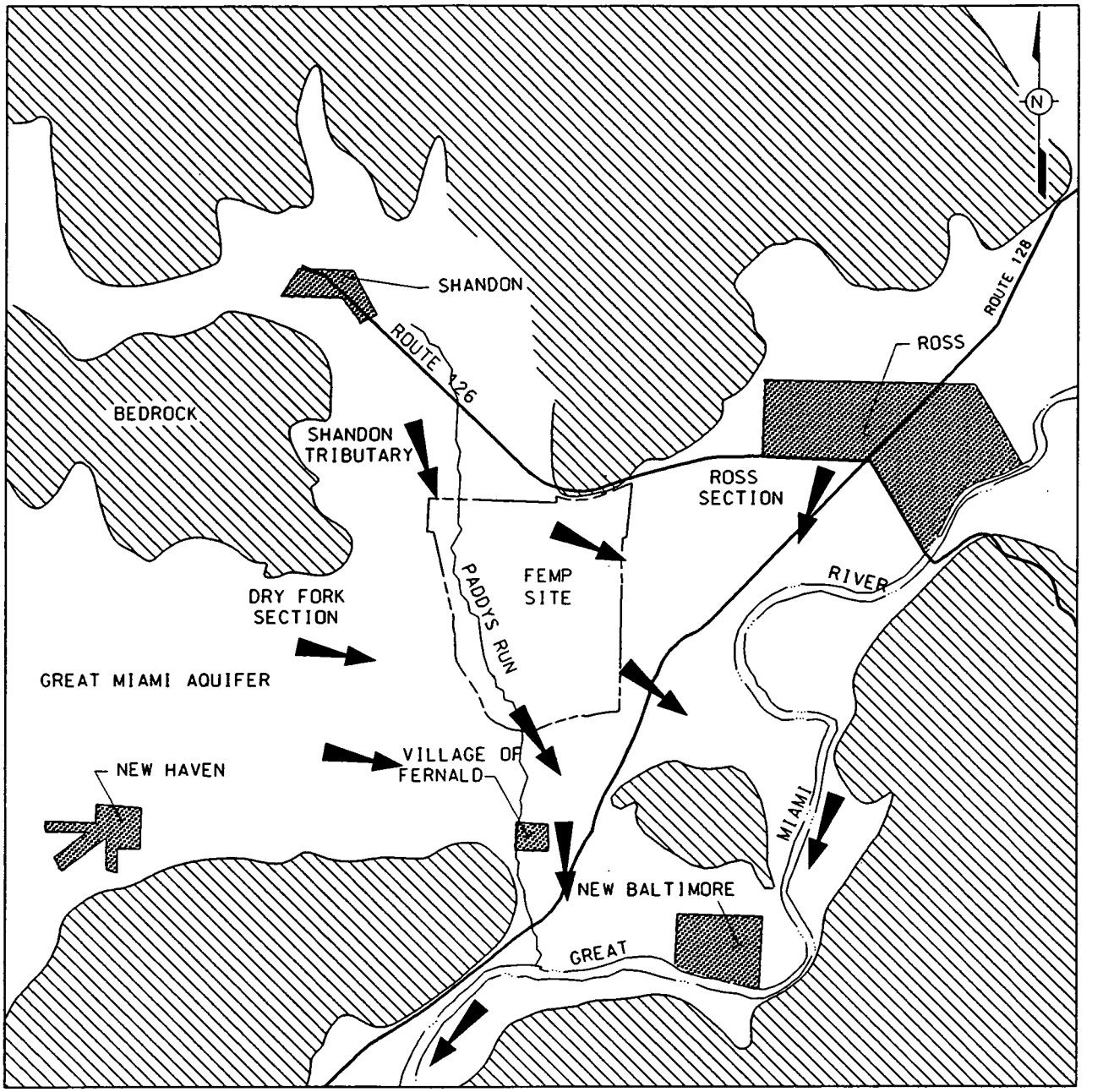
The Great Miami Aquifer is the principal aquifer within the FEMP site boundary. The underground valley in which it occurs varies in width from about one-half mile to over two miles. The valley is filled with extensive deposits of sand and gravel ranging in thickness from 39.6 to 60.9 m (120 to 200 ft) in the valley to only several ft 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 (five to 20 ft) in thickness. 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 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 towards 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).

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 but 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



SCALE
0 750 1500 METERS
SCALE
0 2500 5000 FEET

NOTE:
DIRECTION OF GROUNDWATER FLOW BASED ON APRIL 1986 WATER LEVEL CONTOURS AND GROUNDWATER MODELING OUTPUT (3DPART07.OUT)

LEGEND:
GENERALIZED GROUNDWATER FLOW DIRECTION.
BEDROCK OUTSIDE GREAT MIAMI AQUIFER

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

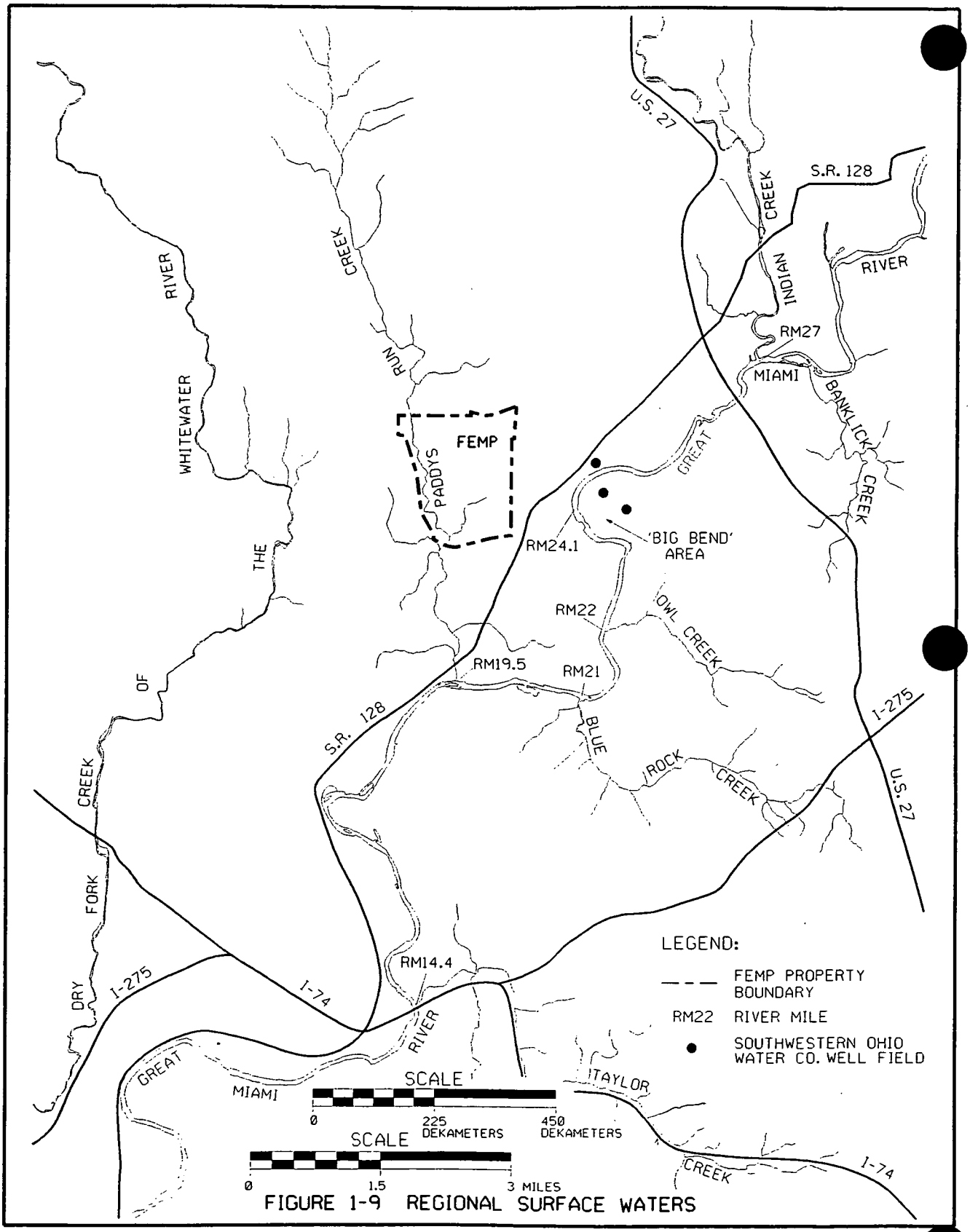


FIGURE 1-9 REGIONAL SURFACE WATERS

409194-A-04 OU4 KNOX
/RES2236/FIG1-9A.DGN 01/19/94 GES

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

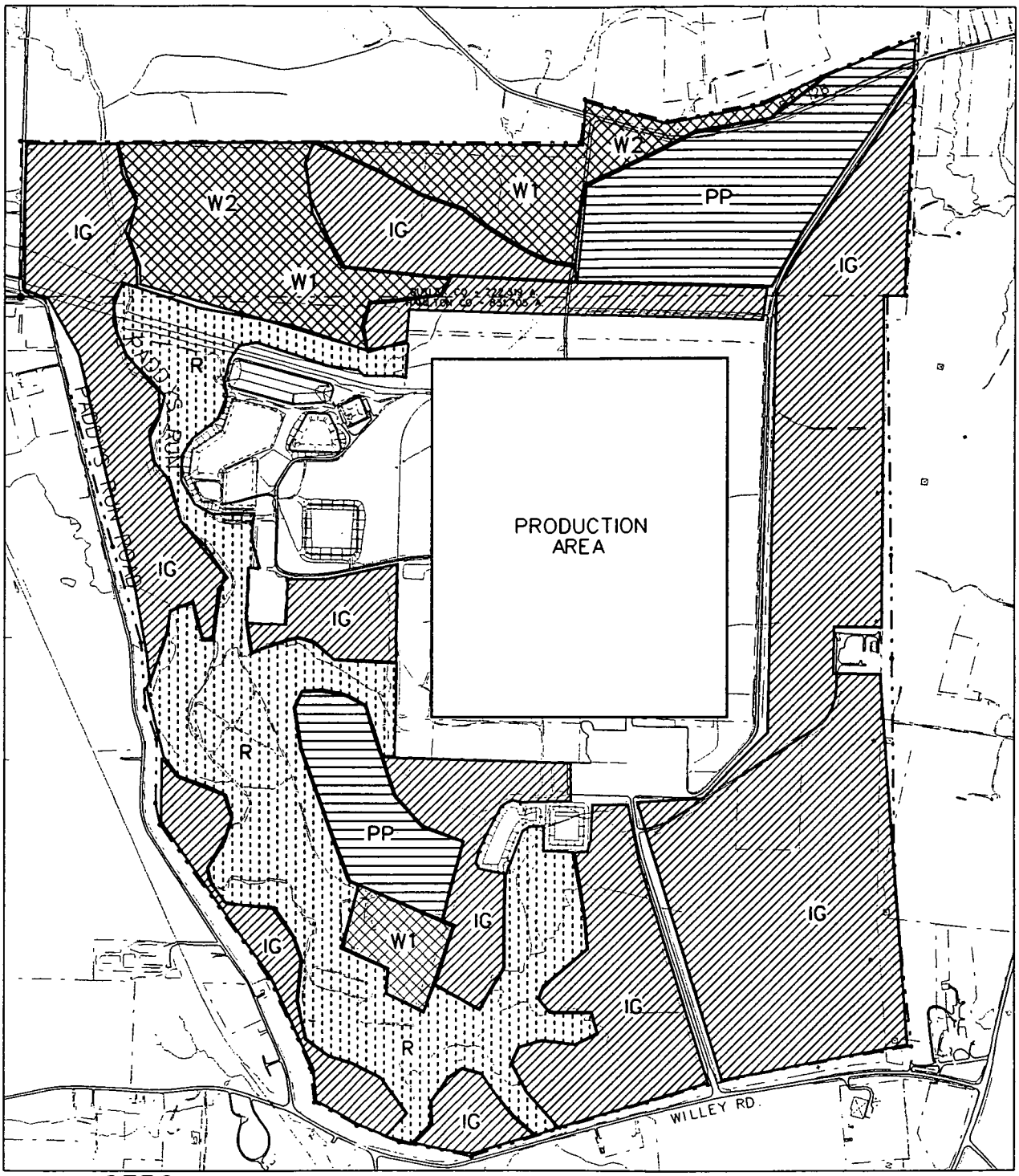
1.5.3.1 Terrestrial Habitats

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. Abundant mammals throughout the FEMP include the white-tailed deer (*Odocoileus virginianus*) and the eastern cottontail rabbit (*Sylvilagus floridanus*). Many 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*).

5501



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)

FIGURE 1-10 HABITAT TYPES PRESENT ON THE FEMP

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

- Pine Plantations. The 21-year old pine plantations cover approximately 41 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 four 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, the majority 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 including 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.

- 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*). 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 (1974-1982) [U.S. Geological Survey (USGS) 1992]. The majority 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 1984-1992 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 include 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 1988-89 RI/FS sampling, 70 taxa of invertebrates were collected with the majority being 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. The 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 listed as federally endangered 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. 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 as federally endangered 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. However, the Ohio Department of Natural Resources (ODNR) indicates that this species inhabits Miami Whitewater Forest, located approximately eight km (five 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 as well as 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. 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 property and southern sections of Paddys Run off property near New Haven Road.

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.

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.

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, 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 11-18, 1992 and January 7-16, 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 Environmental 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).

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 extends west of the "Big Bend" area (Figure 1-13). The 100- and 500-year floodplains of the river also extend northward

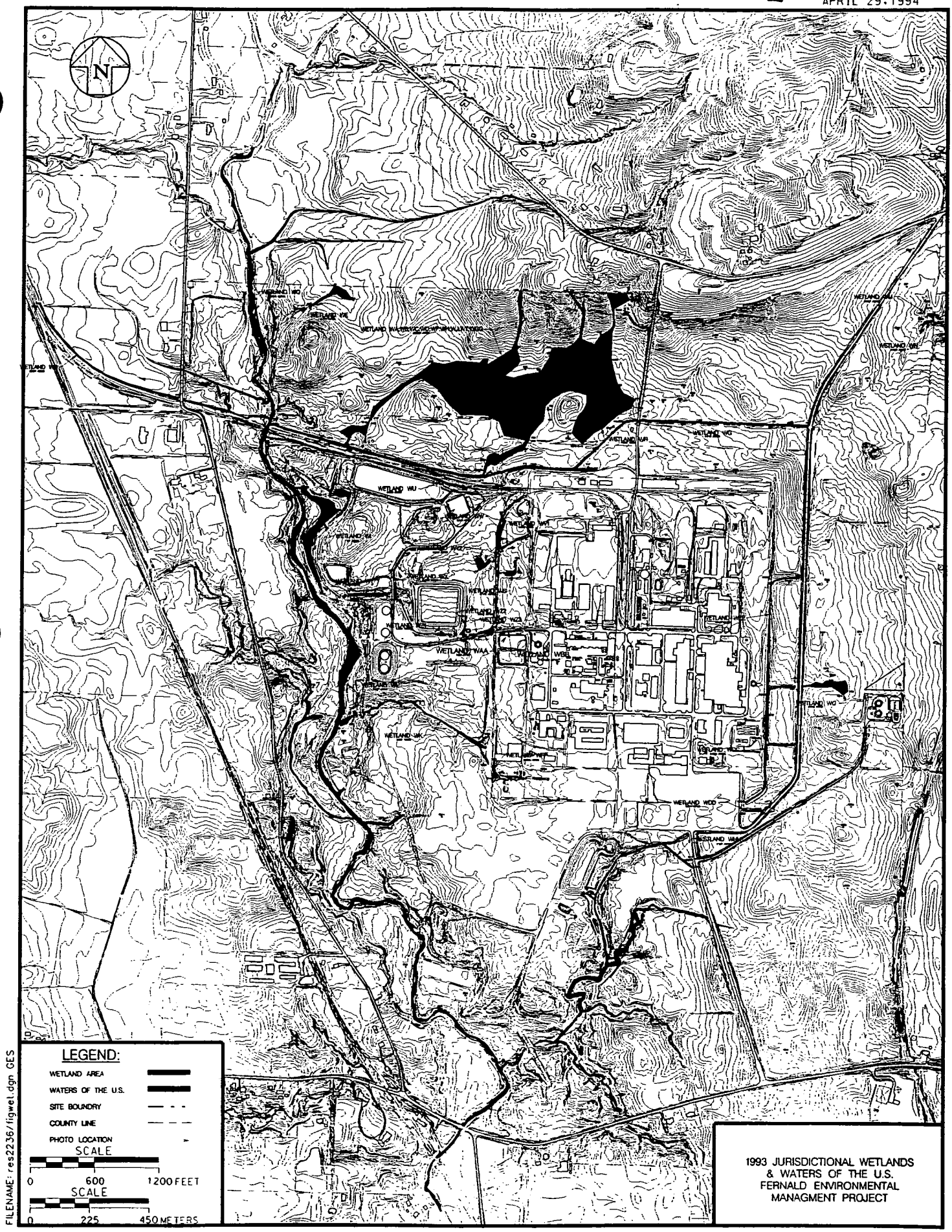


FIGURE 1-11 JURISDICTIONAL WETLANDS AT THE FEMP

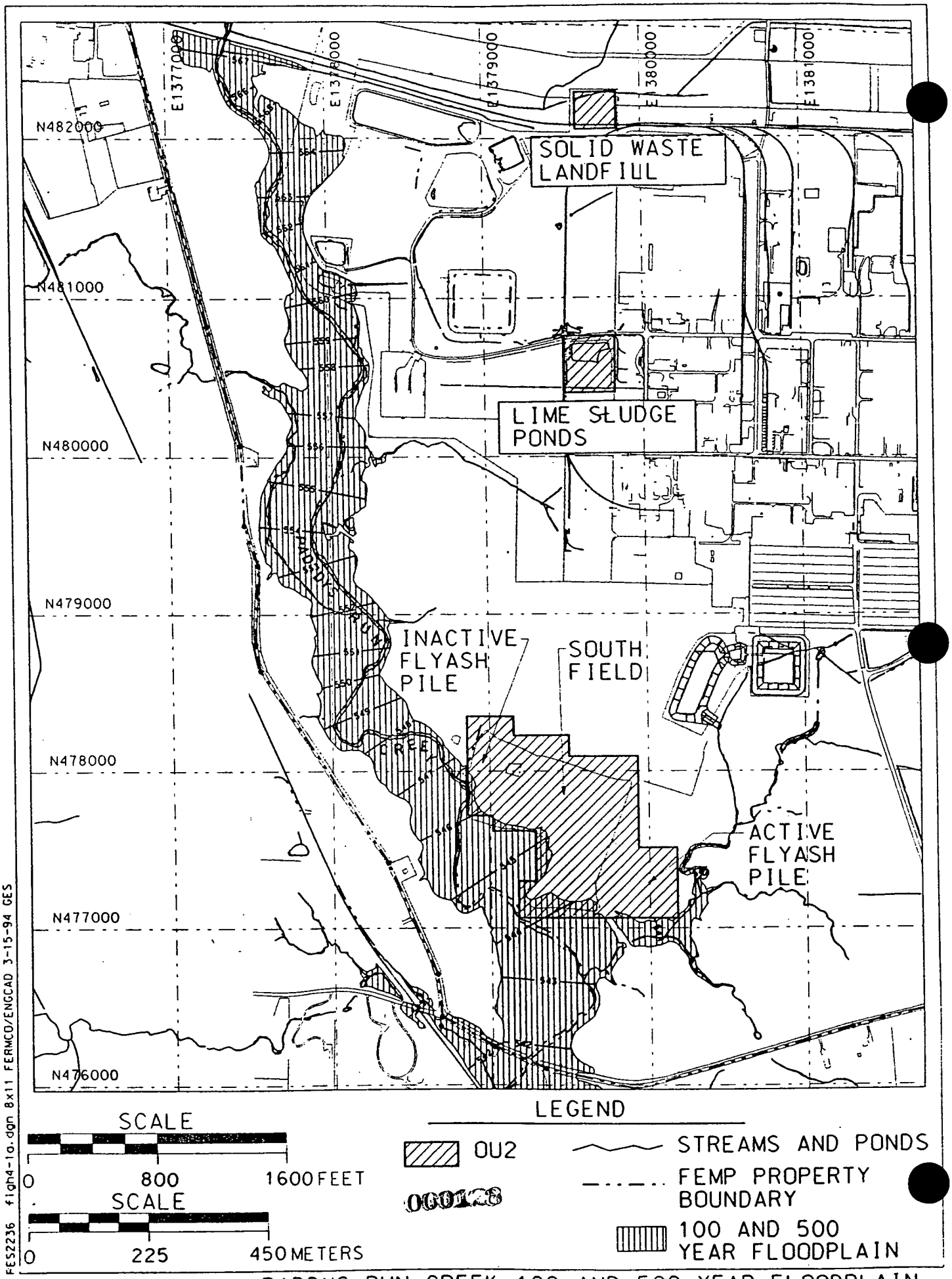
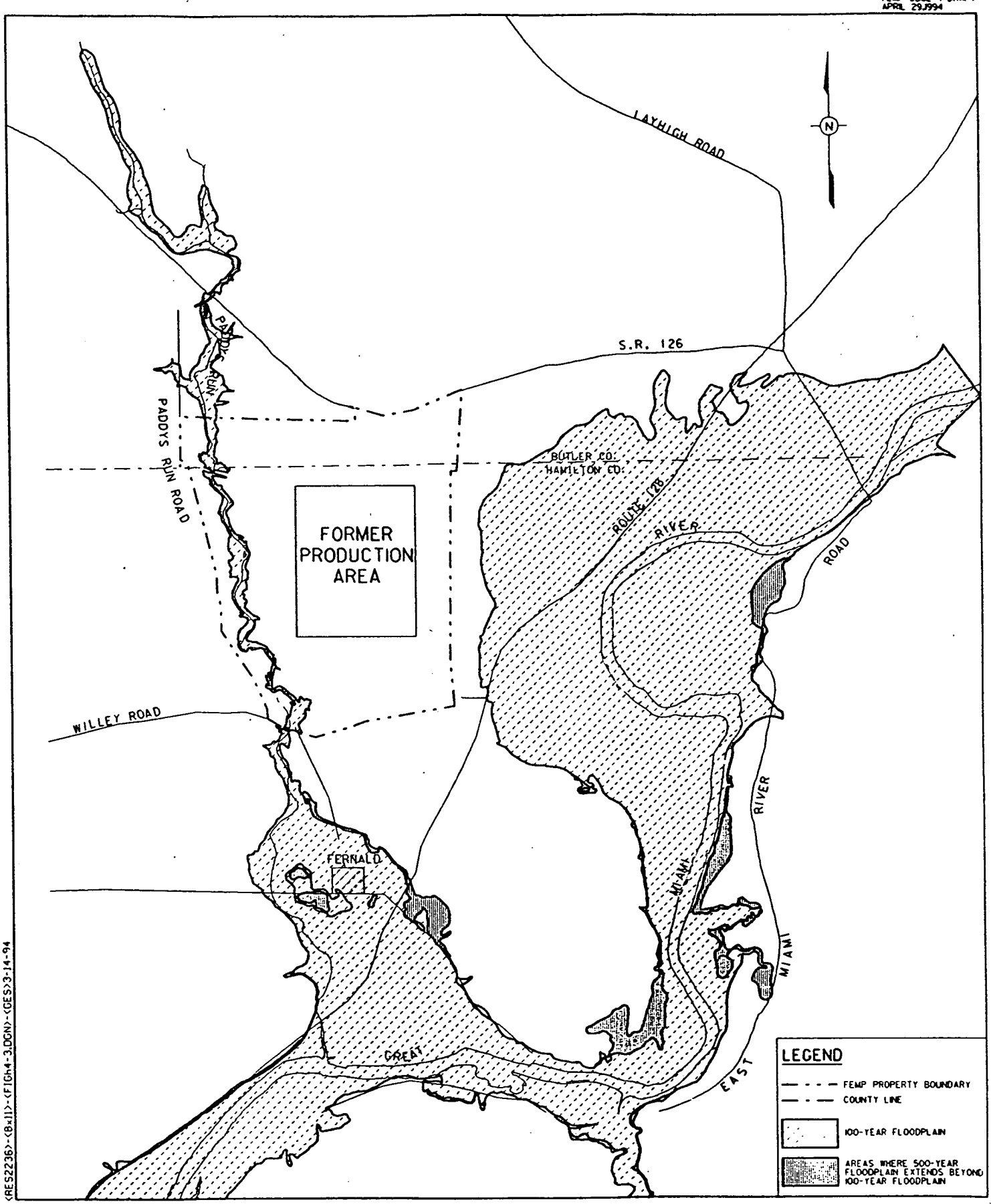


FIGURE 1-12 PADDYS RUN CREEK 100 AND 500 YEAR FLOODPLAIN

FEMP-OU02-4 DRAFT
APRIL 29,1994



(RES2236)-(8x11)-(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

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 11,150 cubic ft per second (cfs). Elevations range from 165 m (542 ft) MSL at the southern boundary of the floodplain studied to 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) miles 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 the 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 eight km (five 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 (2062 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 thirteen county region is 108 residents/sq km (278 residents/sq mi). Population density within the 8 km (5 mi) radius of the site is 352 residents/sq km (917 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 (three 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 five mi south of the FEMP site.

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 three mile 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 pre-historic times to the late eighteenth 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 - 8000 BC). The earliest Paleo-Indian material was found at the Meadowcroft Rockshelter in Pennsylvania ranging 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 upon the hunting of these large mammals such 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, with emphasis on a wider variety of plant foods. 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 (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 - 500 AD) complex in southern Ohio. Information about the Hopewellian culture has been obtained

through mound excavations. This information reflects elaborate ceremonialism. Village and 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 9 ft high and enclosed an area of 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 - 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 so cultivated crops could be raised. After the harvest of crops, the base villages were abandoned for hunting camps in the nearby forests. At approximately 1000 AD, the Woodland Tradition ended in the area of the FEMP site.

1.5.7.4 Mississippian Tradition (1000 AD - 1660 AD)

The Turpin Phase, Fort Ancient (AD 1000 - 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 Turpin 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- 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 four 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 buried 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 - 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, and 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 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, they 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 Indian. 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.

In 1801, the land west of the Great Miami River was placed on sale. Shawnee, Wyandots, Iroquois, and Miami Indians were still in the area of the FEMP site. Chief Kiatla and his daughter Okeana of the Miami tribe spent their summers in the area known as Camp Run. Kiatla Creek and the present village of Okeana were named by the first settlers in honor of the Chief and his daughter.

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, persuant to

the Amended Consent Agreement, which is a site-wide comprehensive operable unit. 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.

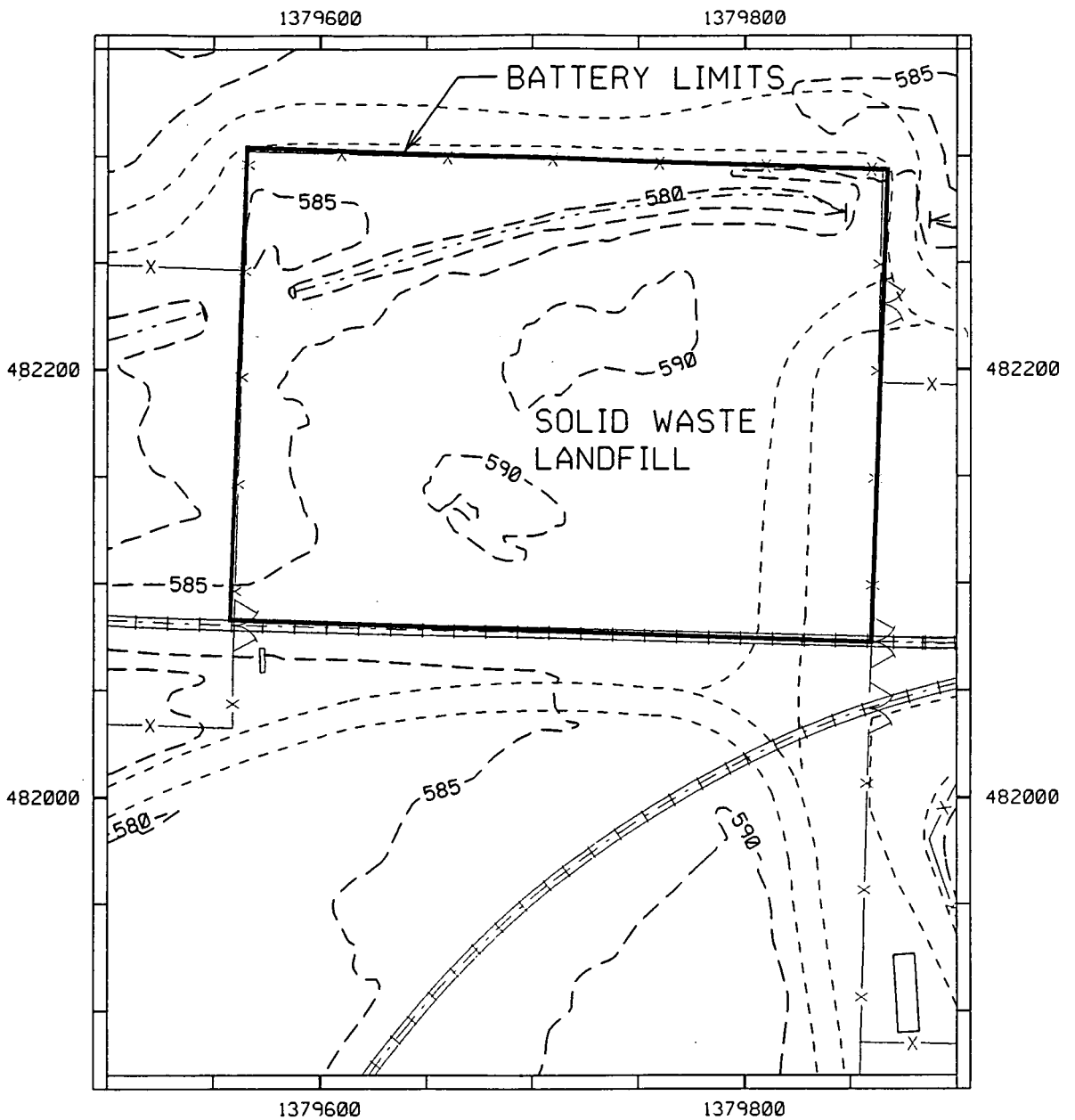
1.6.1 Solid Waste Landfill

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 one 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 with 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



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

fs0108.dgn

nonradioactive asbestos. Field investigation results, however, reveal that some apparent process wastes have been placed in the landfill. Interviews with former FMPC employees were conducted, but 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

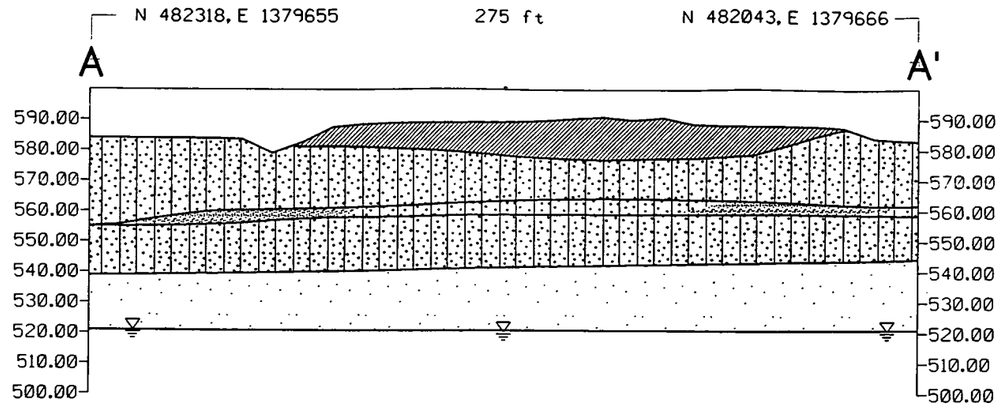
The Solid Waste Landfill is underlain by the glacial overburden (fill or overburden), which has an approximate thickness of 7.6 m (25 ft) and consists of interbedded layers of stiff to hard light yellowish brown to brown silty clay with varying amounts of sand and gravel, as shown in Figure 1-15. Color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

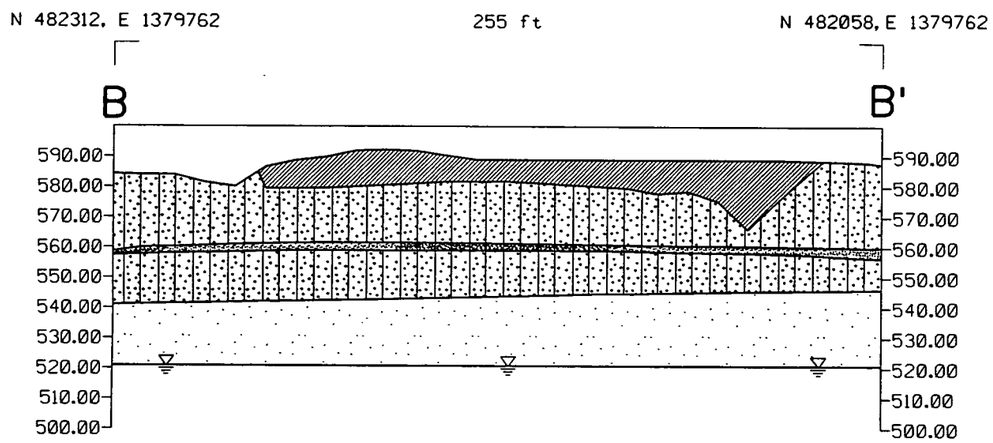
The overburden is underlain by the Upper Great Miami Aquifer, which has an approximate thickness of 27.5 m (90 ft) and consists of very dense dark yellowish-brown sands and gravels. The Upper Great Miami Aquifer is separated from the Lower Great Miami Aquifer by a dark gray clay aquitard.

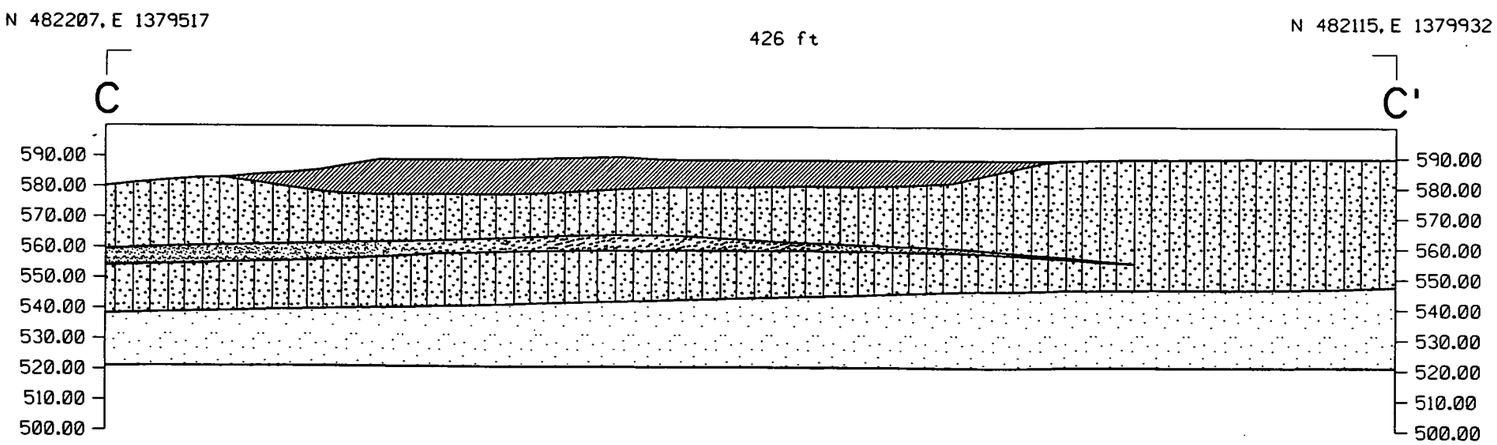
Groundwater (perched water) seepage was observed during excavation of characterization trenches at depths ranging from 0.75 to 2.75 m (2.5 to nine ft) below ground surface. These perched water zones were found in areas of significant porosity or within the fill's void spaces.

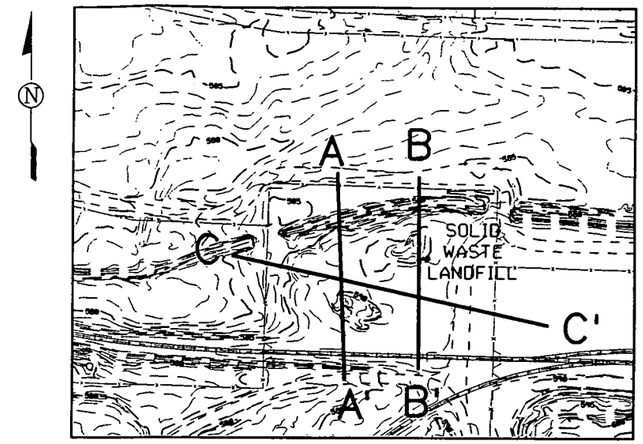
Groundwater elevation within the overburden varies from approximately 177 to 171 m (580 to 560 ft) MSL [two to six m (seven to 20 ft) below ground surface]. Lower water levels observed in Well 1037 were discounted due to faulty well construction. Groundwater within the overburden was found to be present in small isolated and discontinuous pockets of saturated materials. Horizontal groundwater movement is restricted and hydraulic gradients within the overburden can be steep.

- 5501









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

000139

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.

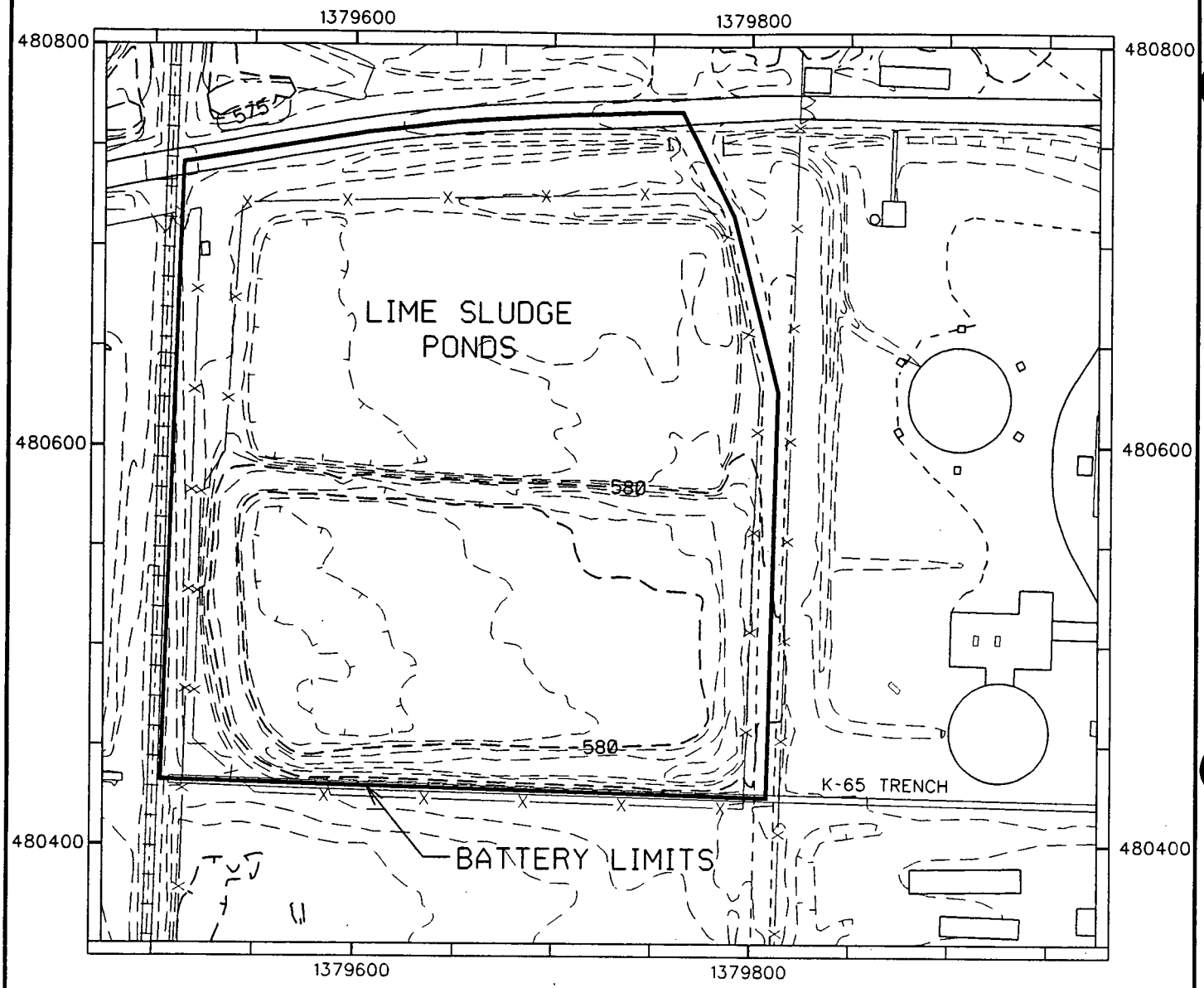
1.6.2.1 Description and History

The North Lime Sludge Pond is an unlined pond with dimensions of approximately 38 by 69 m (125 by 225 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 the topographic low point of the pond.

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 3.8 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 one cubic yd (cu yd) of lime sludge is generated and pumped from the water softening clarifiers to the General



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

fs0334.dgn

000141

FIGURE 1-16
TOPOGRAPHY OF THE LIME SLUDGE PONDS

Sump on a daily basis. 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, FERMCO proposed that the FEMP permit application be modified to reclassify the Lime Sludge Ponds as Solid Waste Management Units (SWMUs) on May 13, 1993. 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 nine 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 two m (seven ft) at Boring Nos. 1039 and 2042.

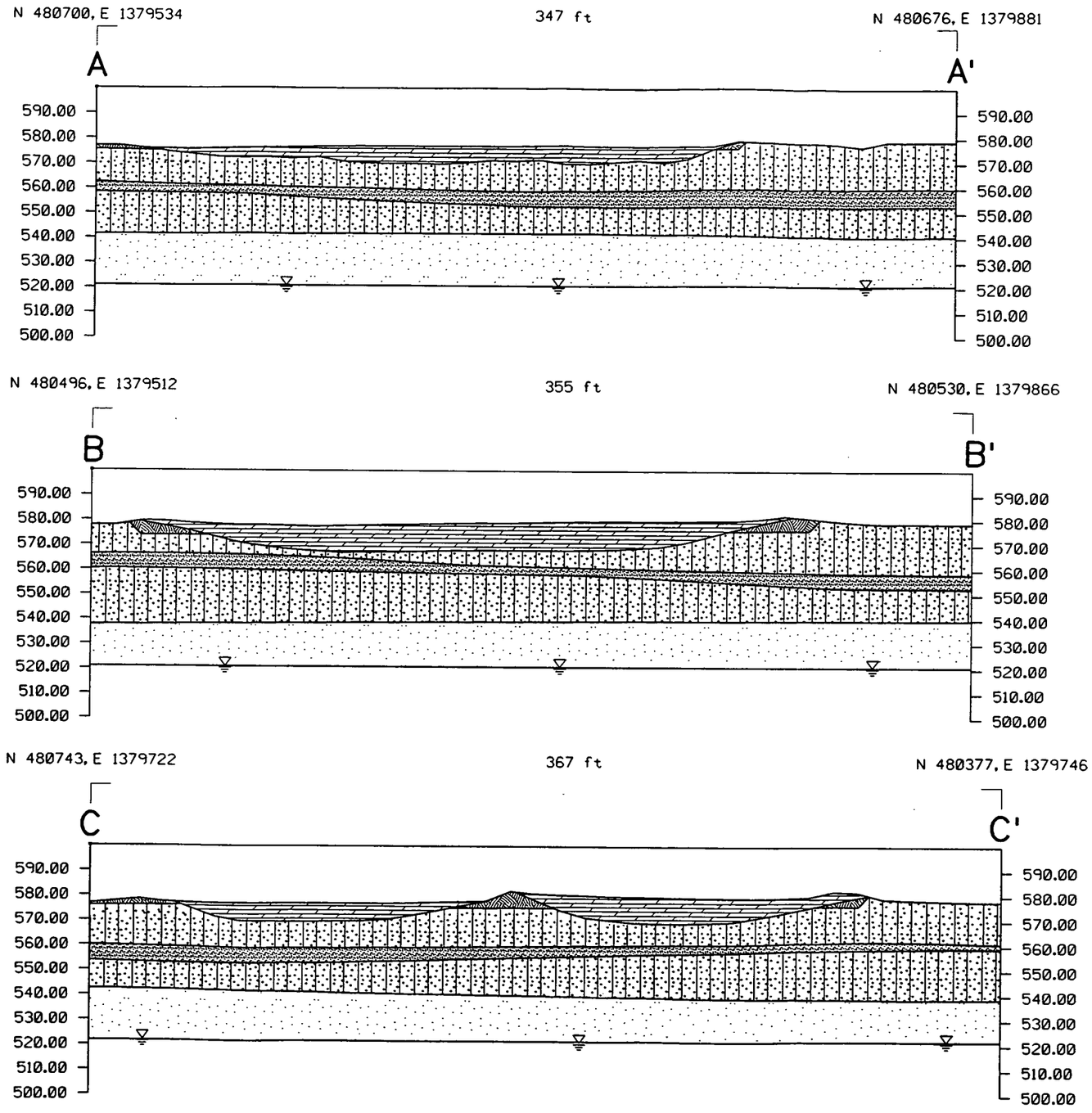
A sand lens, detected in the glacial till at Boring Nos. 1039 and 2042, may extend continuously beneath the Lime Sludge Ponds. The sand lens occurs at a depth of 5.7 m (19 ft) at Boring No. 1039 and at approximately five m (16.5 ft) at Boring No. 2042. This zone is approximately four ft thick and appears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

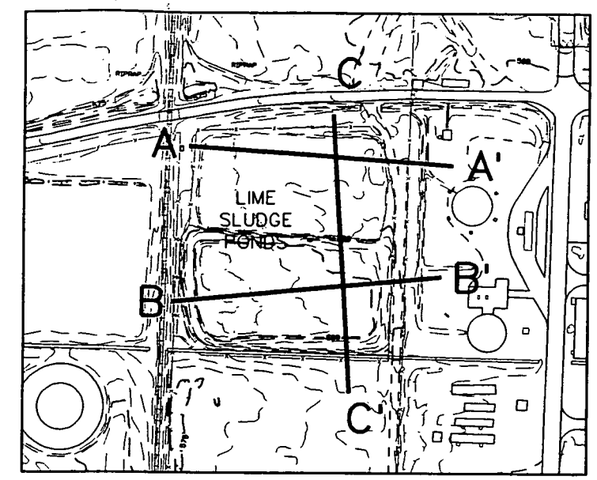
The Great Miami Aquifer underlies the glacial till deposits and consists of glacial outwash deposits containing sand and gravel. The Great Miami Aquifer consists of both an upper and a lower unit, but only the upper aquifer was penetrated by borings or monitor wells in the Lime Sludge Ponds area. The 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 600 m (2000 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 60 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.





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

000144

FIGURE 1-17
GEOLOGIC CROSS SECTIONS
LIME SLUDGE PONDS

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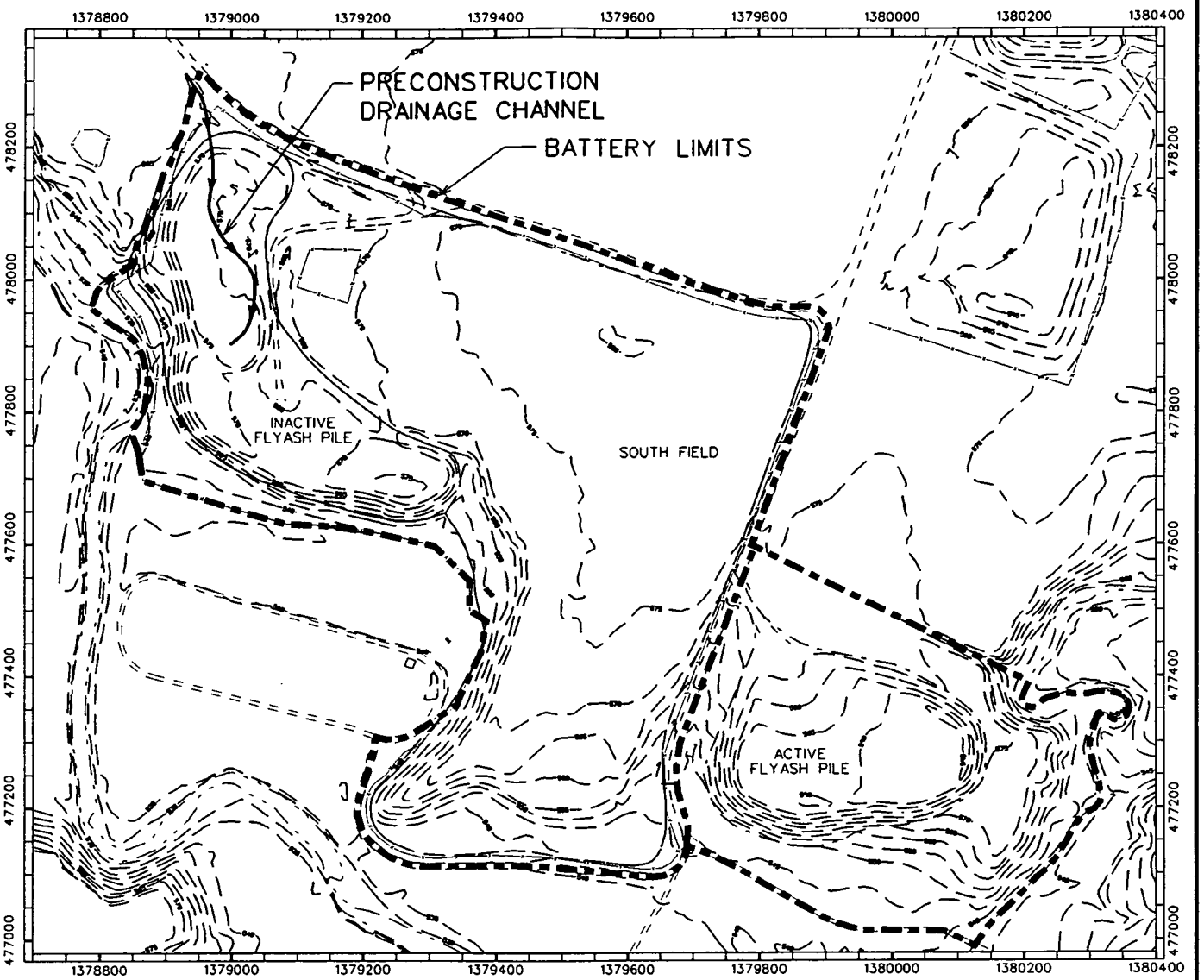


LEGEND
575 ELEVATION CONTOURS
ROADS
STREAM
BATTERY LIMITS
FENCE

N

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

SCALE (FT)
0 250 500

FIGURE 1-18
TOPOGRAPHY OF THE
SOUTH FIELD AND FLYASH PILES

000145

fs0110.dgn

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 (cu m) [43,600 cu yds (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 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 retrieval of 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 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 towards Paddys Run and the running track, respectively. The south-central portion of the Inactive Flyash Pile slopes gently towards 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). The ground surface elevation was raised in these areas to approximately 175 m (575 ft) MSL. Soil fill of approximately 0.3 to one m (one to three 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 six to nine 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 600 m (2000 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.

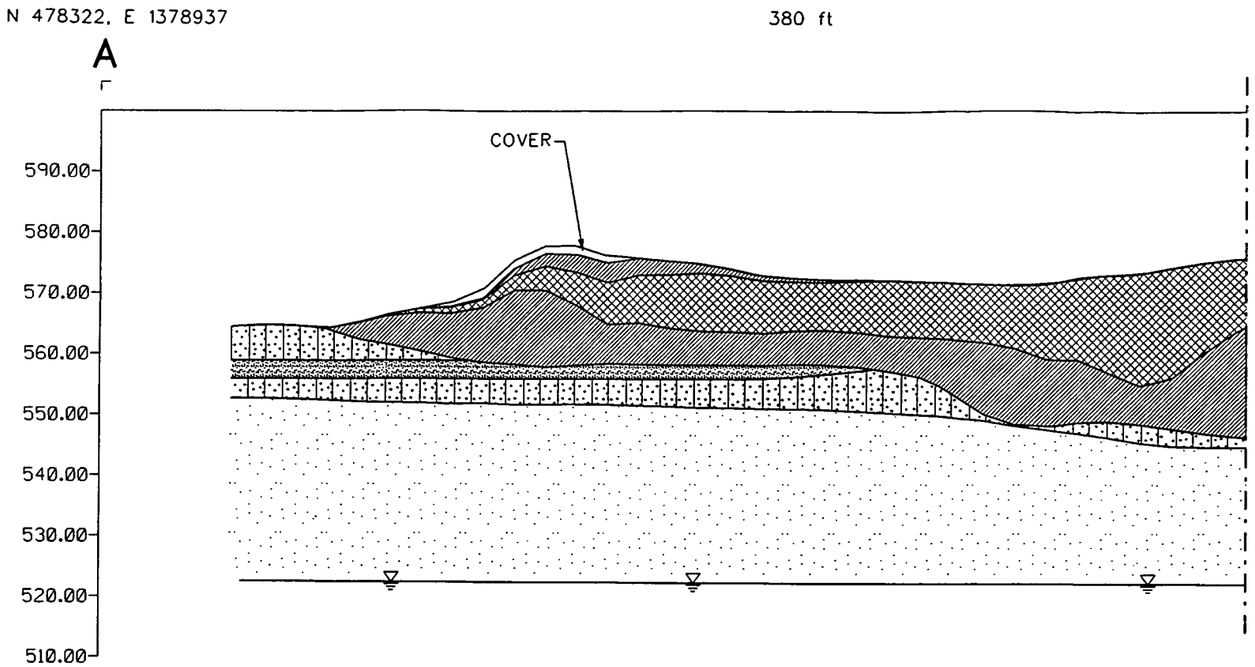
In accordance with the Consent Agreement, a removal action was completed on December 23, 1991 to establish institutional controls in the South Field to prevent unauthorized entry. These controls included installation of chain barrier fencing and posting of radiological "Controlled Area" signs around 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 1.9, included field surveys to identify radioactive "hot spot" areas and retrieval of contaminated debris.

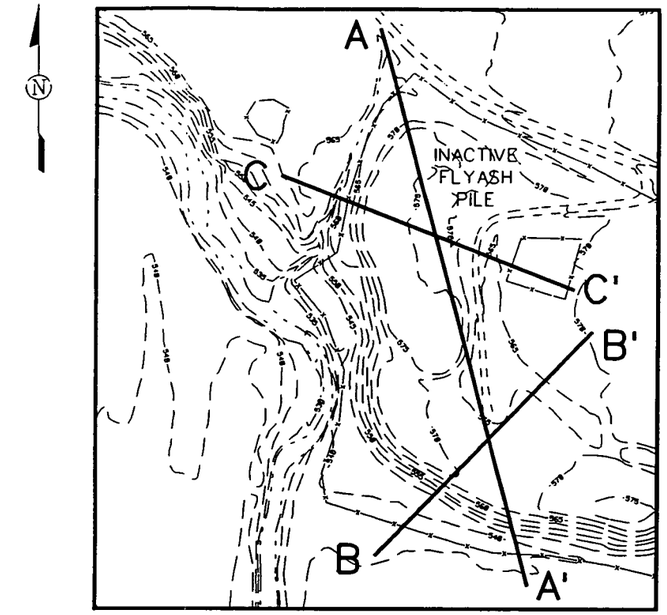
Natural ground surface elevations range from approximately 177 to 165 m (580 to 540 ft) MSL across the South Field from the north to the south and southwest. The north-central portion of the South Field also slopes gently towards the Inactive Flyash Pile in an area where a man-made drainage feature forms 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 four ft). The ground surface elevation was raised in these areas to approximately 175 m (575 ft) MSL. Soil fill of approximately 0.3 to one m (one to three 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

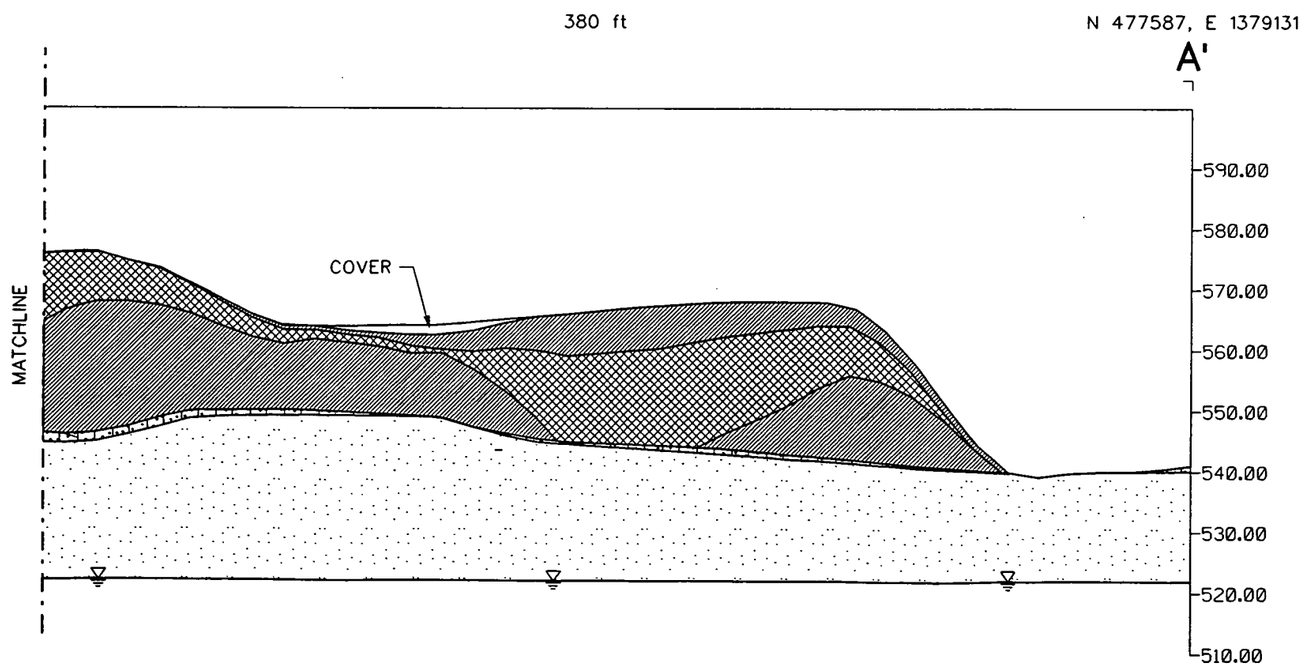
Boring logs indicate that the glacial till beneath the South Field is composed primarily of silty clay interbedded with lenses of clay and silt, sandy clay, and silty sand. Measured from the natural ground surface, the till is approximately 6.1 to 9.2 m (20 to 30 ft) thick along the South Field's northern 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, 1-23, 1-24, 1-25, and 1-26 show geologic cross sections of the South Field.

5501





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

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

0001 9

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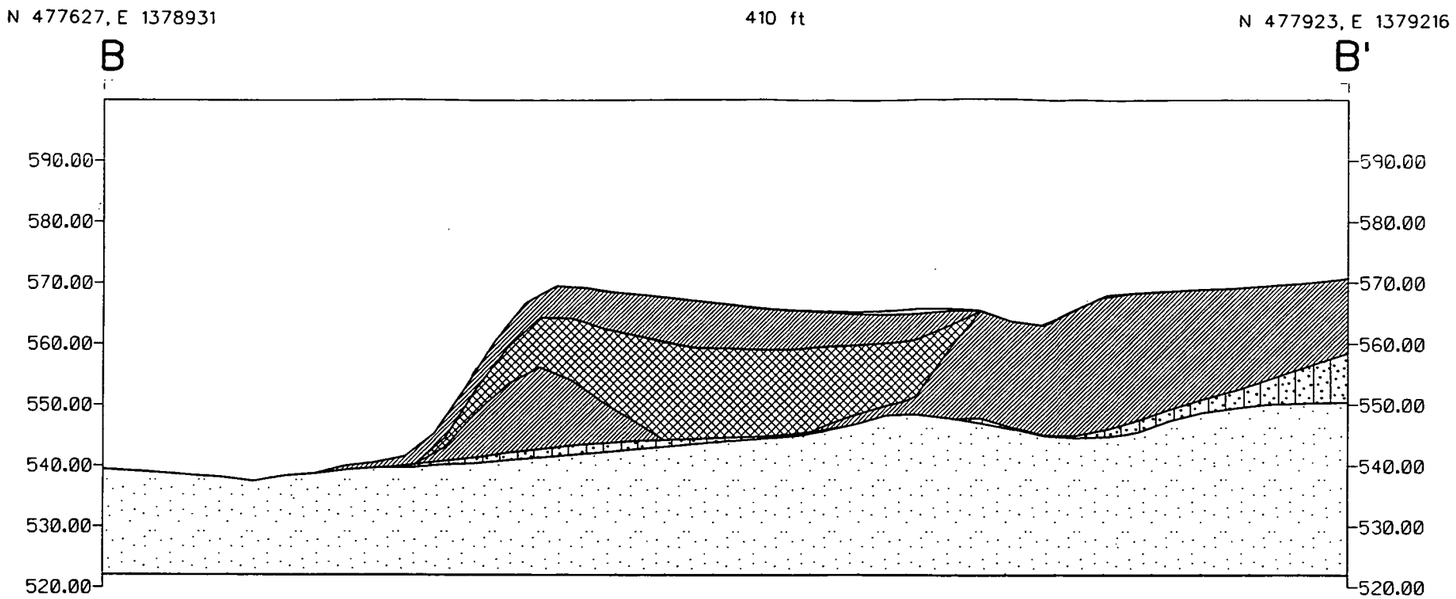
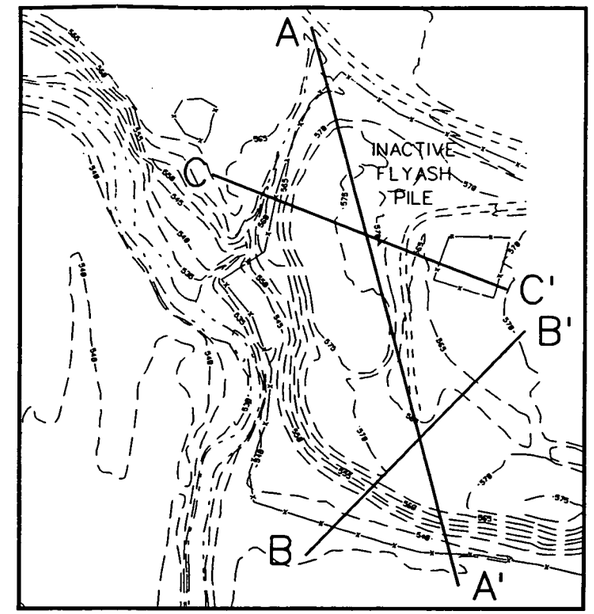
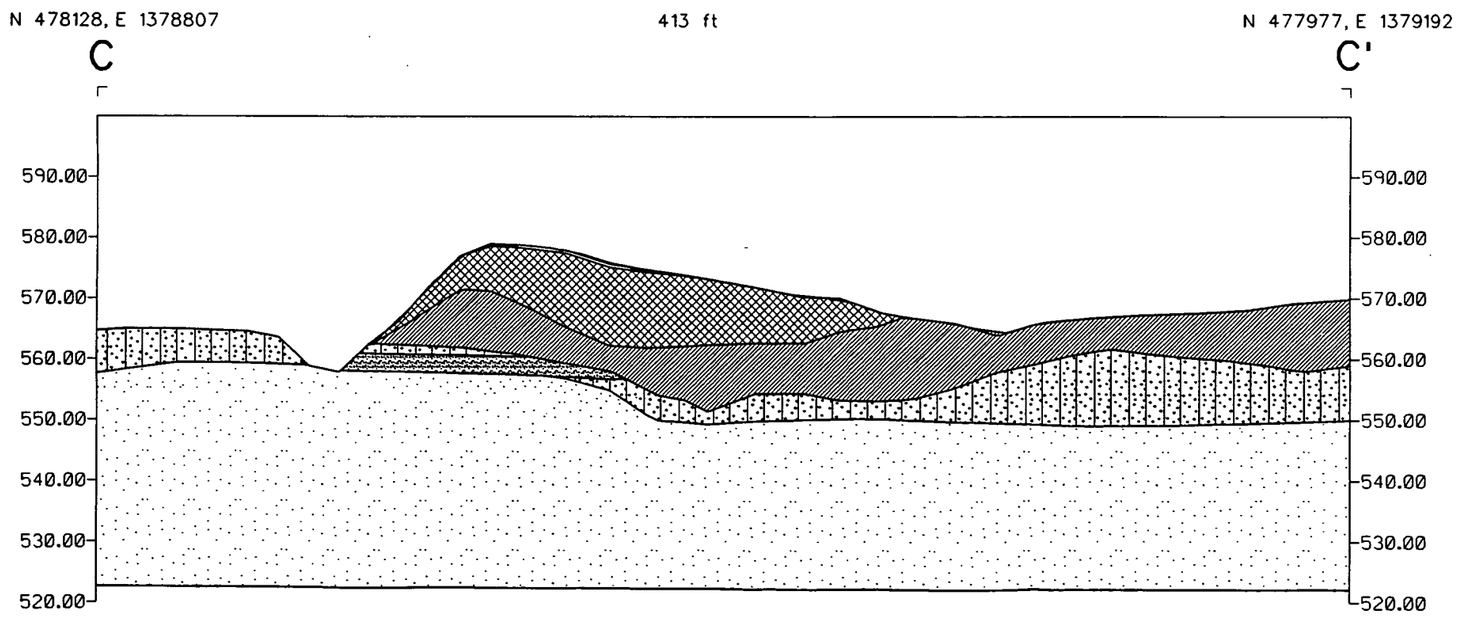




LOCATION KEY (1" = 200')



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.

000150

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

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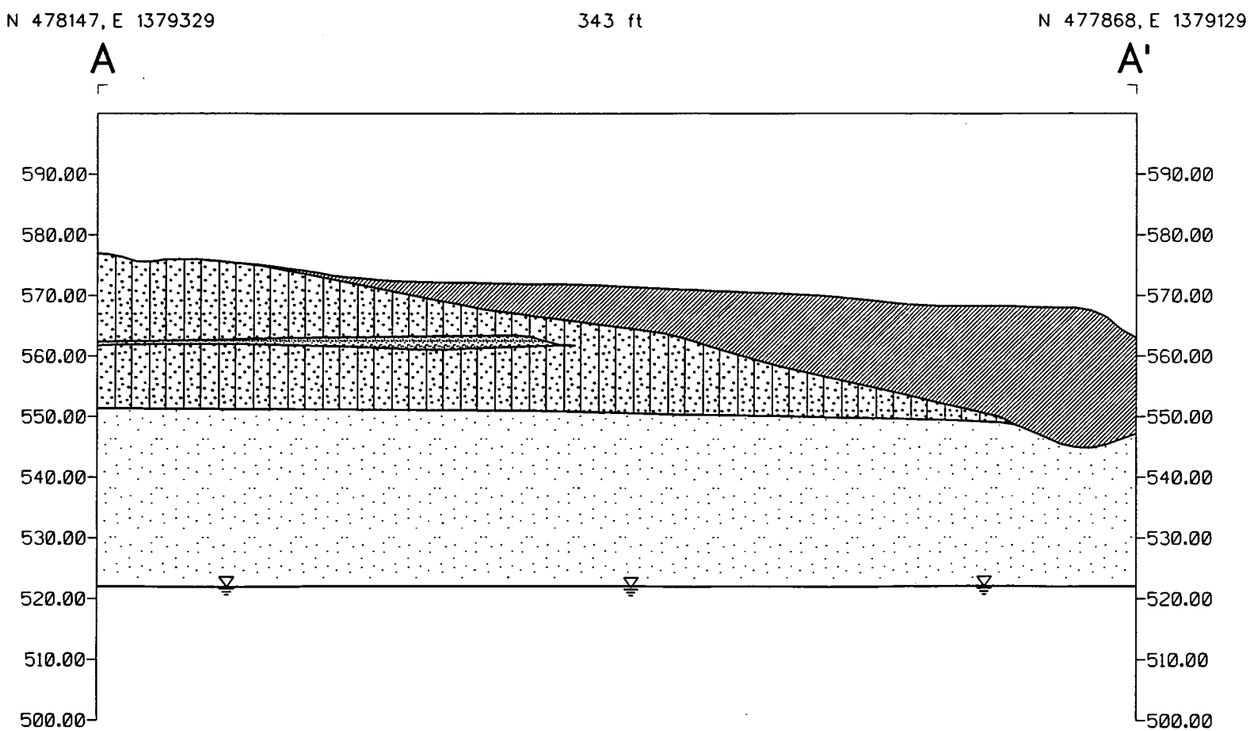
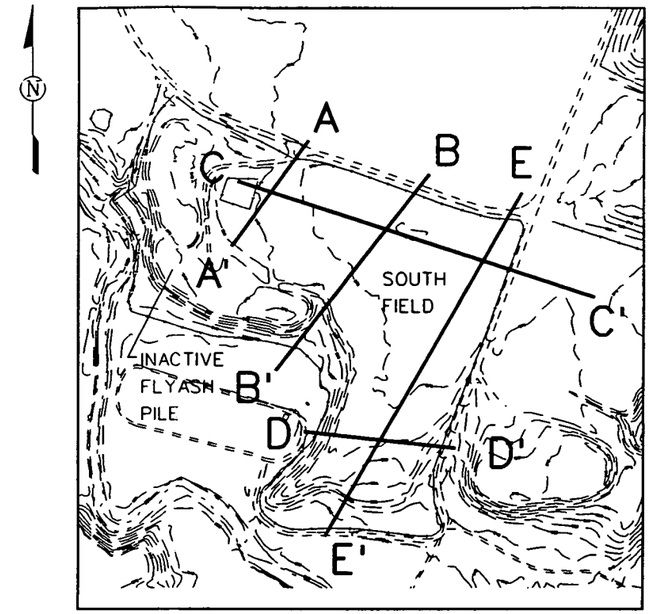
000151

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.

000152

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

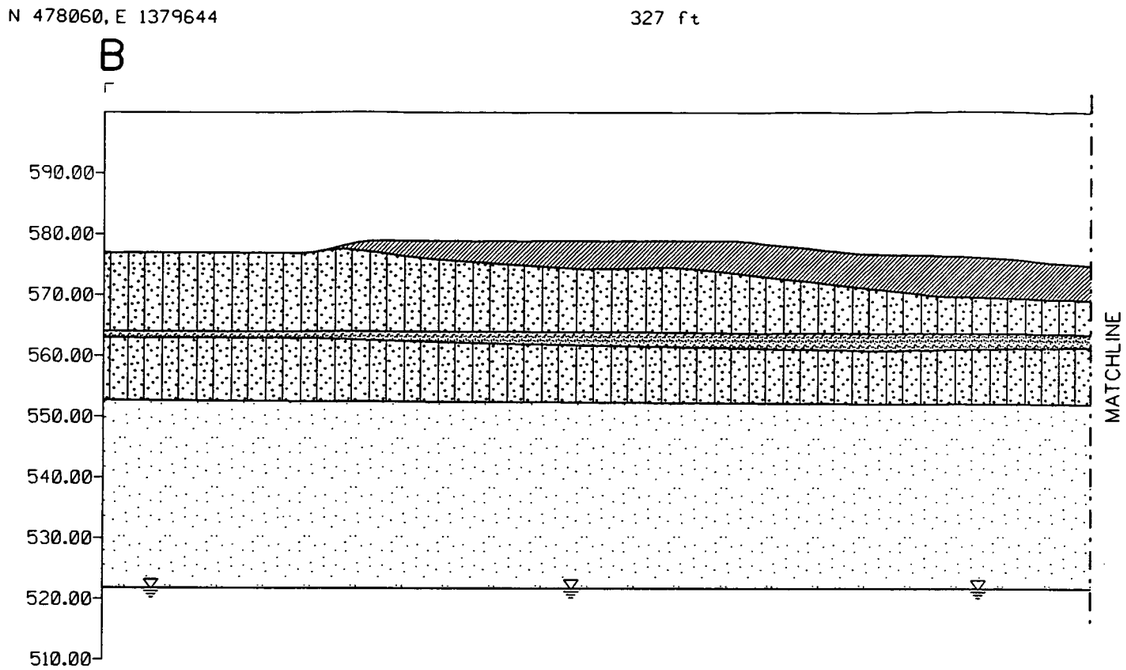
0 25 50 100

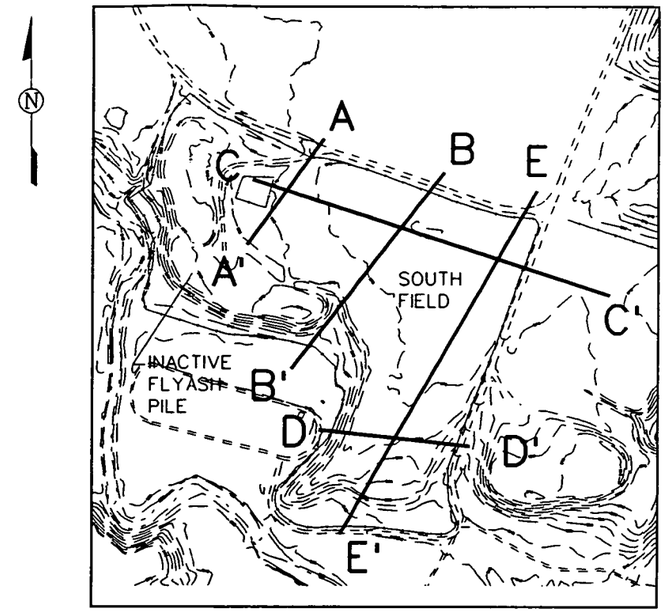
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

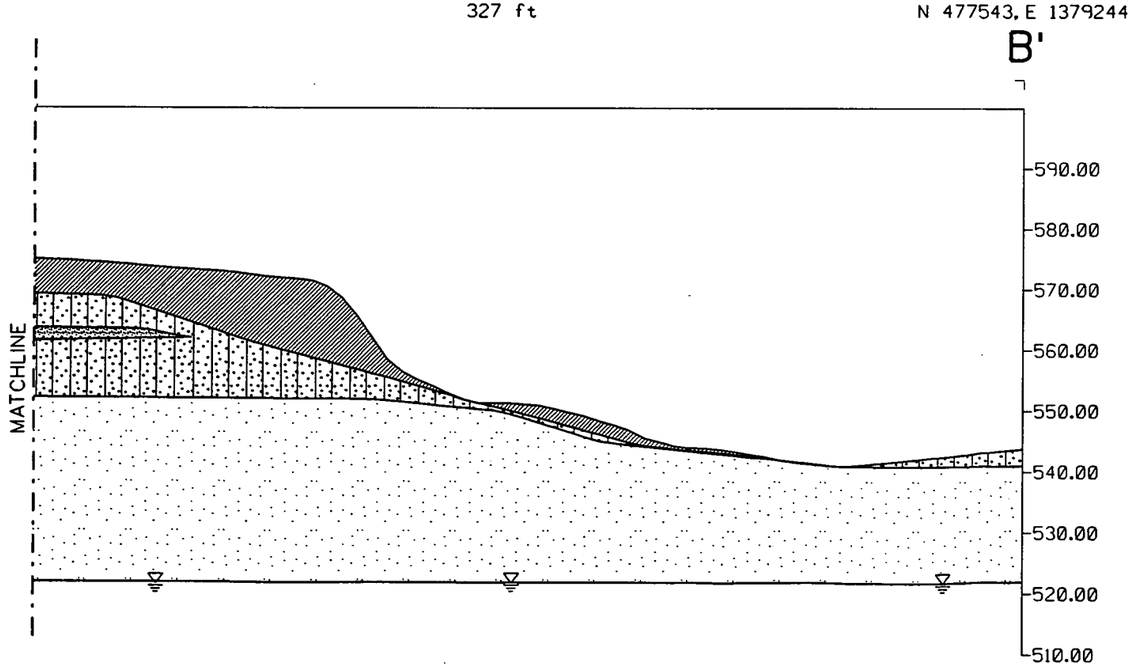
FIGURE 1-22
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 1 OF 5

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.

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

0 25 50 100

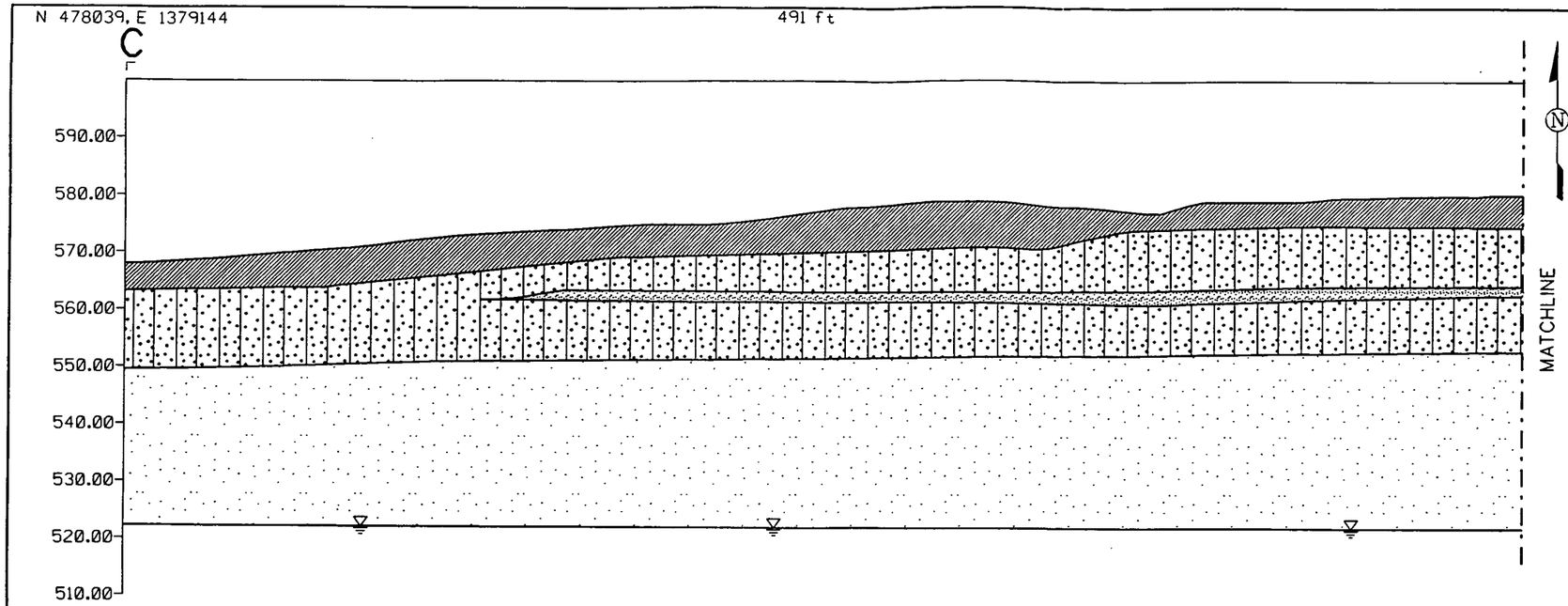
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

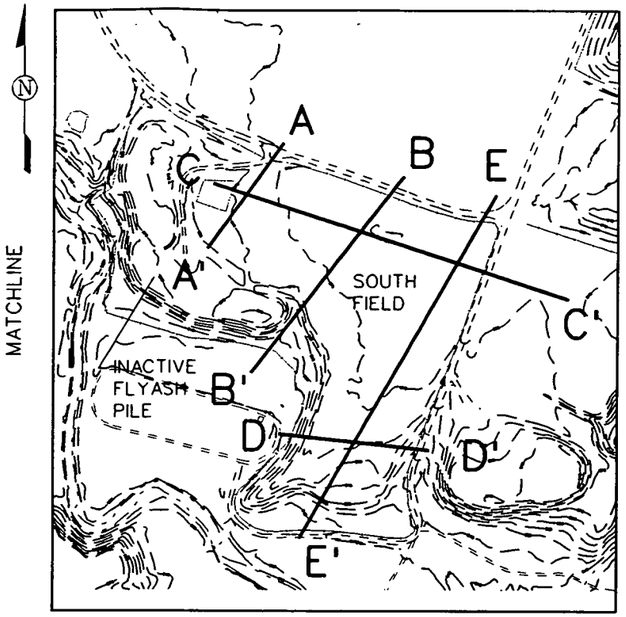
0 6 12 24

000153

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

fs1130.dgn





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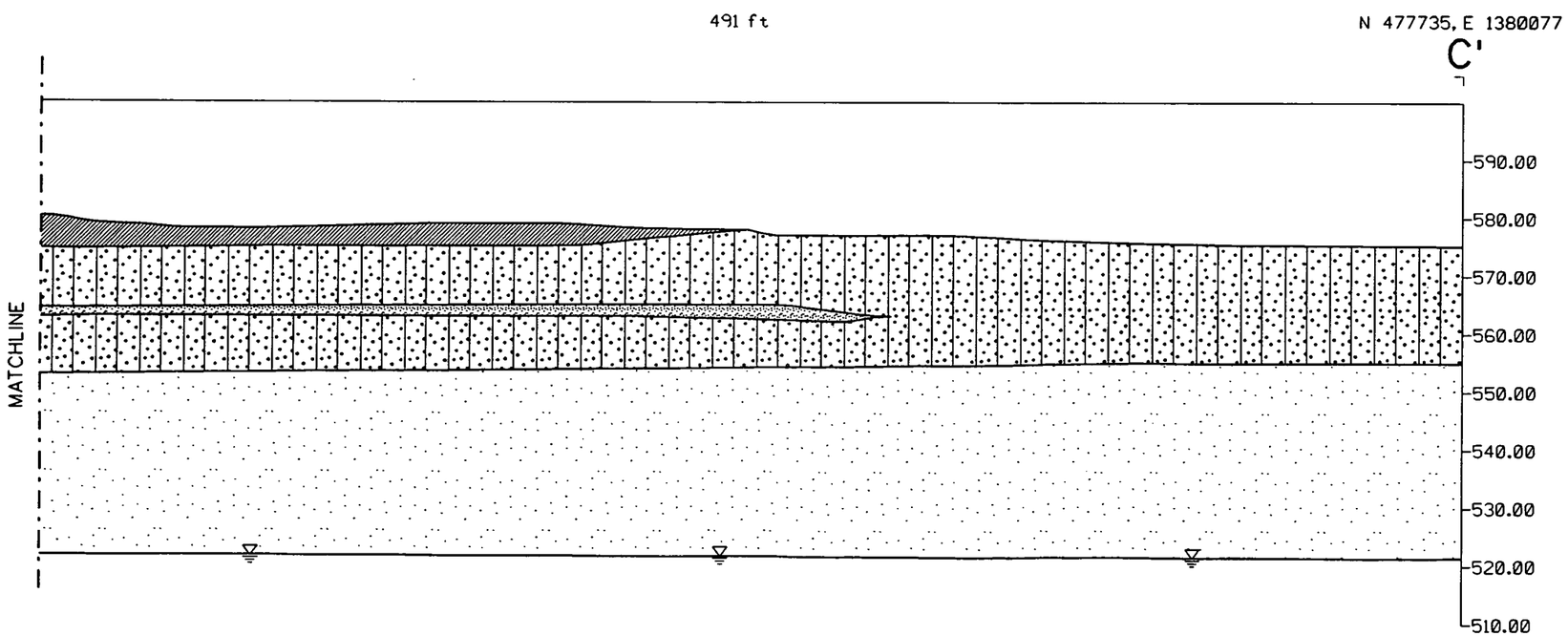


LEGEND

- 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

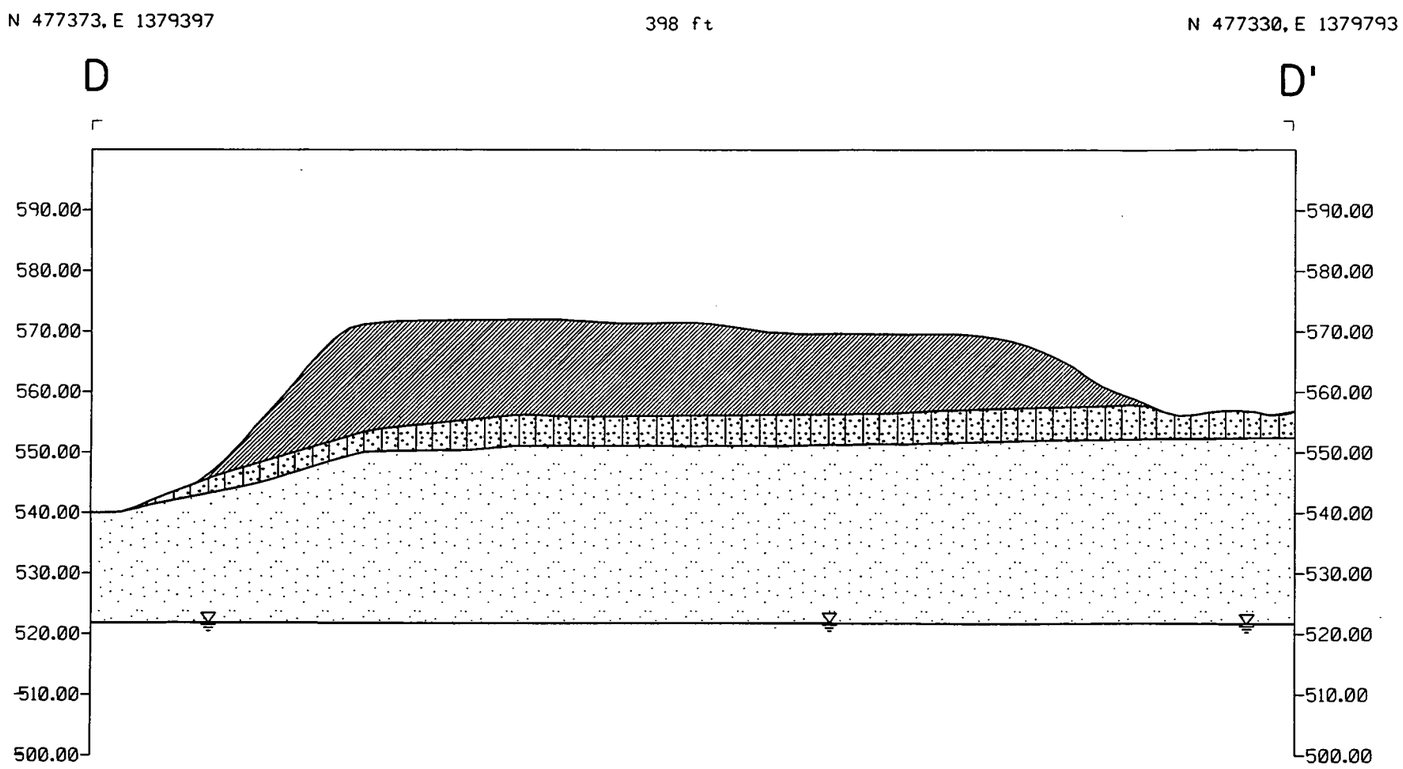
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

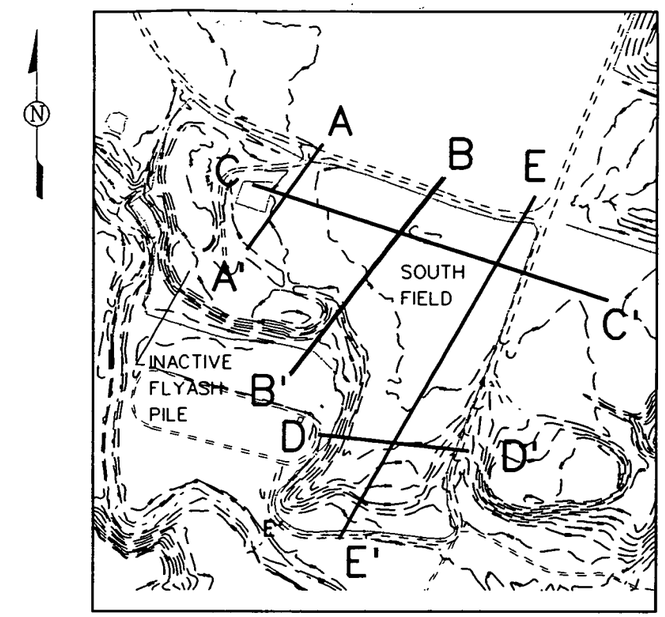
0 6 12 24

fs1131.dgn

000154

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





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.

000155

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

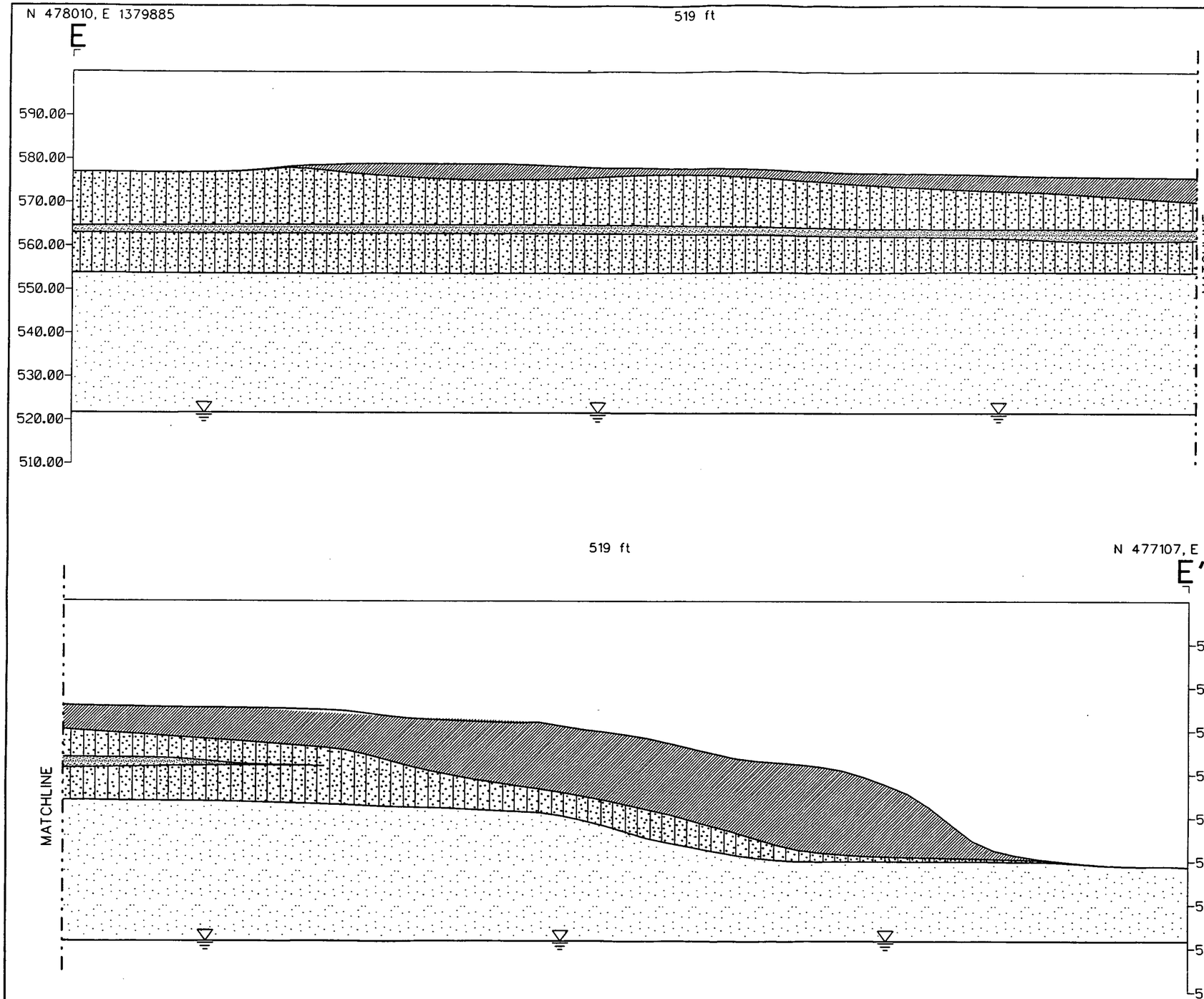
0 25 50 100

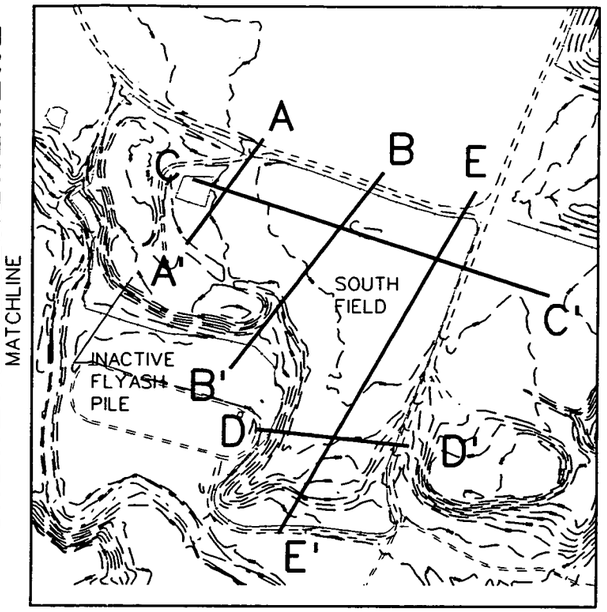
SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m

0 6 12 24

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

fsll46.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.

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

000156

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 900 m (3000 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. On a daily basis, the FEMP's two coal fired boilers combust an average of 40 tons of coal during the spring/summer and 87 tons of coal 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 (three to four 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 one to 12 m (three 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 (see Figure 1-18). The Active Flyash Pile has never been covered and surface vegetation is negligible.

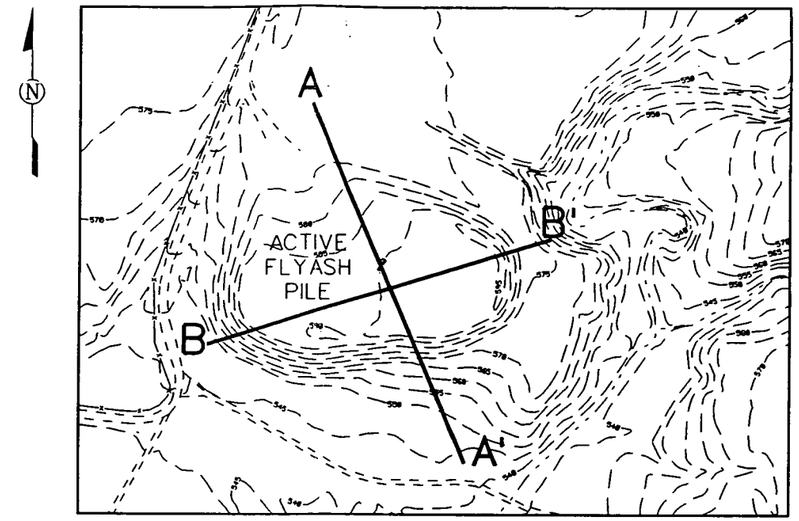
On June 4, 1992, interim control activities to provide protection against wind and storm water erosion from the piles surface were initiated. These control activities, described in greater detail in Section 1.8, included surface crusting agent application on the pile's steep side slopes and misting of 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

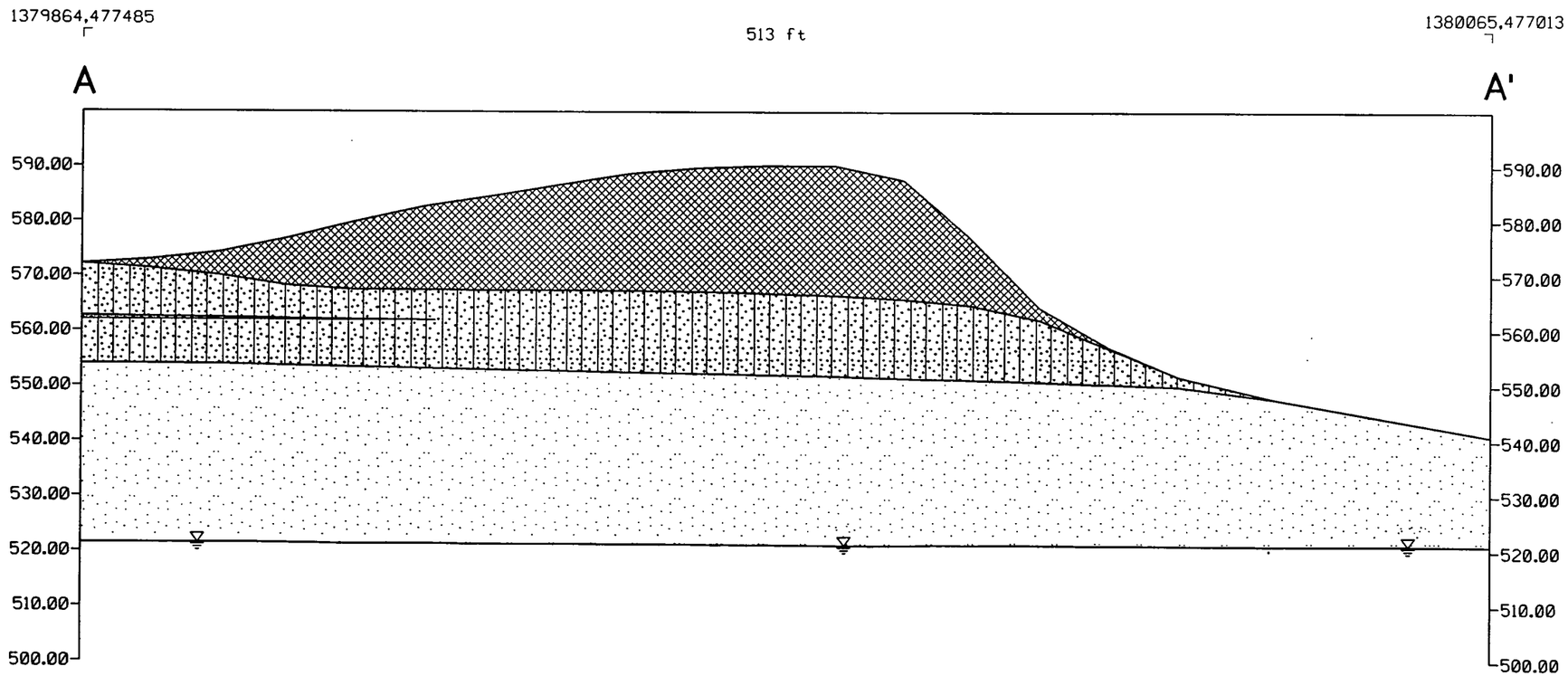
Boring logs from outside of the Active Flyash Pile's northern and southern perimeters indicate that a series of glacial till deposits overlie the Great Miami Aquifer to a maximum depth of approximately 20 ft at the northern end. The till deposits are comprised primarily of silty clay interbedded with lenses of clay and silt, sandy clay, silty sand, and poorly sorted gravels. The deposits generally decrease in thickness towards 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 (one to nine ft) below the natural ground surface at the pile's northern perimeter and from 0.6 to 2.1 m (two to seven ft) at the southern end. These measurements correspond to annual fluctuations of piezometric head of 1.5 and 2.4 m (five and eight 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



LOCATION KEY (1" = 200')



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.

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

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

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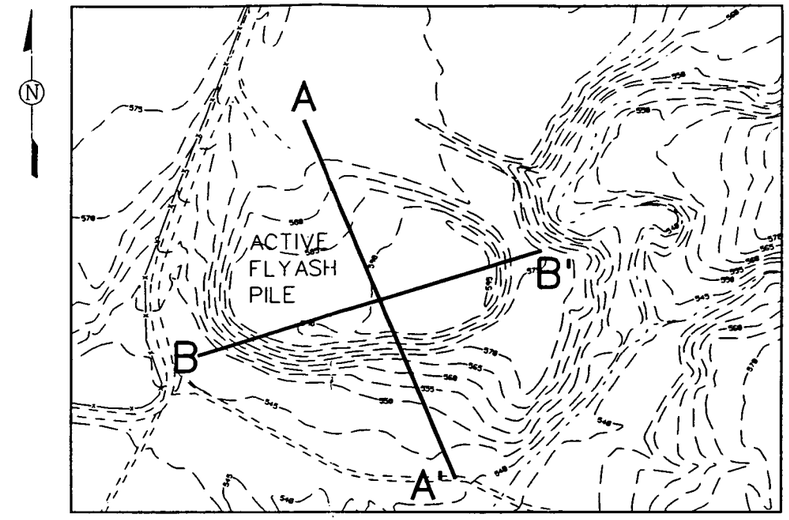

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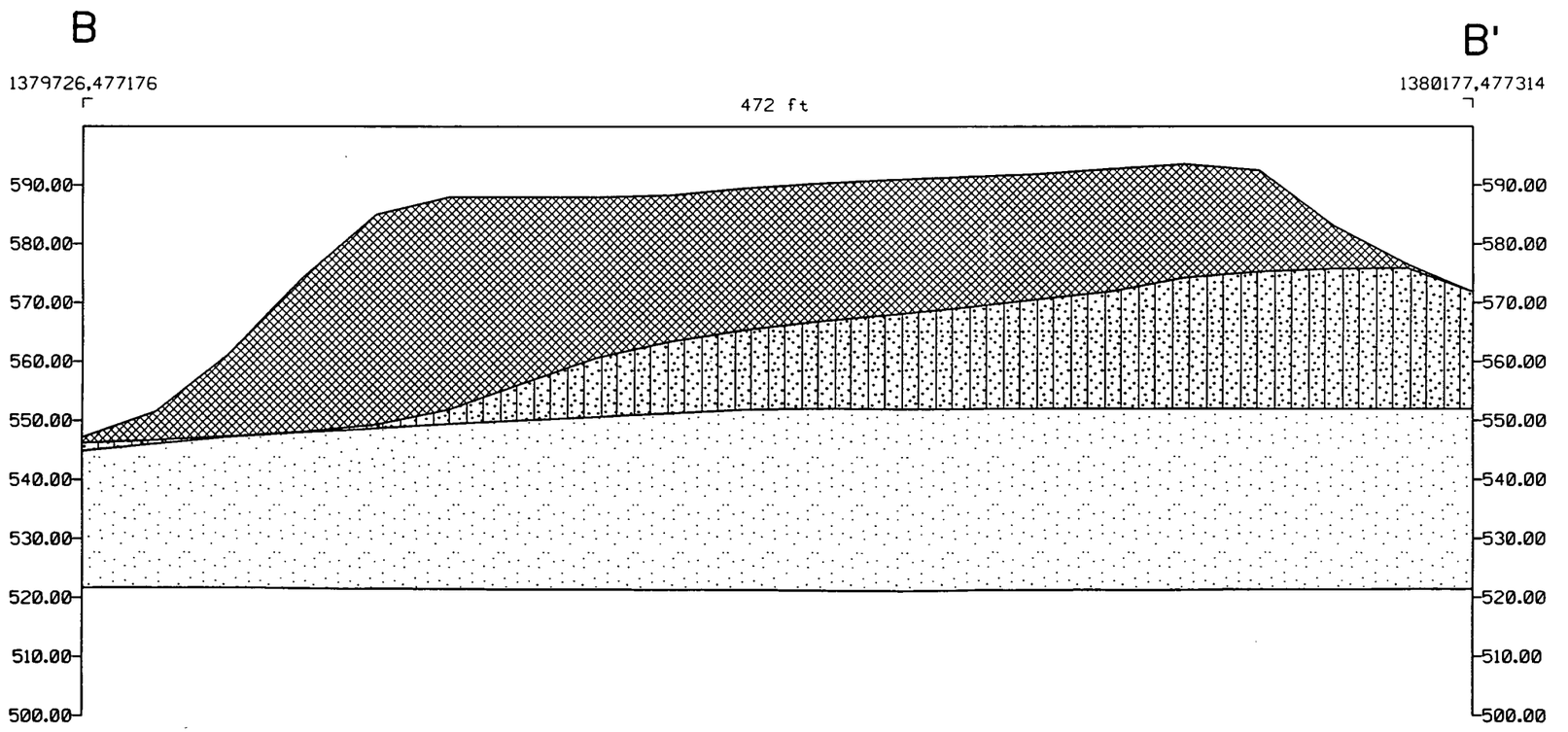

SCALE:
HORIZONTAL 1" = 50'
VERTICAL 1" = 25'

0 25 50 100

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

0 6 12 24

LEGEND

- 575 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.

000150

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

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divide line fluctuates depending on flow conditions, groundwater flow in the area generally occurs in a southeasterly direction. Groundwater Monitoring Wells No. 2048 and 2045 extending into the upper portion of the Great Miami Aquifer indicate a potentiometric surface that can vary annually from between 517 and 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 both 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 report including graphical summaries of analyte distribution by percent.

For this FS Report, the environmental samples have been organized according to the media classifications defined in Table 1-2. Note that several of these classifications are applicable for only one or two of the Operable Unit 2 subunits. For example, the Sludge classification is only applicable for the Lime Sludge Ponds. Sample lists that are 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 Report, 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

TABLE 1-2

DEFINITION OF MEDIA CLASSIFICATIONS

Media Classification	Description
Surface Soil	Soil samples collected on the surface at a depth of 0 - 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 Report.
Other Till	Soil samples classified as Till, but 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 (GMA) 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.

groundwater, and Great Miami Aquifer groundwater in Tables 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 complete discussion of the background data is developed 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 11,600 cu m (15,200 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 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.

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 surface to three m (10 ft) below ground level. The waste materials found at a depth of three 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 three m (10 ft) below ground surface, particularly in the southeast corner of the landfill.

TABLE 1-3

BACKGROUND CONCENTRATIONS FOR SOILS AND GROUNDWATER OPERABLE UNIT 2 REMEDIAL INVESTIGATION FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

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

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
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: Surface (0-6 inches)	Soils: Subsurface (36-42 and 48-54 inches combined)	Groundwater: Perched	Groundwater: 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	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.

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	4	4920	19.9		20.6	134687.5	218.0	199.4	382.2	148364.4	194.0

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- 5501

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	73.6		14.0		390.0	677.3		0.70	1040.0	85.0	4390.0	269.6

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

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Waste materials identified in the landfill included materials possibly originating from the cafeteria, the medical lab, maintenance/construction department, and from the production department. 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

Fifteen 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 was not detected in surface soil samples above background. Molybdenum and silver were consistently detected at concentrations that were ten 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. The radioisotope data suggest that material contaminated with radioisotopes has become part of the soil cover. 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, 41 organic, and radioisotopes of five elements and compounds were detected above background in 19 subsurface soil samples collected during Phase I from near-surface to six m (20 ft) deep. Twenty-three 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 ten ft into the glacial overburden beneath the landfill. Five dioxins 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

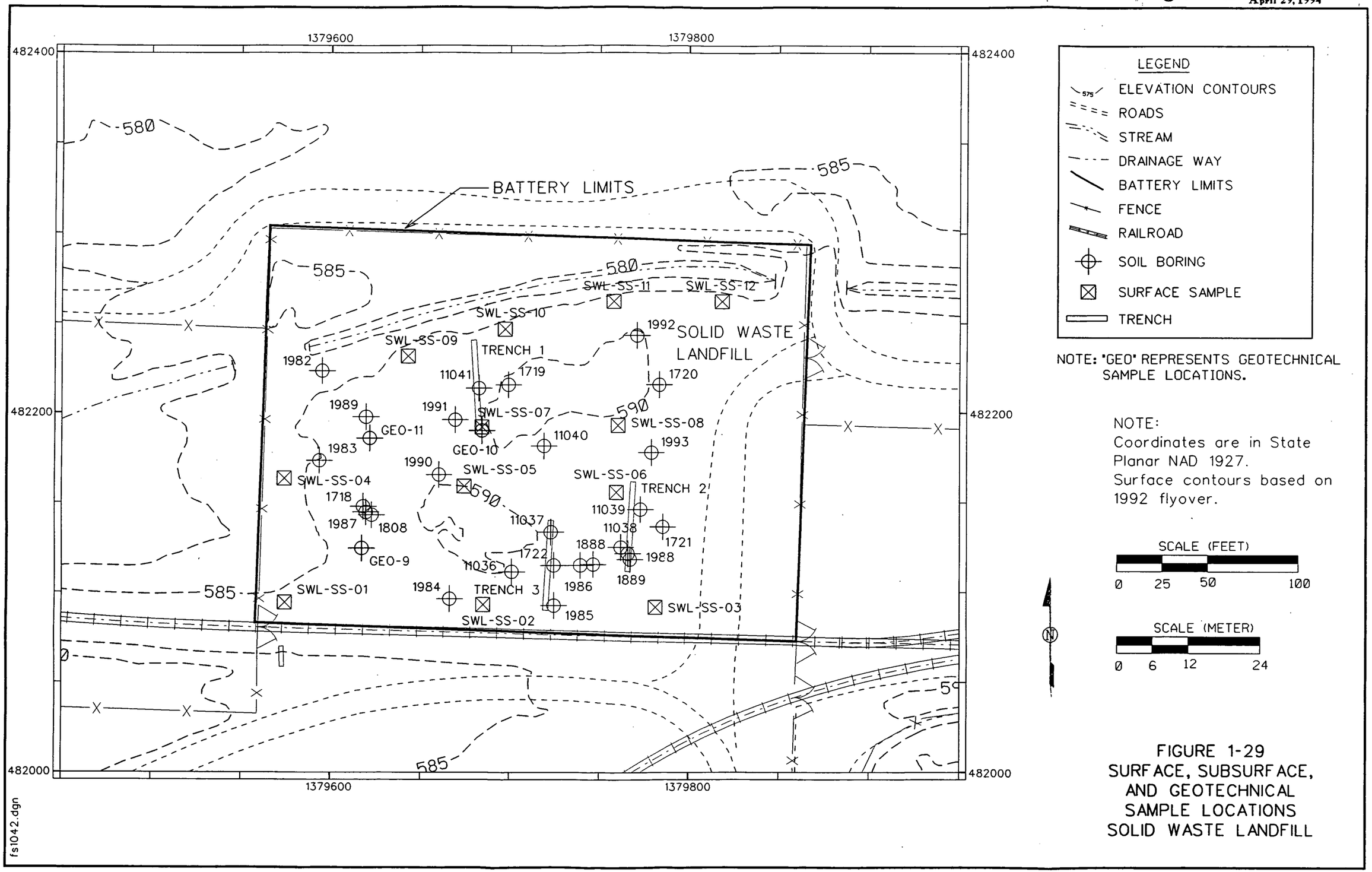


FIGURE 1-29
SURFACE, SUBSURFACE, AND GEOTECHNICAL SAMPLE LOCATIONS SOLID WASTE LANDFILL

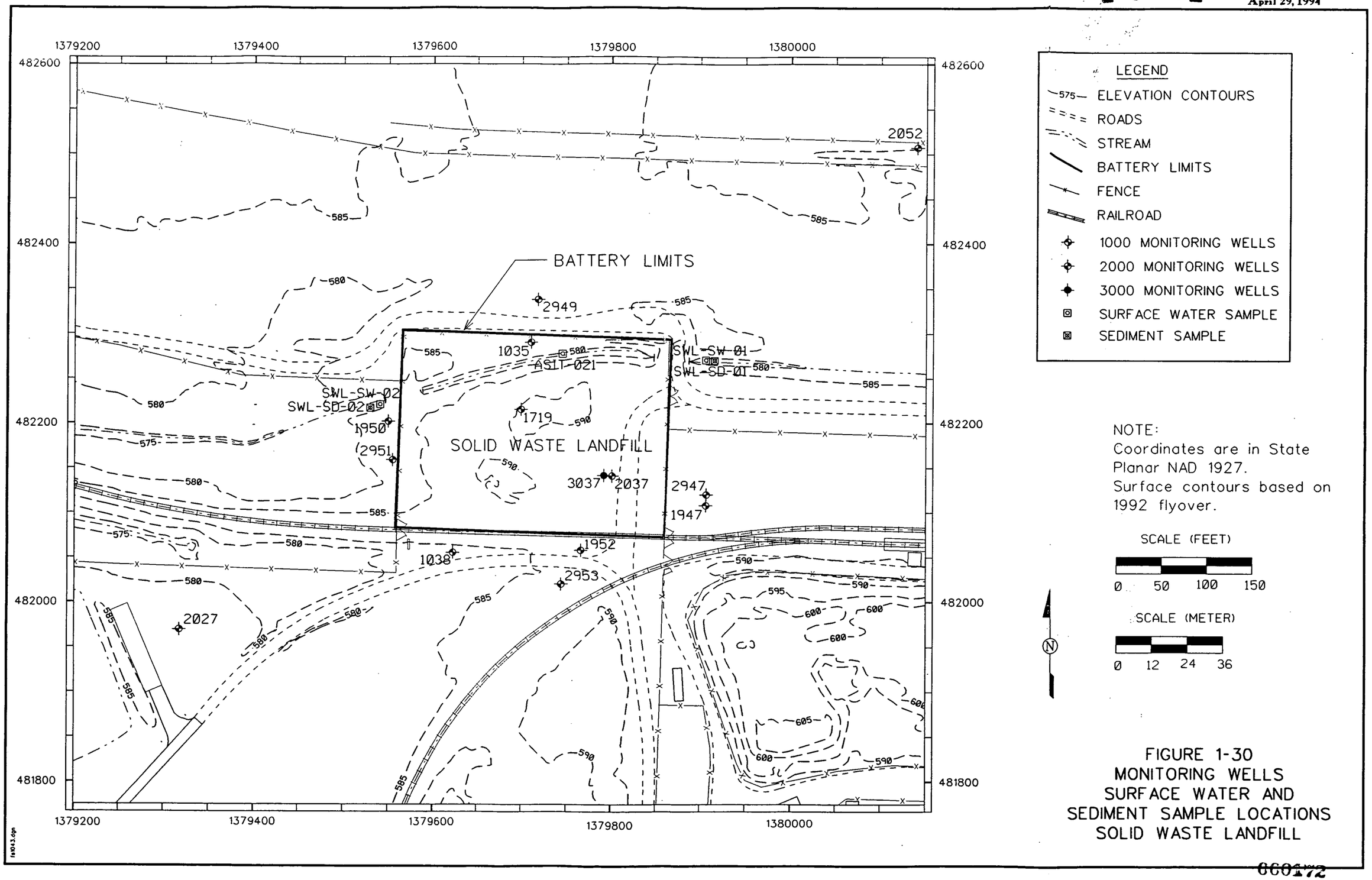
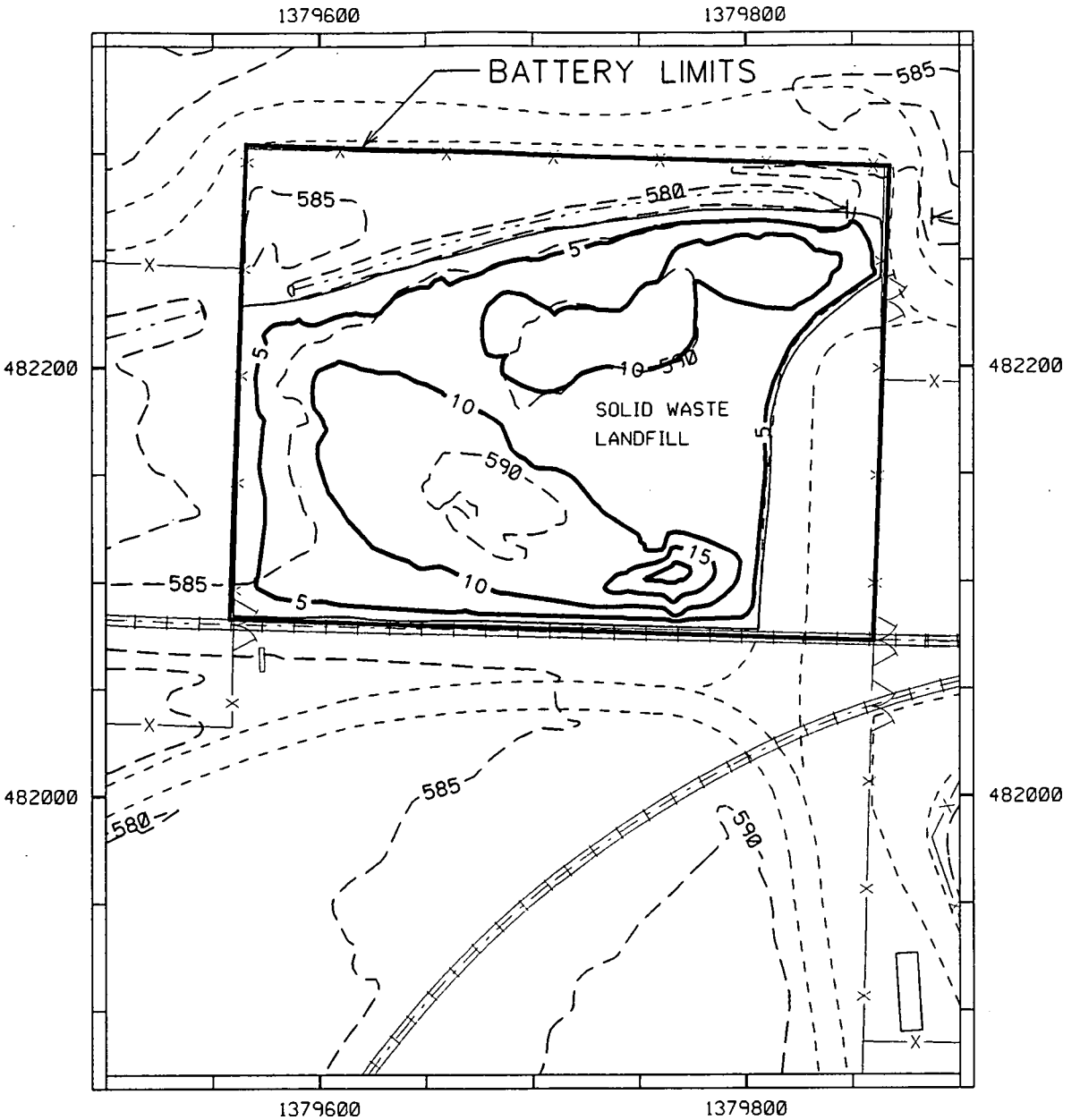


FIGURE 1-30
MONITORING WELLS
SURFACE WATER AND
SEDIMENT SAMPLE LOCATIONS
SOLID WASTE LANDFILL



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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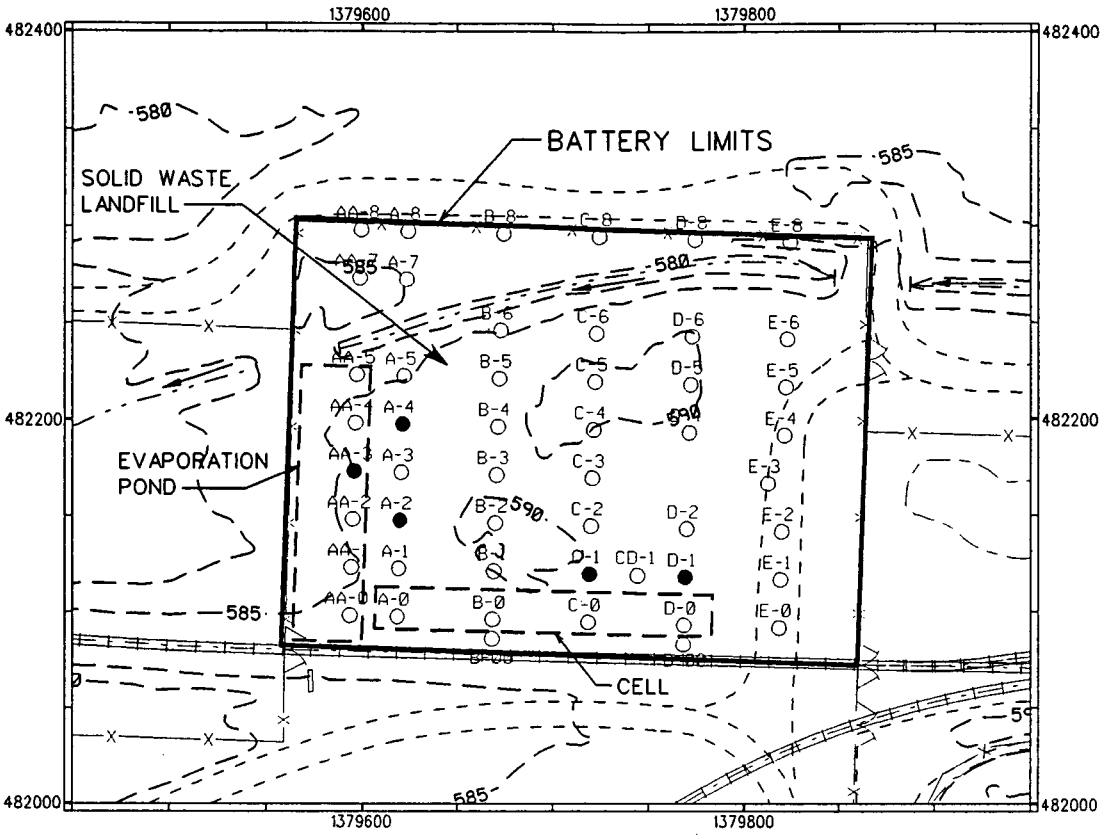

LEGEND

- 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.

N

SCALE (FT)
0 25 50 100 150 200

SCALE (METER)
0 12 24 48 72 96

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

kilogram (mg/kg) to 13.7 microgram per kilogram (μg/kg). Aroclor-1254 and Aroclor-1260 were also detected, but the large number of dioxin detections suggests that the source may be trace contaminants in organic chemicals other than Aroclors.

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.

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

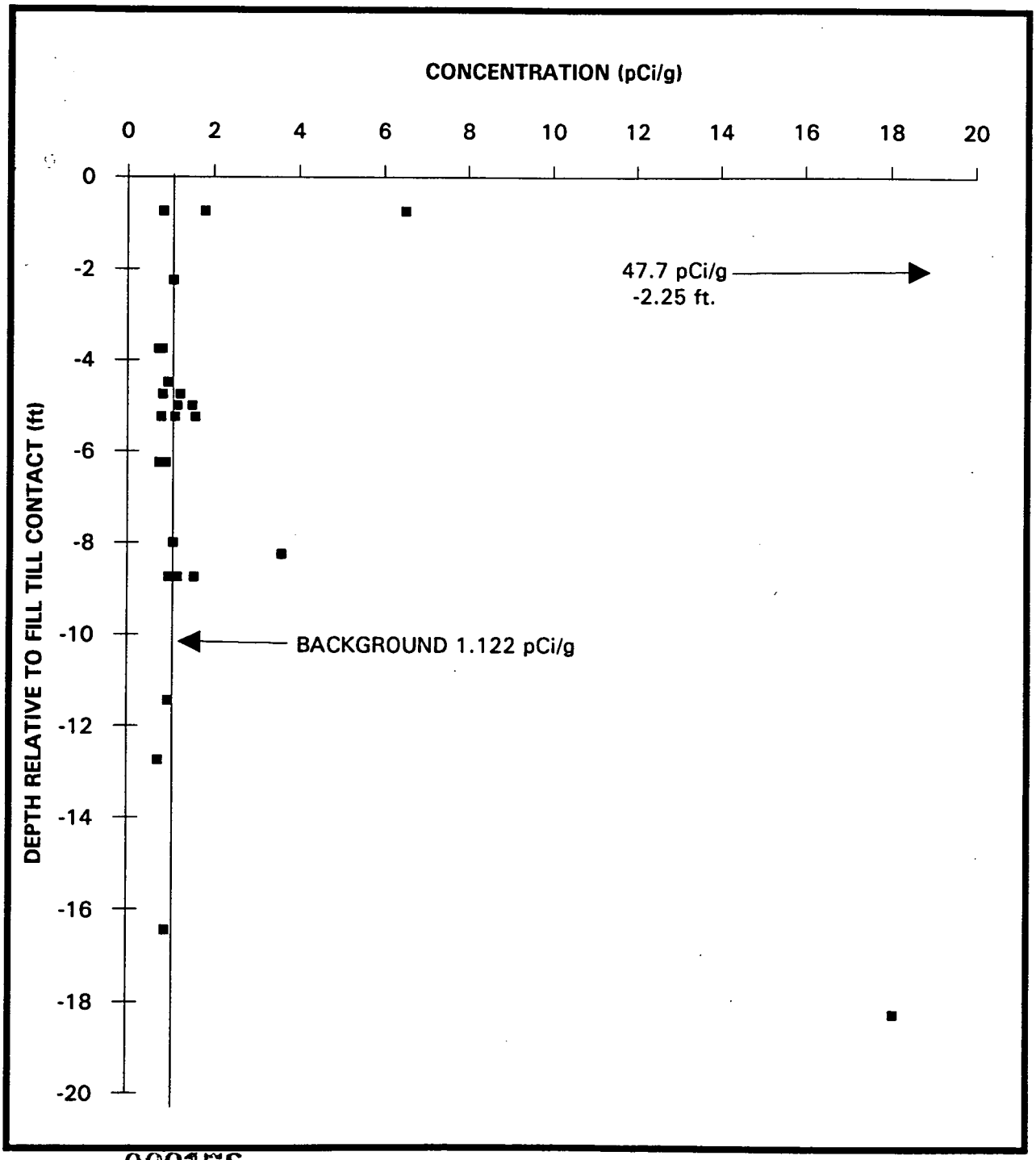

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TABLE 1-5

CONTAMINANTS OF CONCERN, SURFACE SOILS
SOLID WASTE LANDFILL

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
METALS							
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
Chromium	12	12	8.2	19.9	13.3[a]	mg/kg	15.5
RADIONUCLIDES							
Cesium-137	12	5	0.1	0.3	0.1	pCi/g	0.3
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
Technetium-99	12	0	N/A[a]	N/A	0.2	pCi/g	N/A
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
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							
4,4'-DDE	12	1	12.0	12.0	2.9	ug/kg	12.0
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
Carbazole	12	1	77.0	77.0	196.4	ug/kg	77.0
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]Not Applicable

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							
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
Chromium	40	40	4.0	51.8	17.7[a]	mg/kg	20.6
RADIONUCLIDES							
Cesium-137	43	11	0.07	0.5	0.1	pCi/g	0.3
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
Technetium-99	42	3	0.8	5.1	0.4	pCi/g	0.8
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
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							
4,4'-DDE	40	1	12.0	12.0	8.0	ug/kg	12.0
Benzo(a)pyrene	39	26	47.0	260000.0	7472.8	ug/kg	13000.0
Benzo(b)fluoranthene	39	26	49.0	220000.0	6403.7	ug/kg	15000.0
Carbazole	31	11	58.0	89000.0	3177.3	ug/kg	4200.0
Dibenzo(a,h)anthracene	38	15	40.0	79000.0	2324.7	ug/kg	3000.0
Indeno(1,2,3-cd)pyrene	38	23	45.0	150000.0	4468.8	ug/kg	6500.0

[a]Estimated Mean

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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							
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
Chromium	25	25	6.8	29.8	15.4[a]	mg/kg	18.3
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
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
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)pyrene	25	2	290.0	760.0	221.0	ug/kg	290.0
Benzo(b)fluoranthene	25	3	150.0	1200.0	236.0	ug/kg	260.0
Carbazole	18	1	210.0	210.0	193.1	ug/kg	210.0
Dibenzo(a,h)anthracene	25	2	110.0	180.0	190.6	ug/kg	110.0
Indeno(1,2,3-cd)pyrene	25	2	210.0	410.0	203.8	ug/kg	210.0

[a]Estimated Mean

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APR 29, 1994
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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: This is the unsaturated zone.

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.

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. Seven 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.

Six 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.

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 12 metals/inorganics, isotopes of four elements, and no organic

compounds that exceeded the background concentrations. During Phase II, concentrations of 12 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 Monitor 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 12 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 five elements, and one organic compound 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). These data indicate that there has been no impact from the subunit on the regional aquifer. 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 1037 was improperly completed and may provide a pathway for contaminant leakage to the Great Miami Aquifer. A water level hydrograph prepared for Monitoring

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										
Technetium-99	Filtered	2	0	N/A[a]	N/A	9.6	11.0	-	pCi/L	N/A
Technetium-99	Unfiltered	14	0	N/A	N/A	8.1	30.3	-	pCi/L	N/A
ORGANICS										
Carbazole	Unfiltered	4	0	N/A	N/A	N/A	N/A	-	μg/L	N/A

[a]Not Applicable

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Well 1037 showed water levels to vary from 549.76 to 555.8 ft 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, pre-construction engineering drawings, and interpolation completed by using Intergraph Corporation Microstation PC software, is calculated to be approximately 12,600 cu m (16,500 cu yd) (Figure 1-36). The K-65 slurry line trench that is 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 from the roadway at the north boundary during Phase II sampling. Seventeen 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.

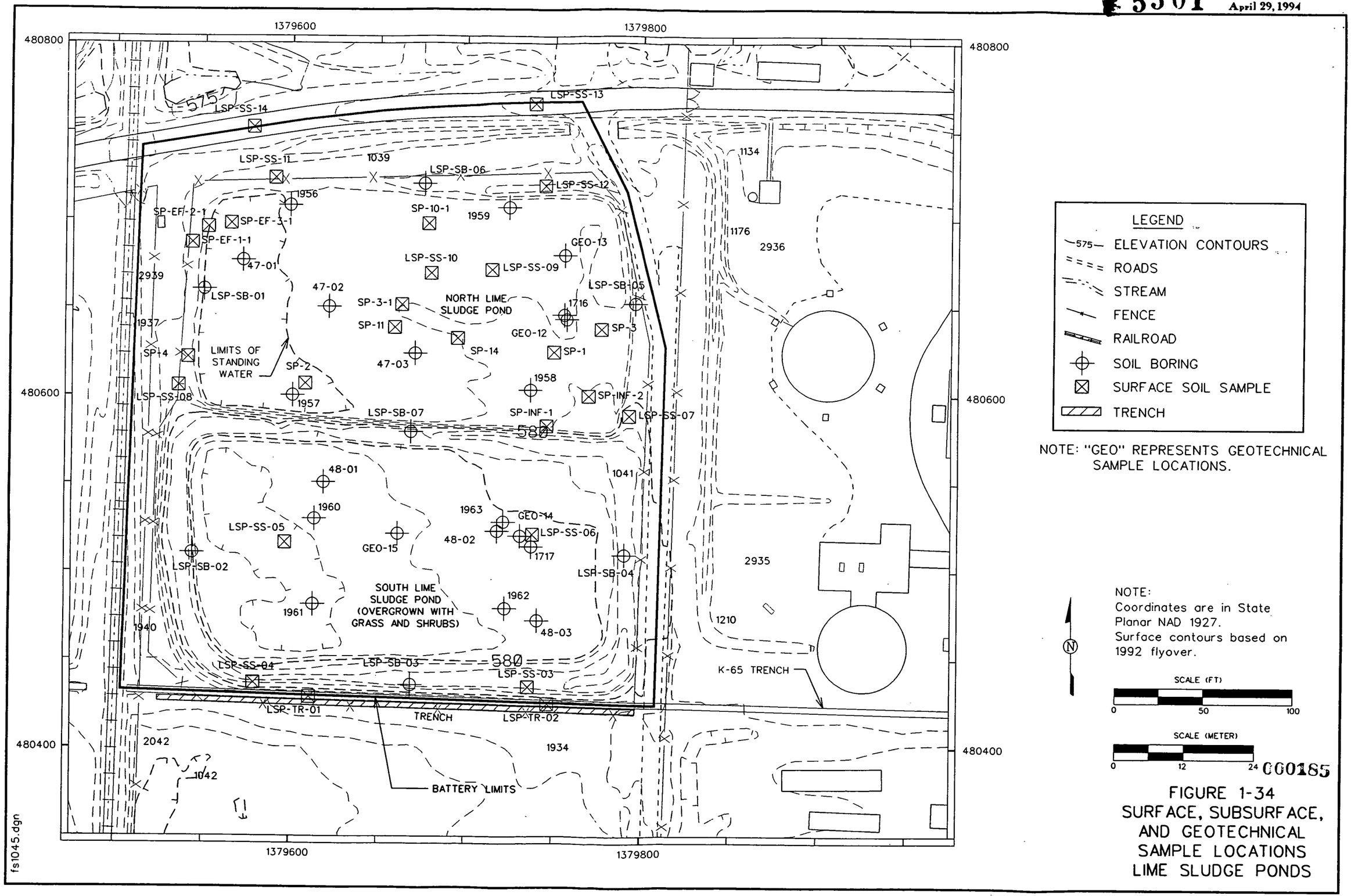

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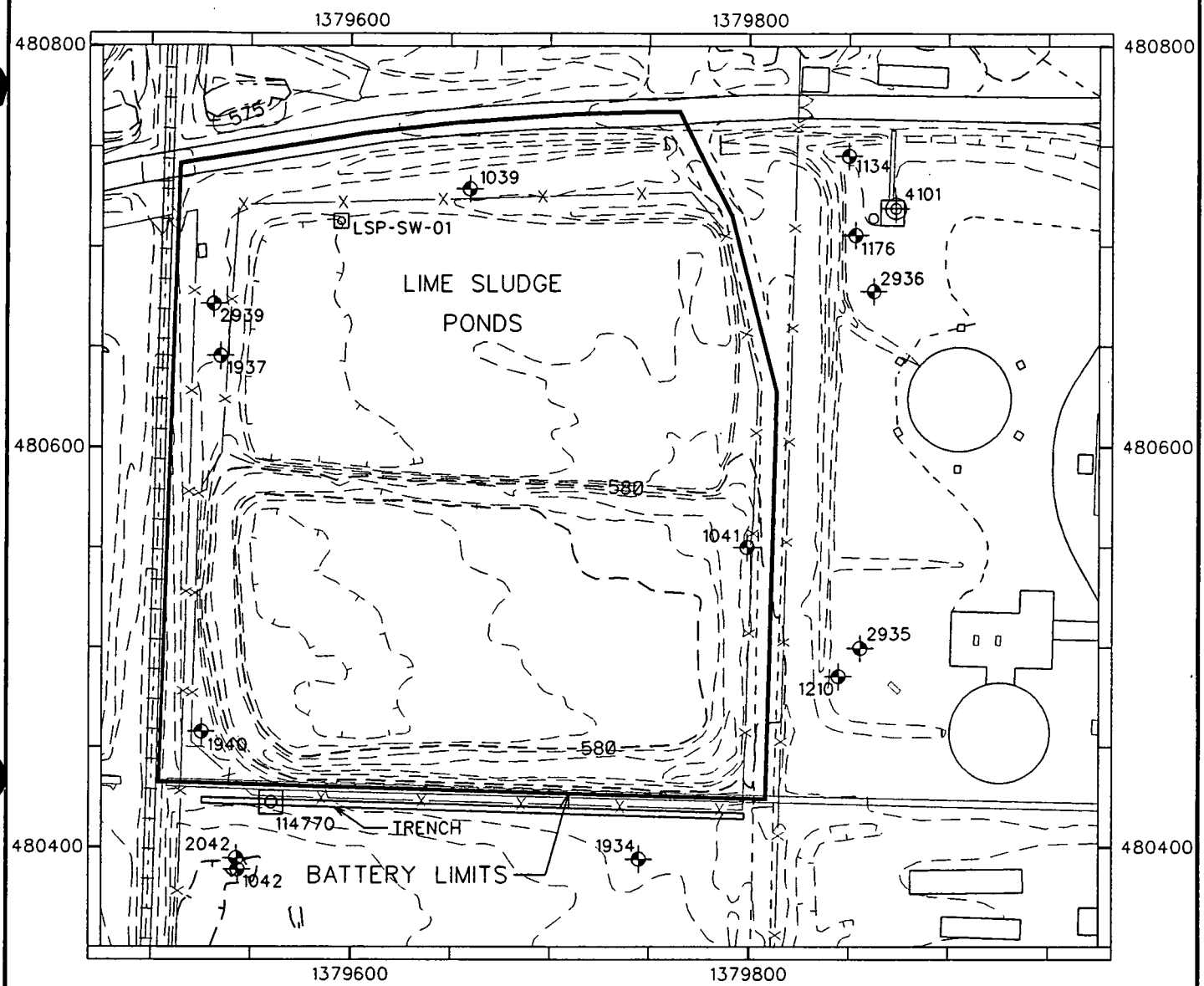
FIGURE 1-34
SURFACE, SUBSURFACE,
AND GEOTECHNICAL
SAMPLE LOCATIONS
LIME SLUDGE PONDS



LEGEND

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

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

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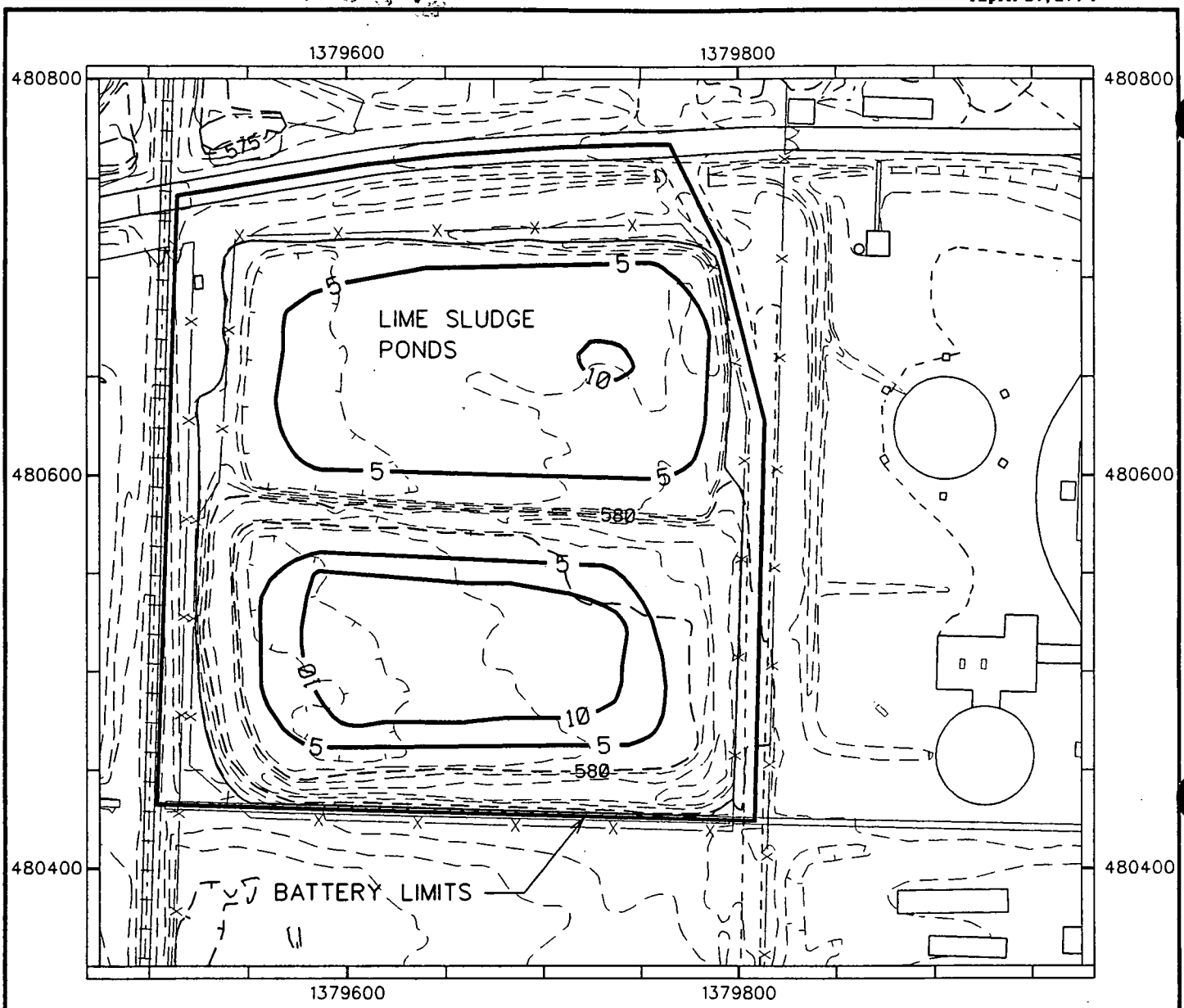

LEGEND

- 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 copper (three of seven samples) and beryllium (three of seven samples). Soil samples collected from beneath the sludge exceeded background concentrations for copper (five of nine samples), beryllium (six of nine samples), zinc (three of nine samples), and arsenic (two of nine samples). A comparison of sludge data with data from soil underlying the sludge indicates that copper, beryllium, and zinc from the sludge have impacted the underlying soil.

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 concentrations. 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 as 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. 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.

In order 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 ten 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 since 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

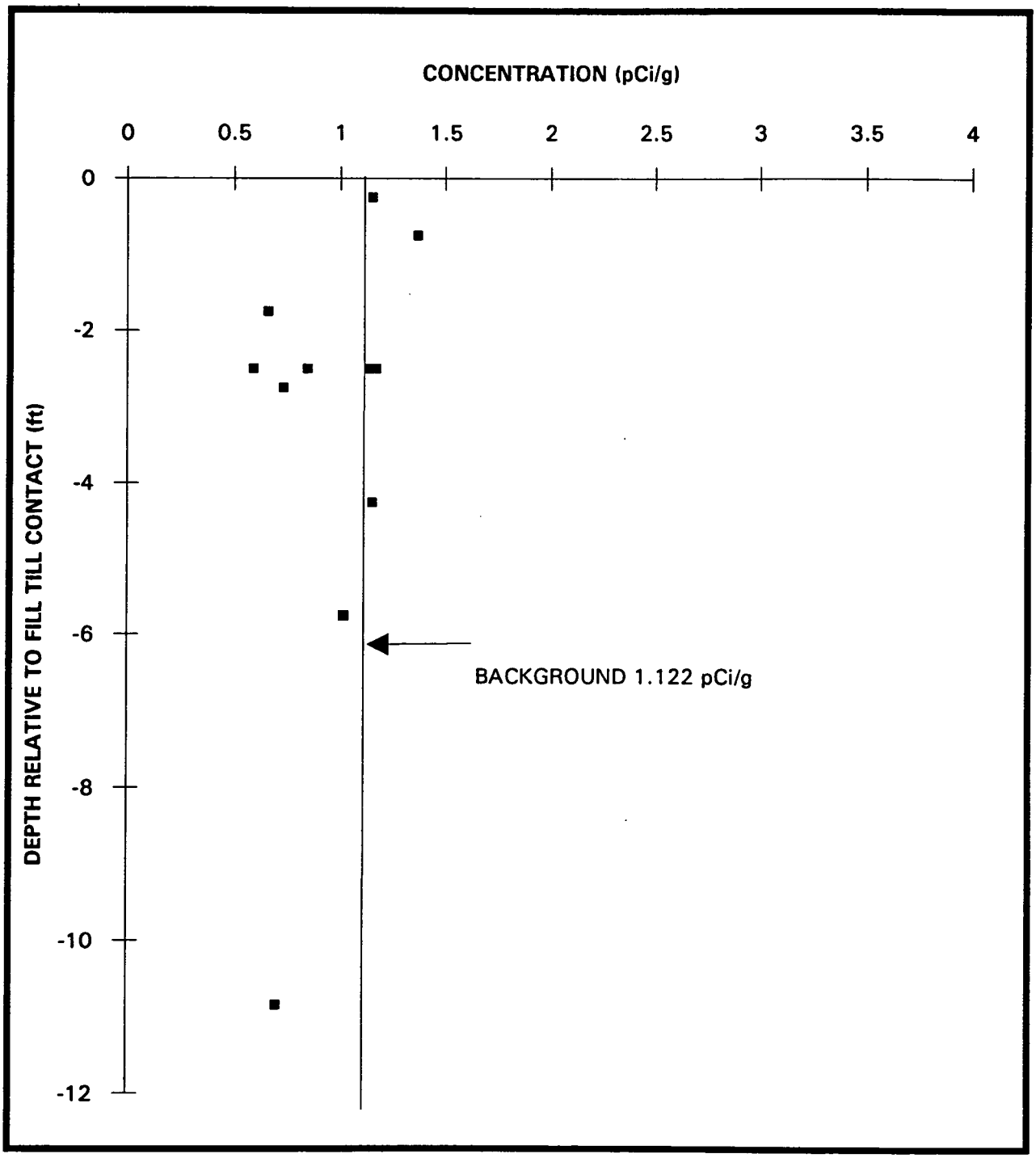

TABLE 1-10

CONTAMINANTS OF CONCERN, SURFACE SOILS
LIME SLUDGE PONDS

Parameter	# of Samples	# of Hits	Min. Hit	Max. Hit	Mean	Units	Conc. Term
METALS							
Arsenic	12	12	3.5	9.5	6.4	mg/kg	7.4
Beryllium	12	10	0.47	2	1.2	mg/kg	1.6
ORGANICS							
Aroclor-1254	12	3	43	590	80.3	µg/kg	590.0
Benzo(a)pyrene	12	3	1	1100	359.7	µg/kg	1100.0
Benzo(b)fluoranthene	12	3	2	1000	339.8	µg/kg	1000.0
Dibenzo(a,h)anthracene	12	2	240	320	262.5	µg/kg	320.0
Indeno(1,2,3-cd)pyrene	12	2	580	720	324.2	µg/kg	720.0
RADIONUCLIDES							
Cesium-137	12	9	0.06	0.9	0.3[a]	pCi/g	0.7
Neptunium-237	12	12	0.04	0.7	0.3[a]	pCi/g	0.8
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
Technetium-99	12	0	N/A[a]	N/A	N/A	pCi/g	N/A
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
Uranium-234	12	12	1.1	26.5	8.9[a]	pCi/g	21.0
Uranium-235/236	12	12	0.03	1.83	0.6[a]	pCi/g	1.7
Uranium-238	12	12	0.9	84	16.9[a]	pCi/g	71.4

[a]Estimated Mean
[b]Not Applicable

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							
Arsenic	15	15	1.7	11.2	5.2[a]	mg/kg	7.2
Beryllium	15	8	0.4	1.5	0.5	mg/kg	0.7
RADIONUCLIDES							
Cesium-137	15	4	0.03	0.1	0.1	pCi/g	0.1
Neptunium-237	7	7	0.04	0.6	0.2[a]	pCi/g	0.6
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
Technetium-99	13	1	0.9	0.9	0.3	pCi/g	0.9
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
Uranium-234	15	15	0.9	6.1	2.2[a]	pCi/g	3.0
Uranium-235/236	15	13	0.03	1.0	0.2[a]	pCi/g	0.4
Uranium-238	15	15	0.7	6.7	2.2[a]	pCi/g	3.1
ORGANICS							
Benzo(a)pyrene	15	0	N/A[b]	N/A	367.7	μg/kg	N/A

[a]Estimated Mean

[b]Not Applicable

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							
Arsenic	10	10	1.1	14.6	7.3[a]	mg/kg	14.9
Beryllium	10	3	0.7	0.9	0.4	mg/kg	0.9
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
Technetium-99	11	0	N/A[b]	N/A	0.3	pCi/g	N/A
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
Uranium-234	11	11	0.6	1.3	1.0	pCi/g	1.1
Uranium-235/236	11	9	0.03	0.1	0.08[a]	pCi/g	0.1
Uranium-238	11	11	0.6	1.4	1.0	pCi/g	1.1
ORGANICS							
Benzo(a)pyrene	10	0	N/A	NA/	209.5	µg/kg	N/A

[a]Estimated Mean
[b]Not Applicable

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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							
Arsenic	20	20	5.1	8.8	7.1	mg/kg	7.7
Beryllium	20	18	0.6	2.1	1.3	mg/kg	1.6
RADIONUCLIDES							
Cesium-137	21	14	0.06	0.3	0.1[a]	pCi/g	0.2
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
Technetium-99	20	2	1.1	1.8	0.3	pCi/g	1.1
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
Uranium-234	21	21	2.7	19.5	5.9	pCi/g	13.4
Uranium-235/236	21	20	0.1	1.3	0.3	pCi/g	0.8
Uranium-238	21	21	2.8	20.4	6.8[a]	pCi/g	8.4
ORGANICS							
Aroclor-1254	22	1	43	43	21.6	µg/kg	43.0
Benzo(a)pyrene	21	2	1	350	201.0	µg/kg	1.0
Benzo(b)fluoranthene	21	3	2	500	200.3	µg/kg	55.0
Dibenzo(a,h)anthracene	21	1	110	110	198.8	µg/kg	110.0
Indeno(1,2,3-cd)pyrene	21	1	210	210	203.6	µg/kg	210.0

[a]Estimated Mean

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	N/A[b]	N/A	0.5	pCi/g	N/A
Thorium-230	1	1	1.3	1.3	1.3	pCi/g	1.3

[a]Estimated Mean

[b]Not Applicable

Note: This is the unsaturated zone.

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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	-[a]	mg/L	10	3	0.01	0.2	0.1
1,1-Dichloroethene	0.7	-	mg/L	9	1	0.011	0.011	0.011
1,2-Dichloroethane	0.5	-	mg/L	10	0	0	0	0
2-Butanone	200.0	-	mg/L	10	3	0.006	0.031	0.021
Benzene	0.5	-	mg/L	10	0	0	0	0
Carbon Tetrachloride	0.5	-	mg/L	10	0	0	0	0
Chlorobenzene	100.0	-	mg/L	10	0	0	0	0
Chloroform	6.0	-	mg/L	10	0	0	0	0
Pyridine	5.0	-	mg/L	8	0	0	0	0
Tetrachloroethene	0.7	-	mg/L	10	1	0.002	0.002	0.002
Trichloroethene	0.5	-	mg/L	10	0	0	0	0
Vinyl chloride	0.2	-	mg/L	10	0	0	0	0
1,4-Dichlorobenzene	7.5	-	mg/L	8	0	0	0	0
2,4,5-Trichlorophenol	400.0	-	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	-	mg/L	8	0	0	0	0
2,4-Dinitrotoluene	0.13	-	mg/L	8	0	0	0	0
Hexachlorobenzene	0.13	-	mg/L	8	0	0	0	0
Hexachlorobutadiene	0.5	-	mg/L	8	0	0	0	0
Hexachloroethane	3.0	-	mg/L	8	0	0	0	0
Nitrobenzene	2.0	-	mg/L	8	0	0	0	0
Pentachlorophenol	100.0	-	mg/L	8	0	0	0	0
Total Methylphenol	200.0	-	mg/L	8	0	0	0	0
2,4,5-TP (Silvex)	1.0	-	mg/L	10	0	0	0	0
2,4-D	10.0	-	mg/L	10	0	0	0	0
Chlordane	0.03	-	mg/L	6	0	0	0	0
Endrin	0.02	-	mg/L	10	0	0	0	0
Heptachlor	0.008	-	mg/L	10	0	0	0	0
Heptachlor epoxide	0.008	-	mg/L	10	0	0	0	0
Methoxychlor	10.0	-	mg/L	10	0	0	0	0
Toxaphene	0.5	-	mg/L	10	0	0	0	0
alpha-Chlordane	0.03	-	mg/L	4	0	0	0	0
gamma-BHC (Lindane)	0.4	-	mg/L	10	0	0	0	0
gamma-Chlordane	0.03	-	mg/L	4	0	0	0	0

[a]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 as Table D-2G through Table D-2I. A comparison of concentrations in upgradient Well 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 1041) and downgradient (Well 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 1042 (30.4 μg/L) and Well 1934 (17.5 μg/L) relative to the upgradient Well 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 1039 (0.251 and less than 0.183 pCi/L, respectively) and relative to upgradient Well 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.

Phase I sampling of one 2000-series well detected one metal, 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 exceeded slightly in Well 2042 (3.39 μg/L) and Well 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 73,300 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 detected concentrations of various analytes. 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 two m (seven foot) 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 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 to the till surface beneath the flyash at Hydropunch™ 11006, 11051, 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 to the interface of flyash and glacial overburden materials near the center of the Inactive Flyash Pile.

Surface and Subsurface Media

Fourteen 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 nine 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-four 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, mercury, cyanide, molybdenum, selenium, and silver. Phase II metal samples displayed elevated copper, lead, and mercury concentrations associated with a sludge material found at 5.8 to 7.3 m (19 to 24 ft) depths 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),

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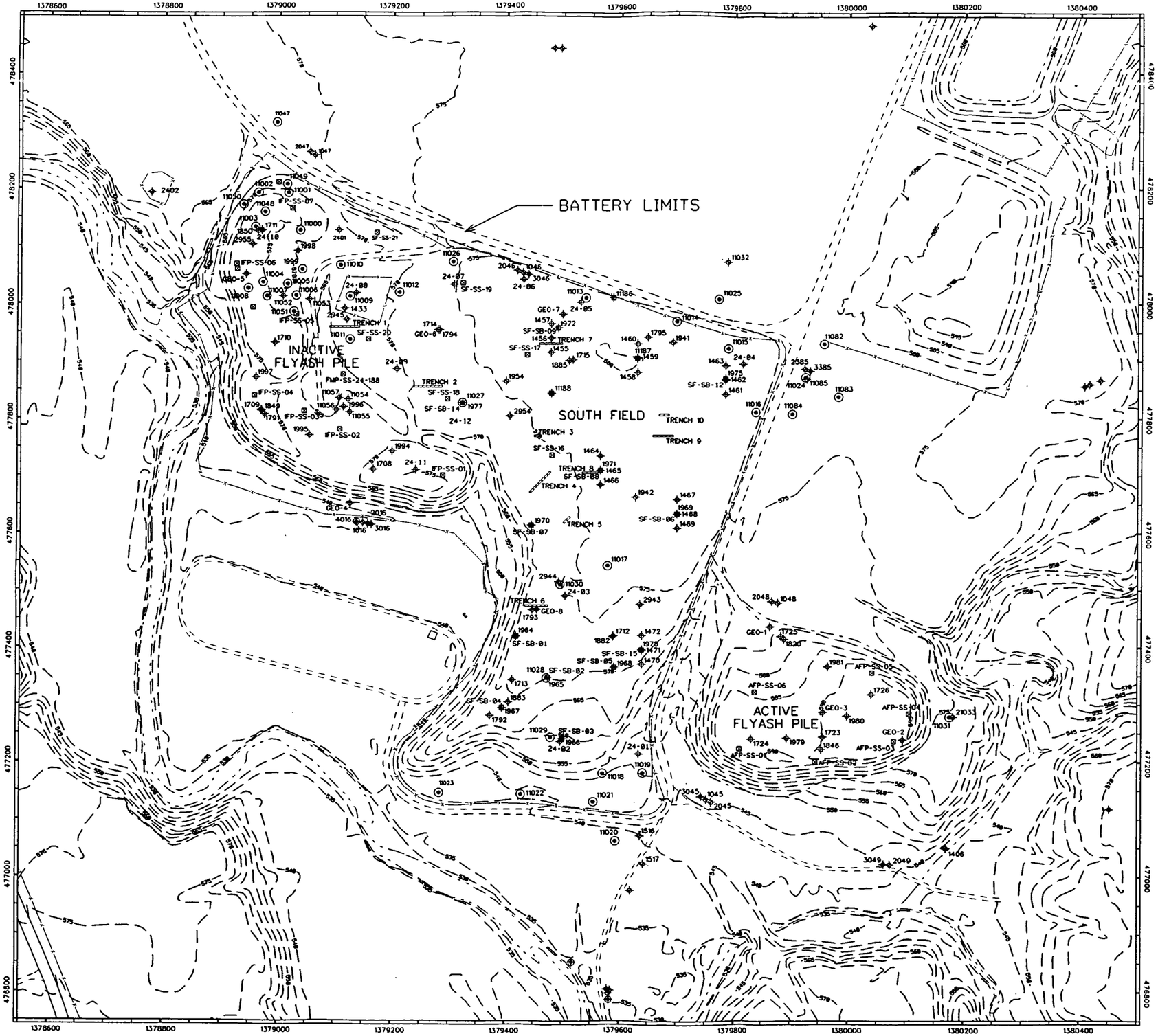

LEGEND

- 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.

SCALE (FT)
0 200 400

SCALE (METER)
0 48 38.4

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

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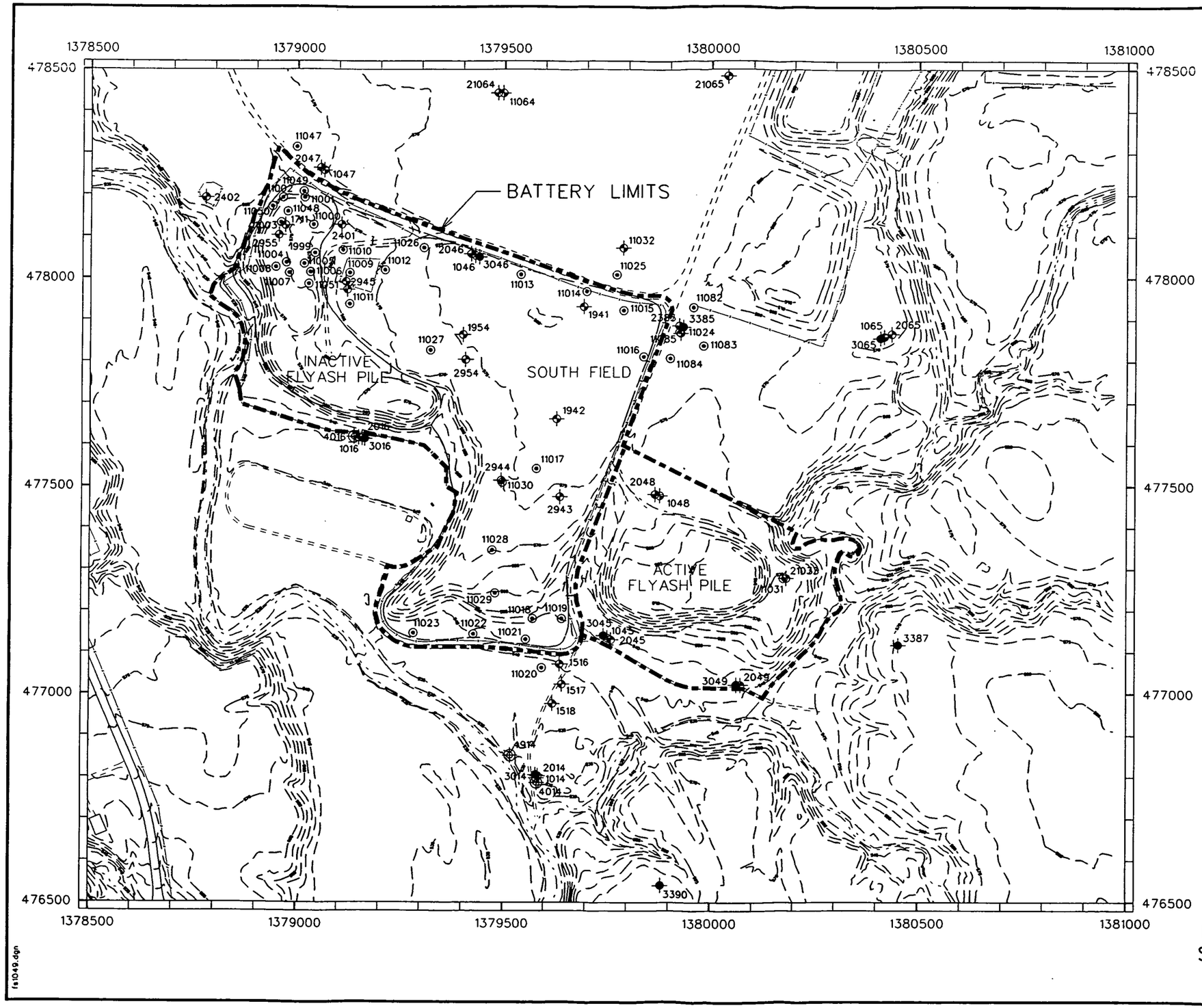

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- RAILROAD
- 1000 MONITORING WELLS
- 2000 MONITORING WELLS
- 3000 MONITORING WELLS
- 4000 MONITORING WELLS
- HYDROPUNCH

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

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

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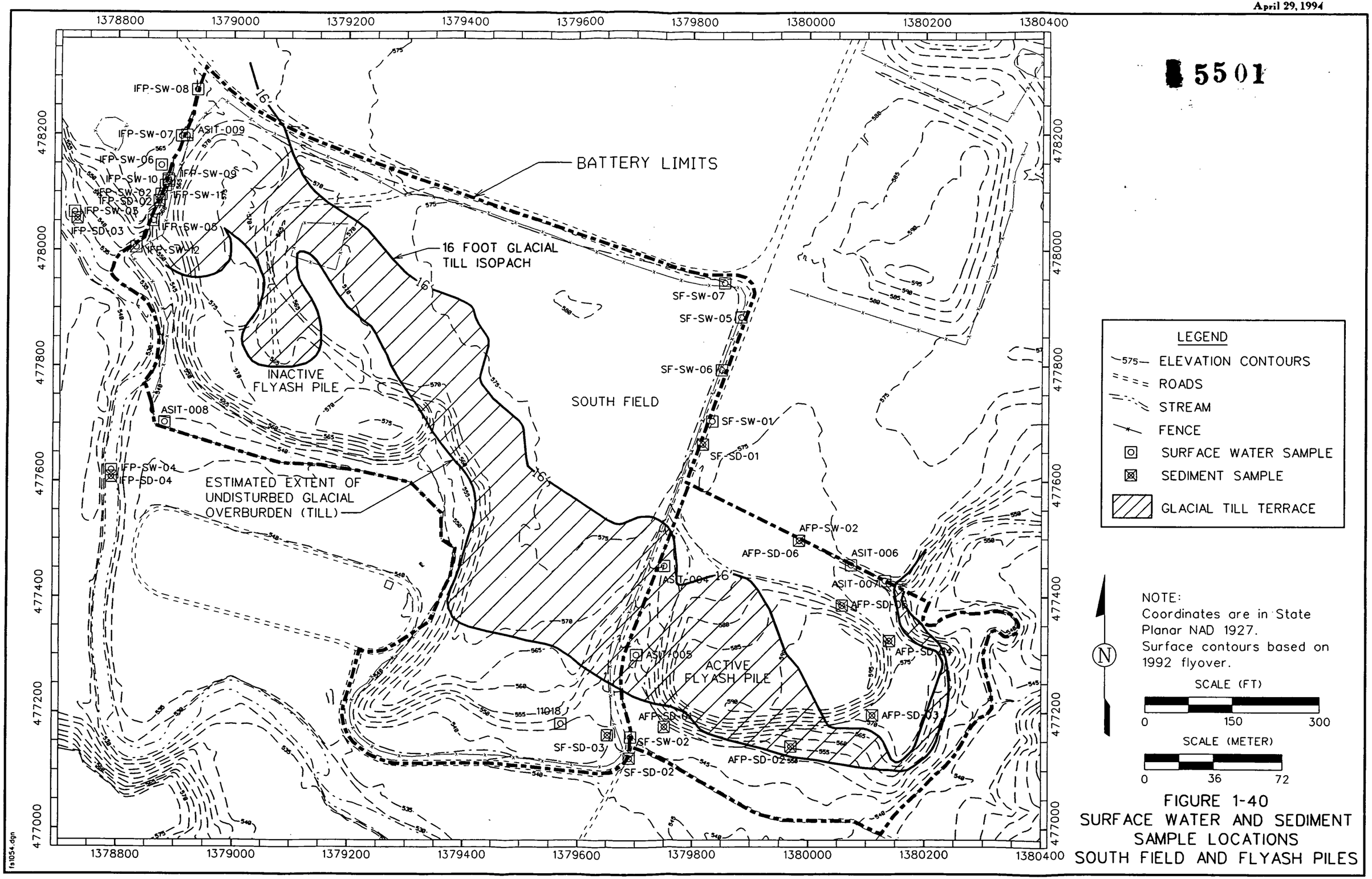

FIGURE 1-40
SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS
SOUTH FIELD AND FLYASH PILES

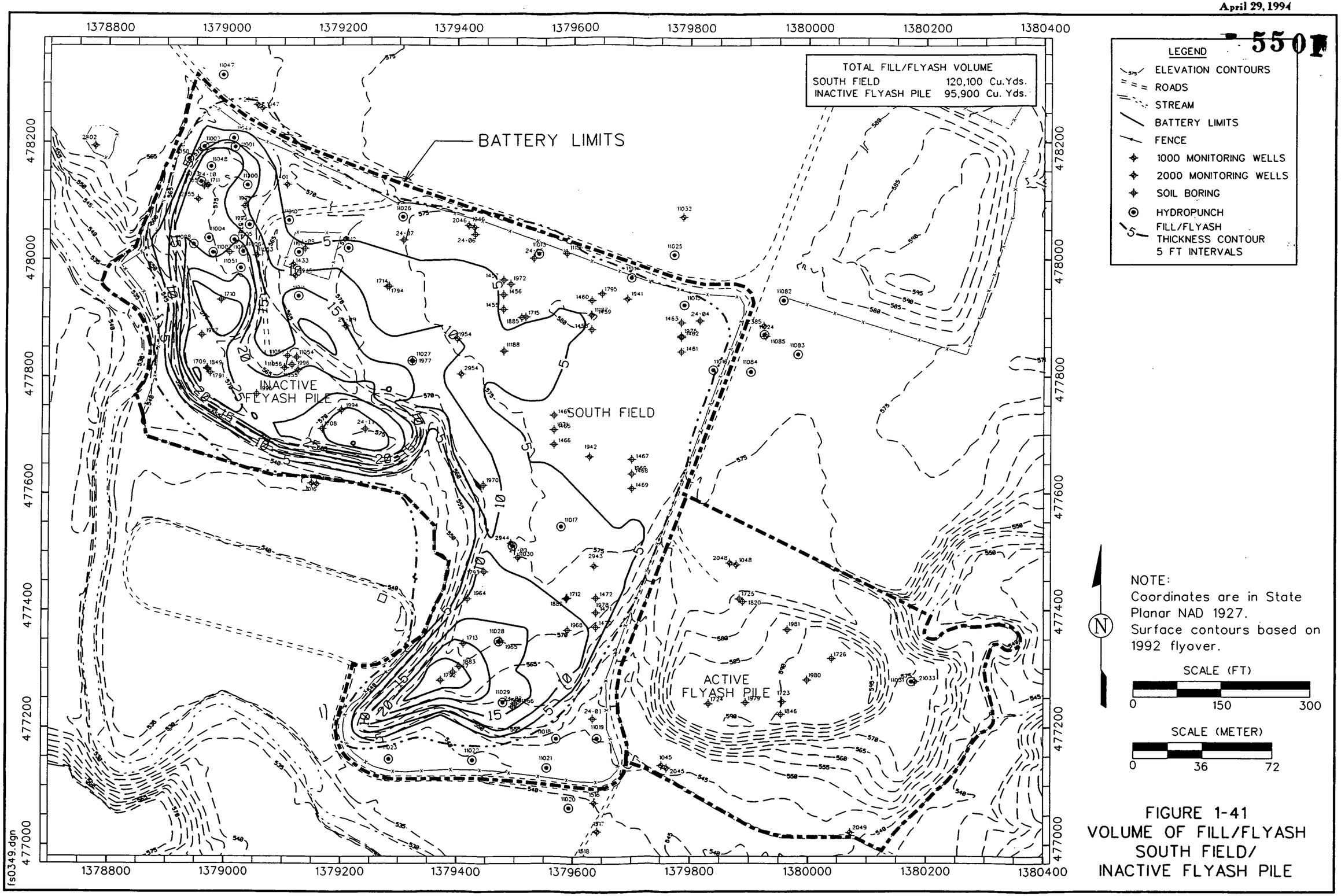

FIGURE 1-41
VOLUME OF FILL/FLYASH
SOUTH FIELD/
INACTIVE FLYASH PILE

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 six to 7.3 m (20 to 24 foot) depths near Hydropunch™ 11006. This depth corresponds to the original till surface and may be the surface upon which 1950 era waste material was deposited. Samples from this depth 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 five m (16-foot) 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 nine of 16 samples throughout the Inactive Flyash Pile and at variable depths. The most common semi-volatile was 2-methylnaphthalene, which was detected in four of 16 samples. Phase II samples detected TCA in ten of 30 samples and also detected acetone (ten samples) and toluene (19 samples). Bis(2-ethylhexyl) phthalate was the most common semivolatile and was detected in 22 of 30 samples while 2-methylnaphthalene was detected once in 30 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 (two 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 (two 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 two 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 1-16 through 1-20. 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 analysis for metals are shown in Table 1-21. No analyses detected concentrations that exceeded the RCRA standard for hazardous waste (40 CFR § 261.24). Likewise, no detected concentrations exceeded the Ohio Exempt Waste Standard (OEPA Policy 4.07 - Design

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

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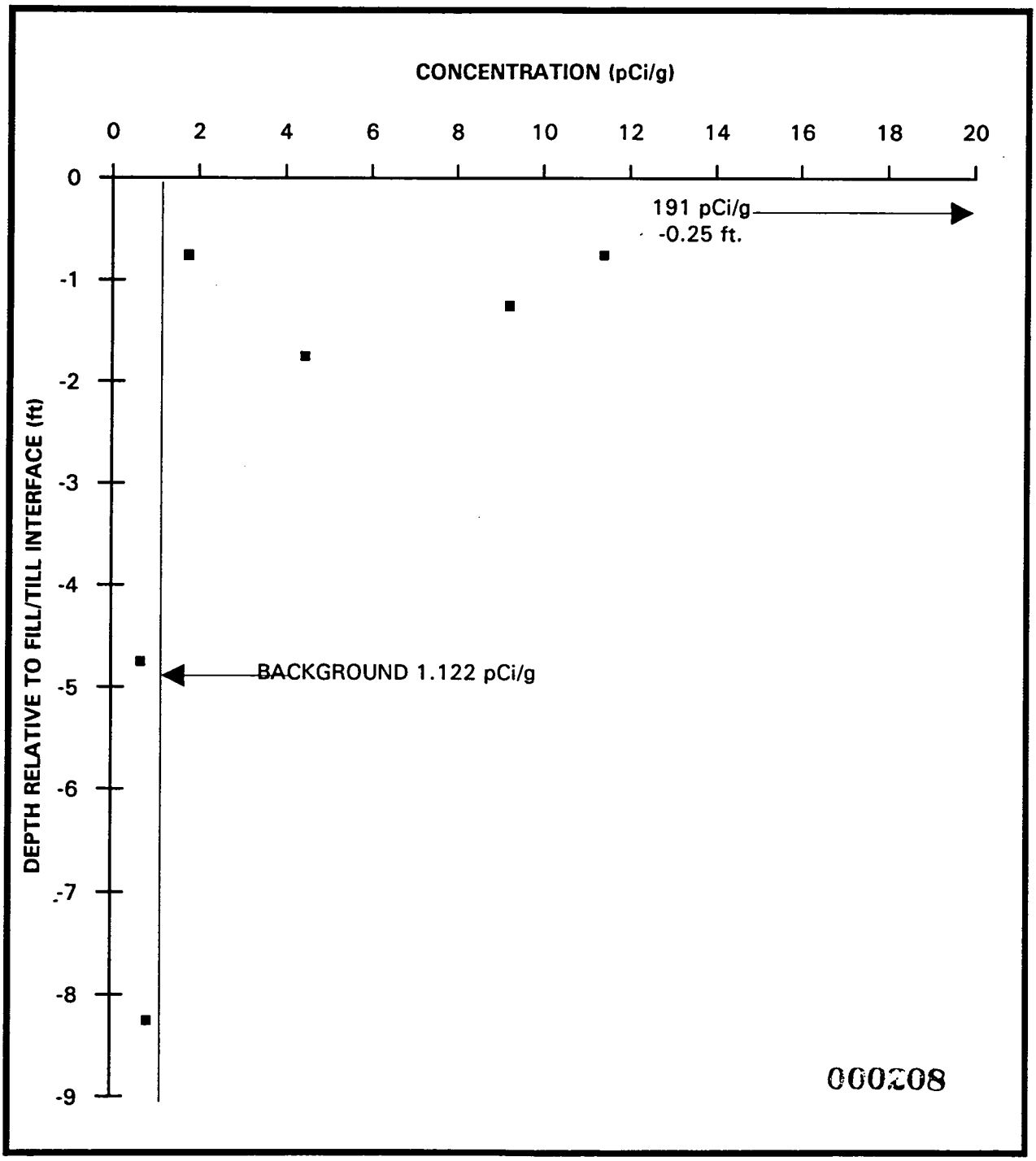

IFP_U238.XLC/4/14/94/10:18 AM/JJB

TABLE 1-16

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
Beryllium	7	6	0.6	2.1	0.8	mg/kg	2.1
RADIONUCLIDES							
Cesium-137	7	5	0.08	0.6	0.3	pCi/g	0.6
Neptunium-237	4	4	0.03	0.1	0.1	pCi/g	0.1
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
Uranium-234	7	7	0.4	10.6	5.6	pCi/g	9.4
Uranium-235/236	7	7	0.04	0.6	0.3	pCi/g	0.5
Uranium-238	7	7	0.4	11.2	5.7	pCi/g	9.7
ORGANICS							
Dibenzo(a,h)anthracene	7	1	2200	2200	499.3	μg/kg	2200.0

[a]Estimated Mean

TABLE 1-17

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
Beryllium	2	1	0.7	0.7	0.4	mg/kg	0.7
RADIONUCLIDES							
Cesium-137	2	1	0.3	0.3	0.2	pCi/g	0.3
Neptunium-237	2	2	0.03	0.1	0.1	pCi/g	0.1
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
Uranium-234	2	2	0.4	6.2	3.3	pCi/g	6.2
Uranium-235/236	2	2	0.04	0.3	0.2	pCi/g	0.3
Uranium-238	2	2	0.4	6.1	3.3	pCi/g	6.1

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TABLE 1-18

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
Beryllium	19	16	0.3	2.1	1.0[a]	mg/kg	1.4
RADIONUCLIDES							
Cesium-137	26	11	0.08	0.6	0.2	pCi/g	0.6
Neptunium-237	21	18	0.03	37.3	2.1	pCi/g	1.9
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
Technetium-99	25	1	0.9	0.9	0.3	pCi/g	0.9
Thorium-228	21	21	0.6	4.1	1.7[a]	pCi/g	2.0
Uranium-234	25	25	0.4	1380	137.3	pCi/g	771.0
Uranium-235/236	25	22	0.04	68.8	7.6	pCi/g	49.1
Uranium-238	24	24	0.4	1570	152.5	pCi/g	803.0
ORGANICS							
Dibenzo(a,h)anthracene	21	2	2	2200	303.7	μg/kg	2.0

[a]Estimated Mean

TABLE 1-19

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
Beryllium	4	4	0.5	1.4	1.0	mg/kg	1.4
RADIONUCLIDES							
Neptunium-237	2	2	0.1	0.2	0.1	pCi/g	0.2
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
Uranium-234	2	2	0.5	0.8	0.6	pCi/g	0.8
Uranium-235/236	2	2	0.04	0.05	0.05	pCi/g	0.1
Uranium-238	2	2	0.7	0.9	0.8	pCi/g	0.9

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TABLE 1-20

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
Beryllium	3	2	0.4	0.9	0.5	mg/kg	0.9
RADIONUCLIDES							
Neptunium-237	2	2	0.09	0.2	0.1	pCi/g	0.2
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-230	3	3	0.9	2.0	1.3	pCi/g	2.0
Thorium-232	3	3	0.3	0.4	0.3	pCi/g	0.4
Uranium-234	3	3	0.5	1.3	0.8	pCi/g	1.3
Uranium-235/236	3	3	0.03	0.08	0.05	pCi/g	0.08
Uranium-238	3	3	0.5	1.4	0.9	pCi/g	1.4

Note: This is the unsaturated zone.

TABLE 1-21

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	-[a]	-	mg/L	5	2	0.002	0.003	0
Iron	-	-	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	-	-	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	-	mg/L	12	3	0.05	0.08	0.07
Zinc	-	-	mg/L	2	0	0	0	0
1,1-Dichloroethene	0.7	-	mg/L	13	0	0	0	0
1,2-Dichloroethane	0.5	-	mg/L	13	0	0	0	0
2-Butanone	200.0	-	mg/L	12	2	0.002	0.004	0.003
Benzene	0.5	-	mg/L	13	0	0	0	0
Carbon Tetrachloride	0.5	-	mg/L	13	0	0	0	0
Chlorobenzene	100.0	-	mg/L	13	0	0	0	0
Chloroform	6.0	-	mg/L	13	0	0	0	0
Pyridine	5.0	-	mg/L	11	0	0	0	0
Tetrachloroethene	0.7	-	mg/L	13	0	0	0	0
Trichloroethene	0.5	-	mg/L	13	0	0	0	0

See footnote at end of table

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TABLE 1-21
(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	-	mg/L	13	0	0	0	0
1,4-Dichlorobenzene	7.5	-	mg/L	11	0	0	0	0
2,4,5-Trichlorophenol	400.0	-	mg/L	11	0	0	0	0
2,4,6-Trichlorophenol	2.0	-	mg/L	11	0	0	0	0
2,4-Dinitrotoluene	0.13	-	mg/L	11	0	0	0	0
Hexachlorobenzene	0.13	-	mg/L	11	0	0	0	0
Hexachlorobutadiene	0.5	-	mg/L	11	0	0	0	0
Hexachloroethane	3.0	-	mg/L	11	0	0	0	0
Nitrobenzene	2.0	-	mg/L	11	0	0	0	0
Pentachlorophenol	100.0	-	mg/L	11	1	0.008	0.008	0.008
Total Methylphenol	200.0	-	mg/L	5	0	0	0	0
2,4,5-TP (Silvex)	1.0	-	mg/L	13	0	0	0	0
2,4-D	10.0	-	mg/L	13	0	0	0	0
Chlordane	0.03	-	mg/L	3	0	0	0	0
Endrin	0.02	-	mg/L	13	0	0	0	0
Heptachlor	0.008	-	mg/L	13	0	0	0	0
Heptachlor epoxide	0.008	-	mg/L	13	0	0	0	0
Methoxychlor	10.0	-	mg/L	13	0	0	0	0
Toxaphene	0.5	-	mg/L	13	0	0	0	0
alpha-Chlordane	0.03	-	mg/L	10	0	0	0	0
gamma-BHC (Lindane)	0.4	-	mg/L	13	0	0	0	0
gamma-Chlordane	0.03	-	mg/L	10	0	0	0	0

[a]Not Applicable

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 soil and subsurface indicates the following:

- Subsurface concentrations of metals are consistent with flyash, except for samples collected from visible waste sludge material.
- Concentrations of organic compounds and radionuclides are significantly higher in subsurface samples, suggesting that surface spillage and leaching is not the cause for observed concentrations.
- 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 that were 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 1.3 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 extent of saturated conditions appeared to be limited to the portion of the subunit north of Hydropunch™ 11051. 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. 1016 is mislabeled and is actually completed in the regional aquifer at the south edge of the Inactive Flyash Pile. The others are Well Nos. are 2402, 2047, and 2016, which are located on the west, northeast, and southern battery limits, respectively. Aluminum, calcium, chromium, uranium, and two organic compounds were detected in Well Nos. 1016 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 1016-2016-3016 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 2955 was installed in the Inactive Flyash Pile during Phase II. Phase II sampling detected aluminum, 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 2402 (5.62 μg/L) and downgradient Well 2954 (2070 μg/L) or downgradient Well 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 aquifer (910 μg/L at IFP-SW-05), and from perched groundwater (6700 μg/L from Hydropunch™ 11002).

Total uranium analysis in Well 2955 (in the north end of the waste unit) and Well 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 2280 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 including 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.

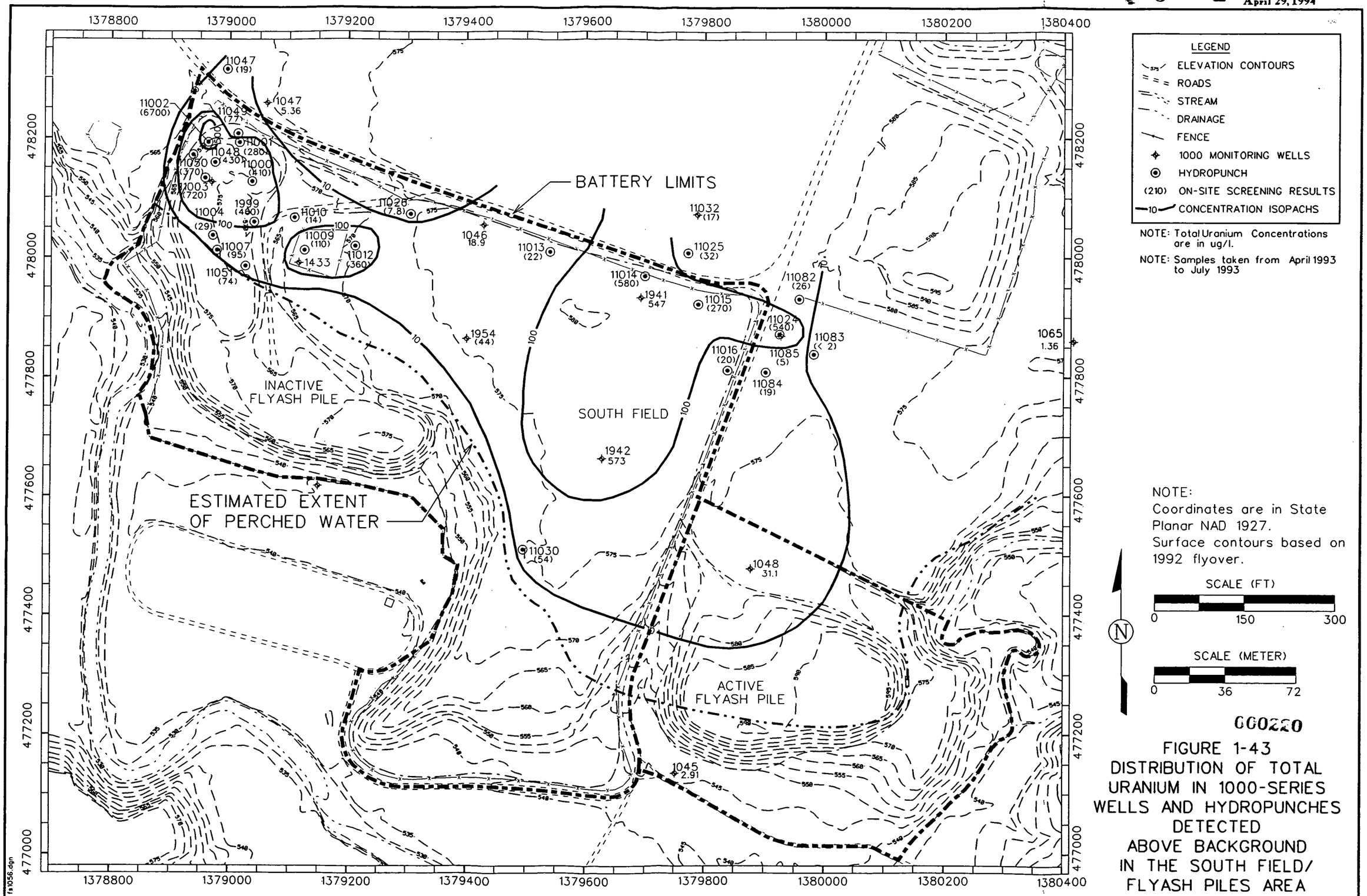

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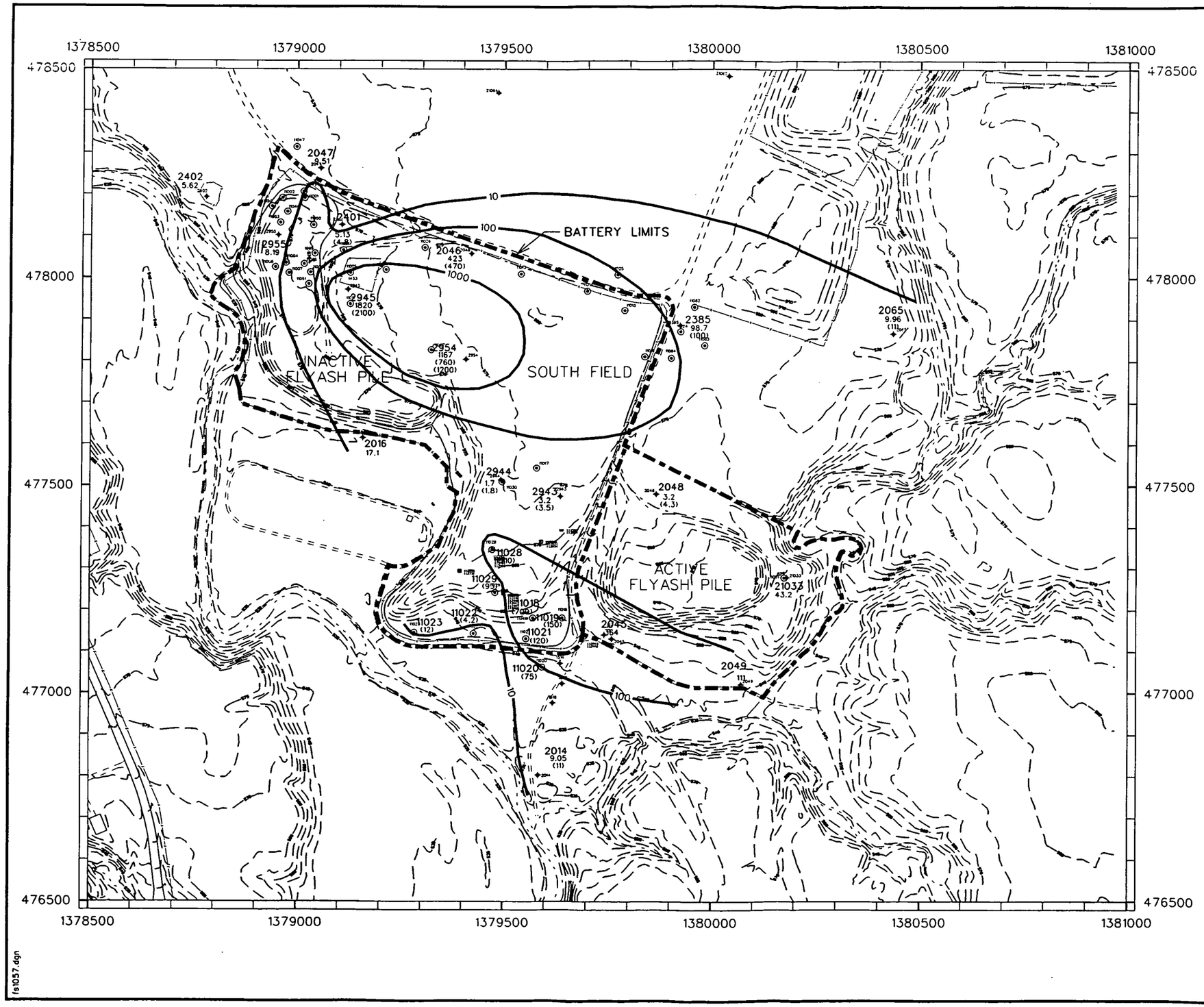
FIGURE 1-43
DISTRIBUTION OF TOTAL URANIUM IN 1000-SERIES WELLS AND HYDROPUNCHES DETECTED ABOVE BACKGROUND IN THE SOUTH FIELD/ FLYASH PILES AREA



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

000221

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

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 1-22. The highest concentrations were detected in samples from 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 - 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 two to three 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 three ft. A horizontal boring, SP-7, yielded lead concentrations above background in a composite sample taken from 0 to five ft beyond the surface of the Firing Range, but below background in samples taken deeper in the boring. The data suggest that lead from bullets was stopped in the soil within 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 1-22 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 - Sixteen metals, isotopes of seven 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 (12 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.

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

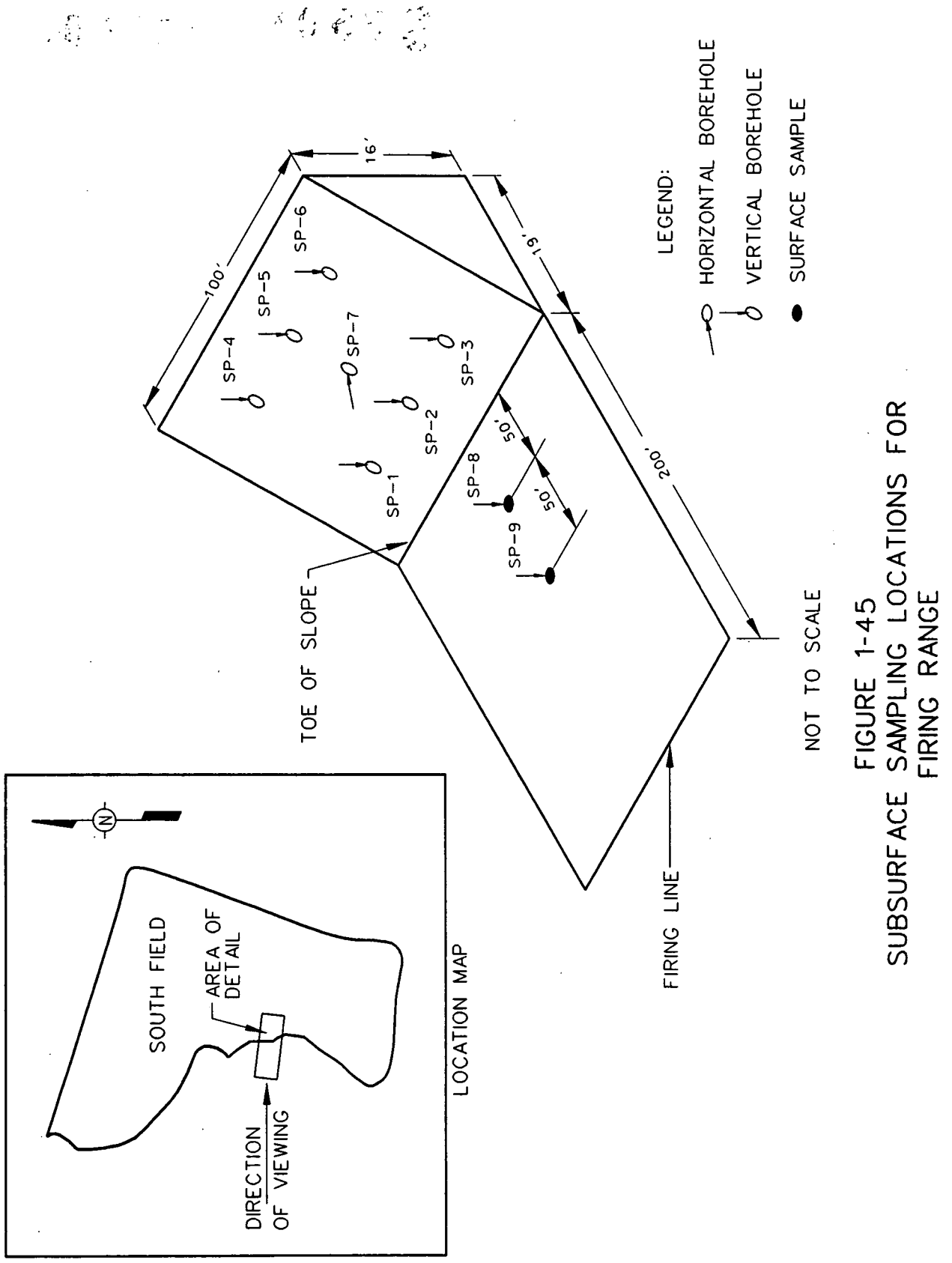


FIGURE 1-45
SUBSURFACE SAMPLING LOCATIONS FOR FIRING RANGE

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TABLE 1-22

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.

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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-Engery 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.

Seventeen 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-three 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 (five 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 three 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 three ft) deep in Trench 4 (Sample 113722) included: total uranium (1170 μg/g); total thorium (55.8 μg/g); copper (436 mg/kg); lead (385 mg/kg); vanadium (30.4 μg/g), and zinc at (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 four ft of the soil.

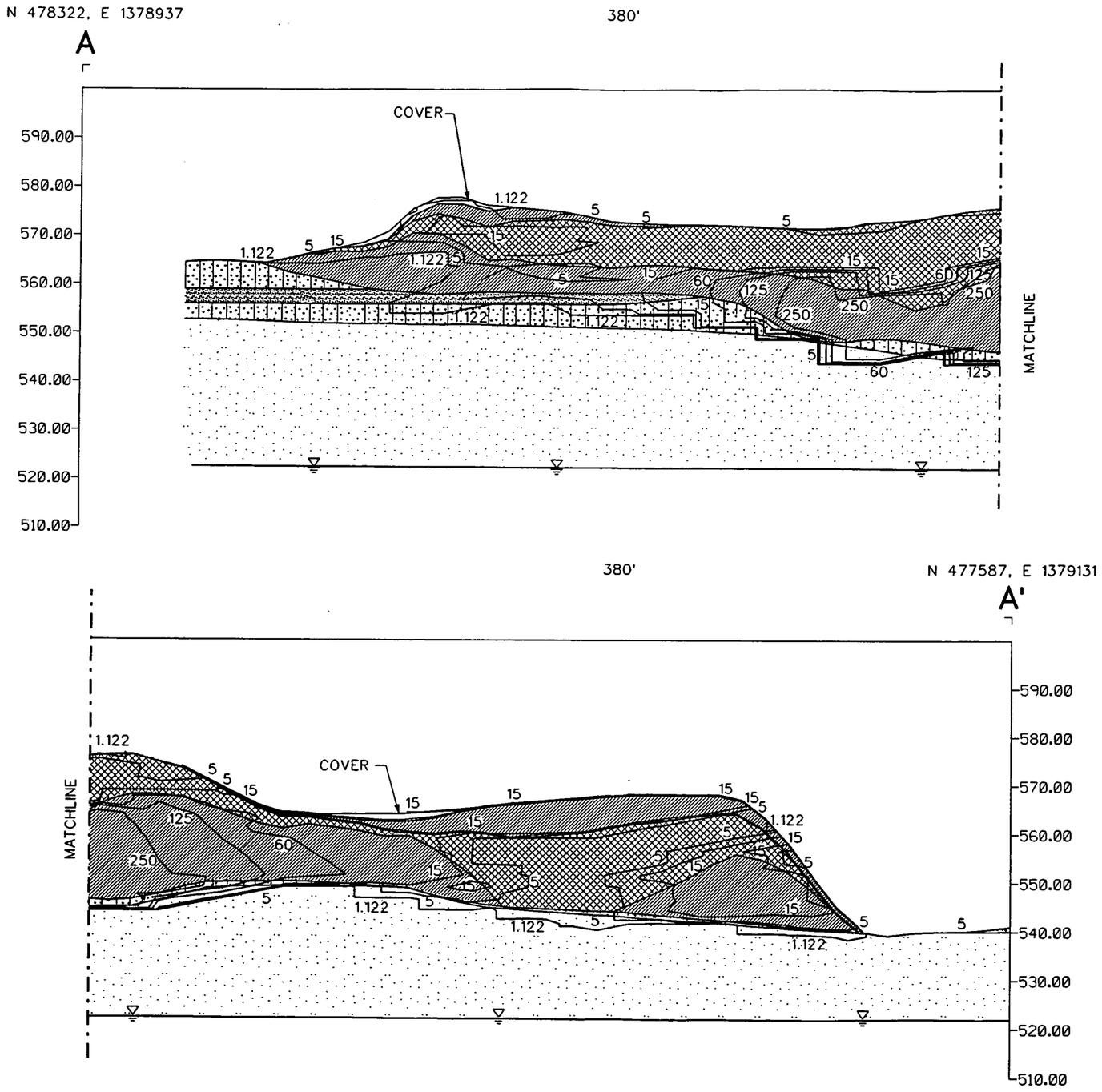
Uranium-238 results from subsurface data were kriged and the output processed to provide a model of contaminant distribution in the Inactive Flyash Pile and adjacent areas of the South Field. A conceptual model for contamination located in a geological cross-section of the South Field and Inactive Flyash 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 show that the glacial till is truncated by erosion. The projected extent of the glacial till is shown on Figure 1-40. In this area downward infiltration of groundwater is much more rapid than where the glacial overburden is present.

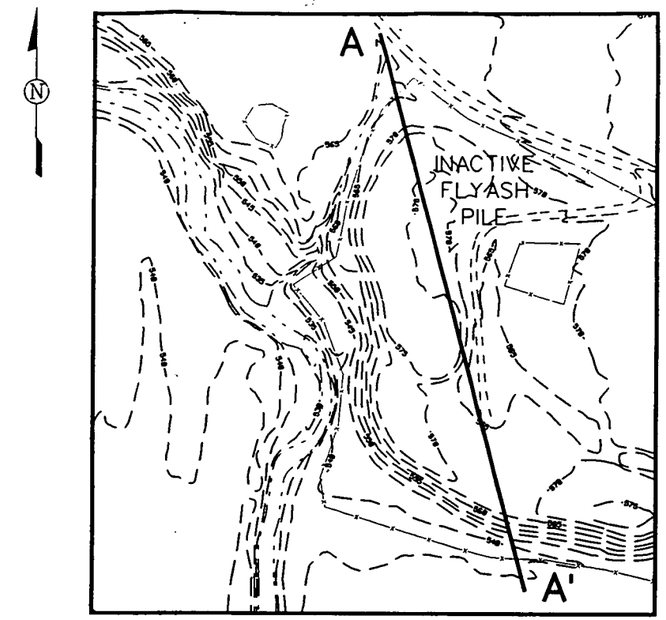
Most soil samples representing the Great Miami Aquifer were collected from Boring Nos. 1518, 1517, and 1518; these borings are located outside the South Field battery limits. Radionuclides were detected above background from the Great Miami Aquifer in only one sample from Monitoring Well

3046 at 30.5 to 31 m (100 to 101.5 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, this figure 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 Tables 1-23 through 1-26. 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.





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

SCALE:
HORIZONTAL 1 cm = 6 m
VERTICAL 1 cm = 3 m
0 6 12 24

FIGURE 1-46 000228
CONCEPTUAL MODEL FOR SUBSURFACE DISTRIBUTION OF U-238 CONTAMINATION SOUTH FIELD/INACTIVE FLYASH PILE

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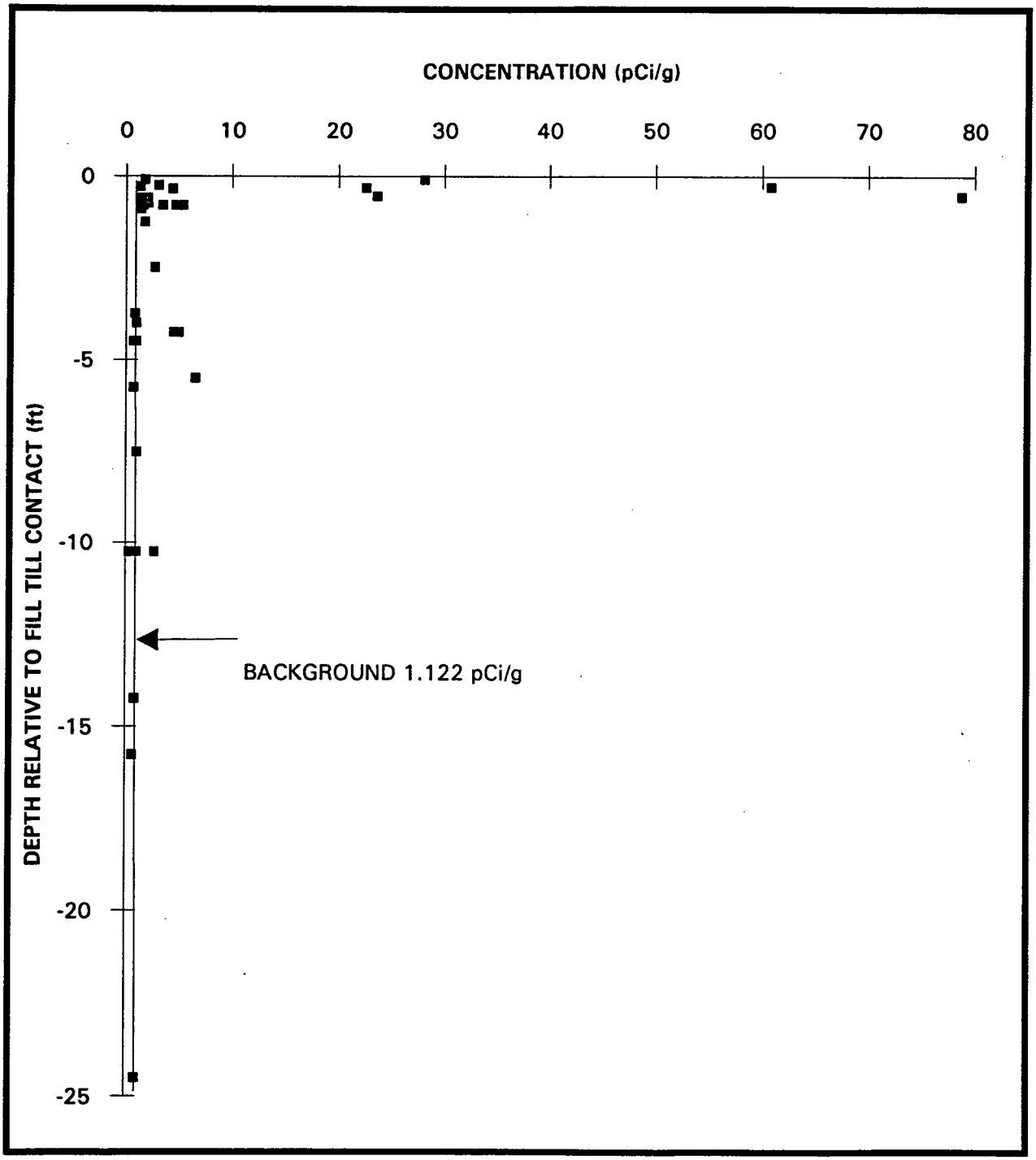
FIGURE 1-47
U-238 CONCENTRATION VS DEPTH RELATIVE TO TILL/FILL INTERFACE SOUTH FIELD



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

TABLE 1-23

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
Chromium	21	20	8.8	21.5	12.6	mg/kg	14.2
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
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

000230

TABLE 1-24

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
Chromium	67	66	6.1	36.2	16.0[a]	mg/kg	17.6
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
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 1-25

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
Chromium	10	9	6.5	19.9	13.5	mg/kg	19.9
RADIONUCLIDES							
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
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

[a]Estimated Mean

TABLE 1-26

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
Chromium	2	1	5	5	3.8	mg/kg	5.0
RADIONUCLIDES							
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
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

[a]Estimated Mean

Note: This is the unsaturated zone.

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Surface Water and Sediment

There are no perennial sources of surface water in the South Field subunit. Samples were collected after rain events occurred 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 Monitoring Well 1941 (540 μg/L) and Well 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. Nineteen 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, selenium, silver, and zinc are common to the sediment and soils of the South Field. This indicates that the source for 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 require relatively long contact time to leach out of geologic materials. Chloride and fluoride are present at 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 are similar to concentrations found in samples of surface soil at the South Field. Organic compounds are 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. 1516, 1517, and 1518) were mislabeled and actually monitor the regional aquifer. Phase I sampling detected six 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 twelve Hydropunch™ samples were collected in order to define groundwater conditions in the perched groundwater in the South Field. During Phase II, 21 metals, isotopes of six elements, and four organic compounds exceeded background concentrations.

Metals with concentrations that exceeded background in 1000-series wells included aluminum, antimony, calcium, magnesium, manganese, silicon, and zinc. Maximum detected concentrations were close to background values except for antimony and silicon, which have a background concentration of 0.00 mg/L. This indicates that elevated concentrations of metals detected in subsurface samples are not reflected by significant impacts to 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 1047 and Well 1046 detected low concentrations of total uranium, while downgradient Wells 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 1433 may originate as leachate from buried waste. Buried waste materials were also encountered while drilling Well 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), dimethyl phthalate (1 μg/L), and tributyl phosphate (1 μg/L) in Well 11032 located north and upgradient of the South Field. Acetone was detected at 6 μg/L in Well 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 11 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 six 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 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. Several sources potentially exist 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 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 2016 (17 μg/L) to Well 2944 (1.5 μg/L) and Well 2048 (1.3 μg/L). The southeastern part of the total uranium plume appears to flow past Well 2045 (364 μg/L), Well 2049 (111 μg/L), and possibly Well 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 upon 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 1048, which is north of the pile. Flyash was the only material detected in all other subsurface samples collected from the flyash pile.

Surface and Subsurface Media

During Phase II, surface samples were collected from eight locations within 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 samples and subsurface 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, and bis(2-ethylhexyl)phthalate were detected in both surface and subsurface samples.
- 1,1,1-trichloroethane, 1,1-dichloroethane, chloro-phenols, and xylene were detected in subsurface samples but not in surface samples.
- The concentration of all organics decrease between three to 5.2 m (10 to 17 ft) deep and below the flyash/soil interface. Organics appear to be present at trace amounts throughout the flyash from the surface to about three 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

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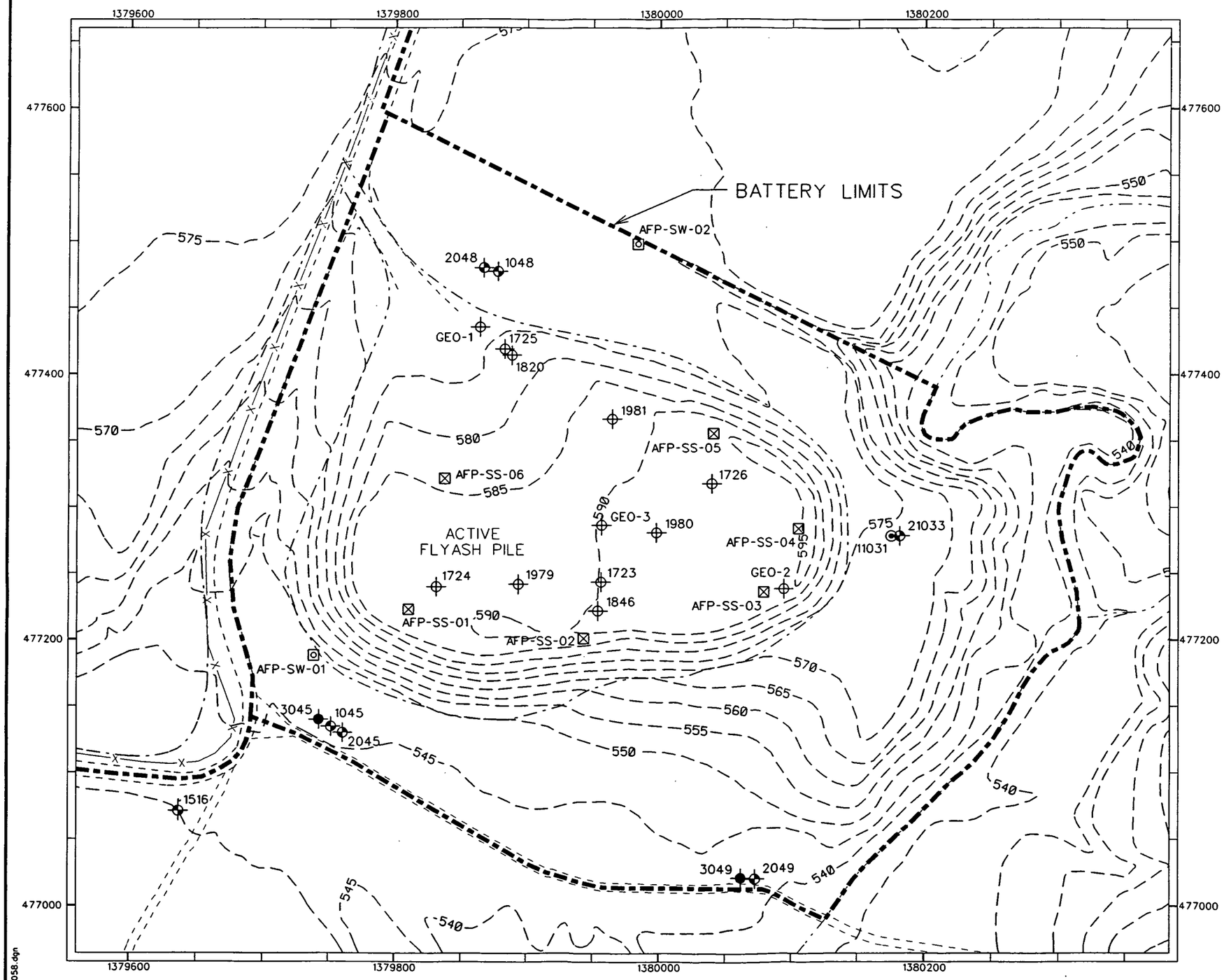

LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- 1000 MONITORING WELLS
- 2000 MONITORING WELLS
- 3000 MONITORING WELLS
- SOIL BORING
- HYDROPUNCH
- SURFACE SAMPLE
- SURFACE WATER SAMPLE

NOTE: "GEO" REPRESENTS GEOTECHNICAL SAMPLE LOCATIONS.

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

N

SCALE (FT)
0 80 160

SCALE (METER)
0 19.2 38.4

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

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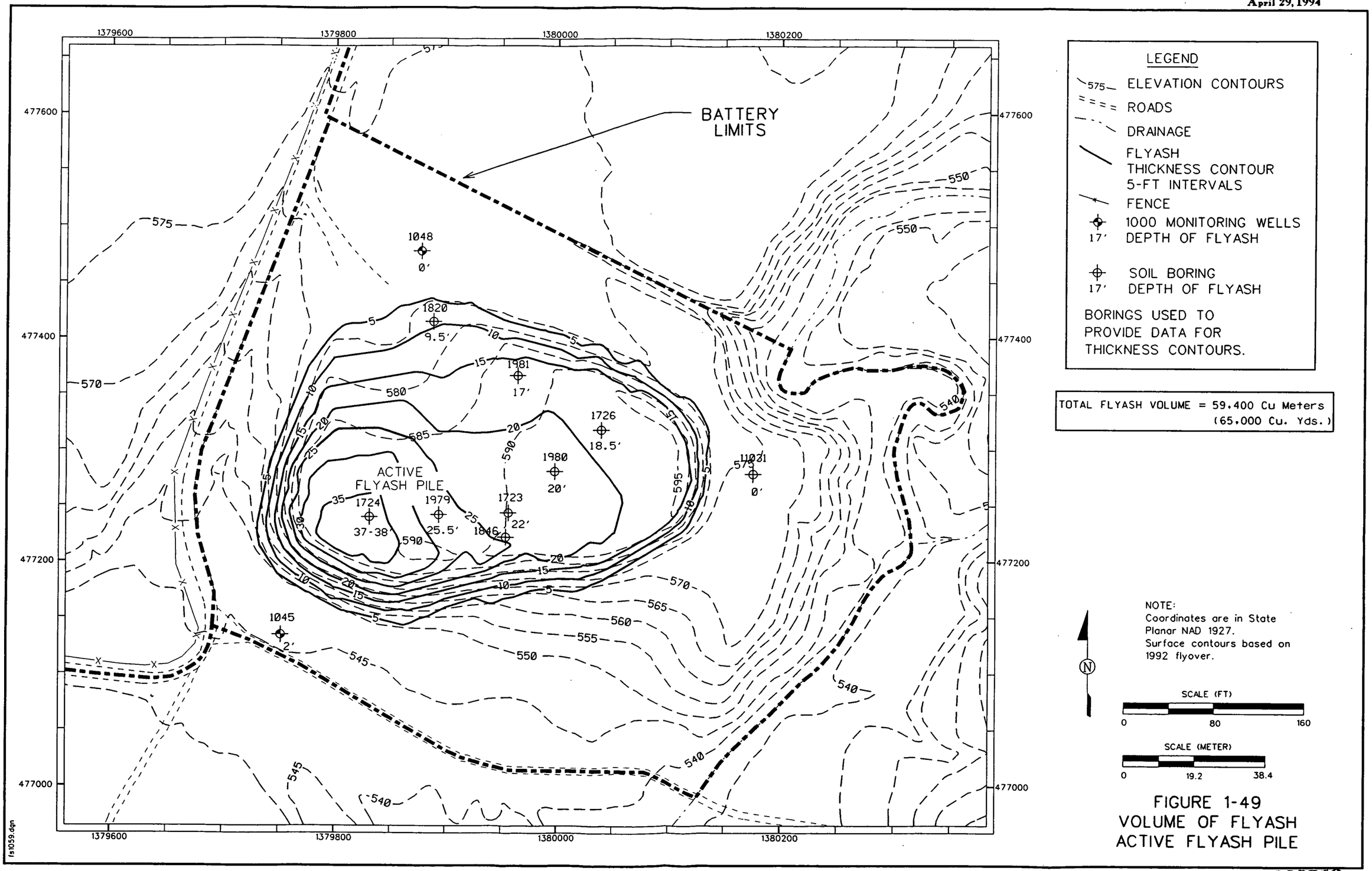

FIGURE 1-49
VOLUME OF FLYASH
ACTIVE FLYASH PILE

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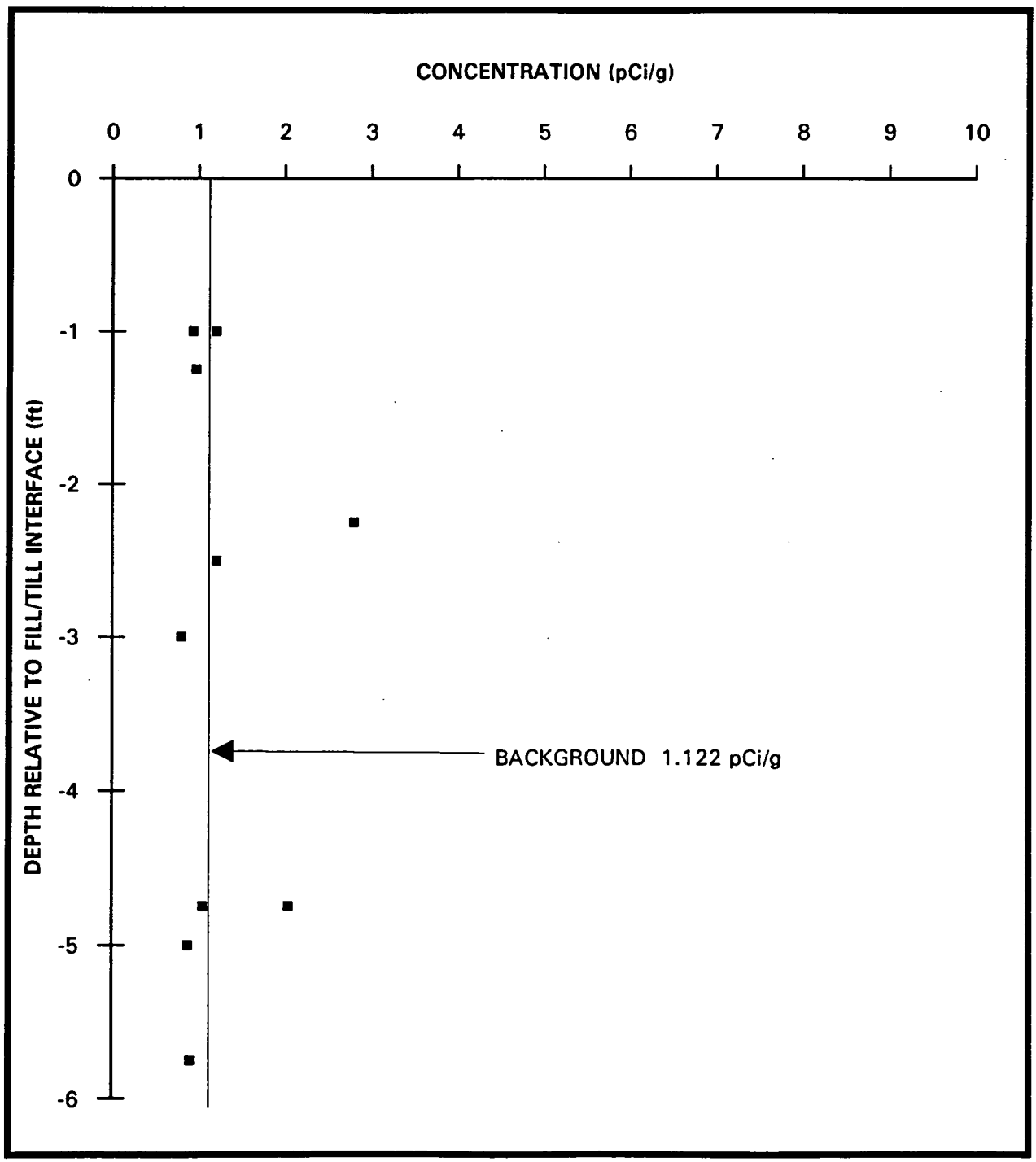
FIGURE 1-50
U-238 CONCENTRATION VS DEPTH RELATIVE TO FILL/TILL INTERFACE ACTIVE FLY ASH PILE



AFP_U238.XLC/4/14/94/10:19 AM/JJB

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 1-27 through 1-30. 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 1-31. 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).

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.

TABLE 1-27

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							
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
Uranium-234	14	14	2.4	4.4	3.3[a]	pCi/g	3.6
Uranium-235/236	14	13	0.08	0.2	0.1	pCi/g	0.2
Uranium-238	14	14	2.9	4.4	3.4	pCi/g	3.6

[a]Estimated Mean

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TABLE 1-28

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							
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
Uranium-234	39	39	0.8	17.3	3.7	pCi/g	12.3
Uranium-235/236	39	26	0.04	4.1	0.4	pCi/g	3.4
Uranium-238	39	39	0.9	12.6	4.0	pCi/g	9.7

TABLE 1-29

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							
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
Uranium-234	4	4	0.9	1	0.9	pCi/g	1.0
Uranium-235/236	4	2	0.03	0.03	0.2	pCi/g	0.03
Uranium-238	4	4	0.8	1.1	0.9	pCi/g	1.1

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TABLE 1-30

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
Uranium-234	3	1	0.9	0.9	0.5	pCi/g	0.9
Uranium-238	3	1	0.8	0.8	0.5	pCi/g	0.8

Note: This is the unsaturated zone.

TABLE 1-31

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	-[a]	-	mg/L	6	1	0.02	0.02	0.02
Iron	-	-	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	-	-	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	-	mg/L	14	9	0.02	0.2	0.07
Zinc	-	-	mg/L	4	2	0.2	1.3	0.8
1,1-Dichloroethene	0.7	-	mg/L	14	0	0	0	0
1,2-Dichloroethane	0.5	-	mg/L	14	0	0	0	0
2-Butanone	200.0	-	mg/L	14	2	0.003	0.010	0.065
Benzene	0.5	-	mg/L	14	0	0	0	0
Carbon Tetrachloride	0.5	-	mg/L	14	0	0	0	0
Chlorobenzene	100.0	-	mg/L	14	0	0	0	0
Chloroform	6.0	-	mg/L	14	0	0	0	0
Pyridine	5.0	-	mg/L	13	0	0	0	0
Tetrachloroethene	0.7	-	mg/L	14	0	0	0	0
Trichloroethene	0.5	-	mg/L	14	0	0	0	0

See footnote at end of table

TABLE 1-31
(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	-	mg/L	14	0	0	0	0
1,4-Dichlorobenzene	7.5	-	mg/L	12	0	0	0	0
2,4,5-Trichlorophenol	400.0	-	mg/L	12	0	0	0	0
2,4,6-Trichlorophenol	2.0	-	mg/L	13	0	0	0	0
2,4-Dinitrotoluene	0.13	-	mg/L	13	0	0	0	0
Hexachlorobenzene	0.13	-	mg/L	13	0	0	0	0
Hexachlorobutadiene	0.5	-	mg/L	12	0	0	0	0
Hexachloroethane	3.0	-	mg/L	12	0	0	0	0
Nitrobenzene	2.0	-	mg/L	12	0	0	0	0
Pentachlorophenol	100.0	-	mg/L	13	0	0	0	0
Total Methylphenol	200.0	-	mg/L	4	0	0	0	0
2,4,5-TP (Silvex)	1.0	-	mg/L	15	0	0	0	0
2,4-D	10.0	-	mg/L	15	0	0	0	0
Chlordane	0.03	-	mg/L	4	0	0	0	0
Endrin	0.02	-	mg/L	15	0	0	0	0
Heptachlor	0.008	-	mg/L	14	0	0	0	0
Heptachlor epoxide	0.008	-	mg/L	14	0	0	0	0
Methoxychlor	10.0	-	mg/L	15	0	0	0	0
Toxaphene	0.5	-	mg/L	15	0	0	0	0
alpha-Chlordane	0.03	-	mg/L	11	0	0	0	0
gamma-BHC (Lindane)	0.4	-	mg/L	15	0	0	0	0
gamma-Chlordane	0.03	-	mg/L	11	0	0	0	0

[a]Not Applicable

Two surface water sampling locations were identified for off-site analyses during Phase I adjacent to the road at the western edge of the Active Flyash Pile. 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 samples; 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 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. Six metals, isotopes of three elements, and four semivolatile organic compounds were detected above background in the sediment sample from Phase II. No 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 three 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.

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 2943); Well 21033 (constructed during Phase II) is located downgradient. Phase I sampling of 2000-series wells detected three metals and isotopes of two elements that exceeded background; no organic compounds were analyzed in Phase I samples. Phase II sampling detected four 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 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 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 2943 and 2048 contained 1 μg/L and 3 μg/L total uranium, respectively. Downgradient Well 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

In order to determine the extent to which uranium leaches from contaminated subsurface soils in the Operable Unit 2 subunits, the Toxicity Characteristic Leaching Procedure (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 1-32. The initial soil samples and TCLP extract were analyzed for total uranium. Since the volume of the soil sample (100 grams) and the

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TABLE 1-32
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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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 the majority 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.

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 SSOD. An average flow rate of 3,300 ft^3/sec was used for the Great Miami River, based on previous studies (DOE 1993a).

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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 (CPCs) mass reaching the SSOD 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.

Groundwater Pathway

Rainfall and surface water runoff infiltrating through 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).

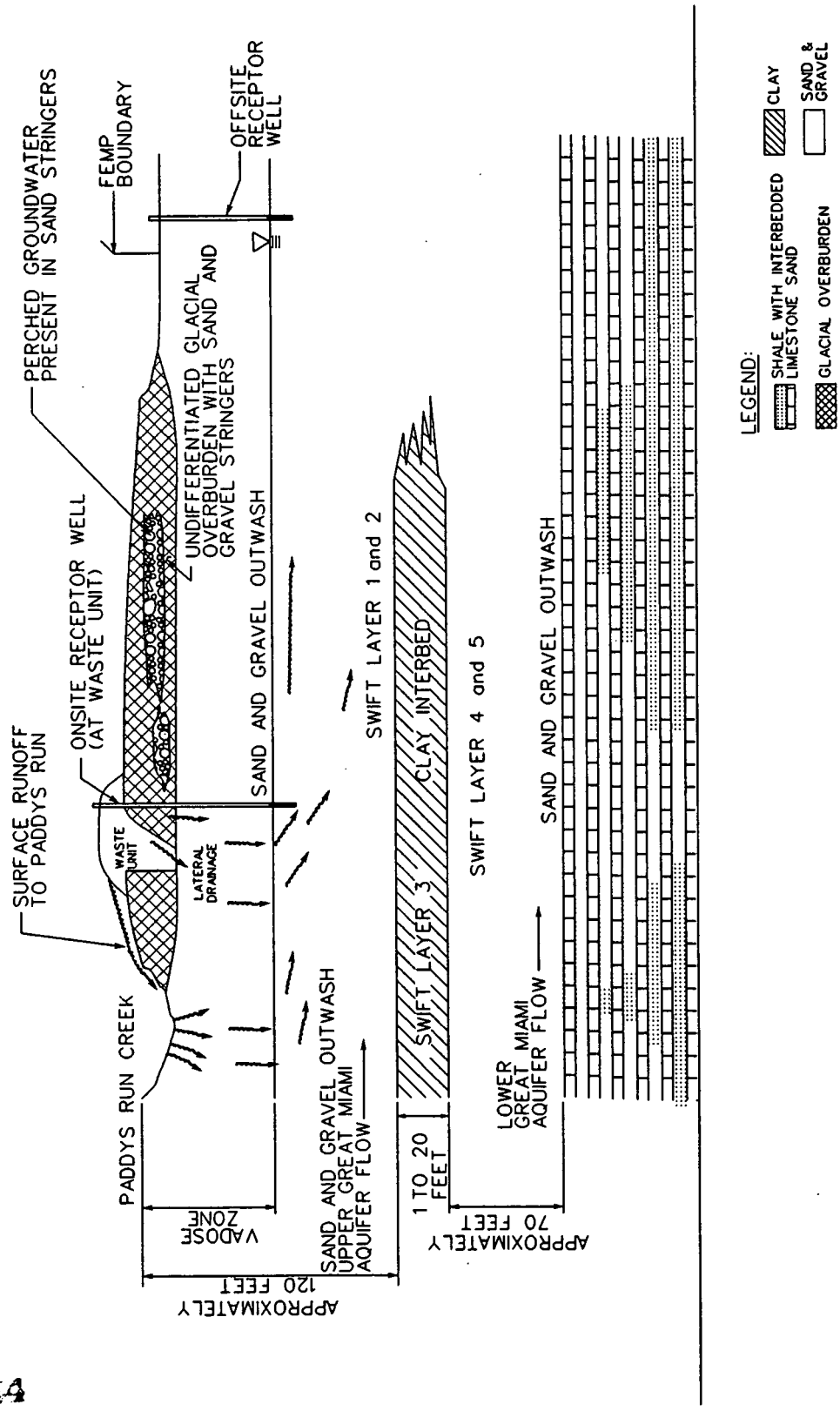

FIGURE 1-51
CONCEPTUAL MODEL OF LOADING TO THE GREAT MIAMI AQUIFER AND CONTAMINANT TRANSPORT BY GROUNDWATER

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- 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 unit within the glacial overburden was not included in the vadose zone pathway modeling because this layer has much higher permeability and less adsorption potential as compared to clay and silts in glacial overburden. 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 Sandia Waste Isolation Flow and Transport (Computer Model) (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 subunits were used in the groundwater modeling. For uranium-238, the waste

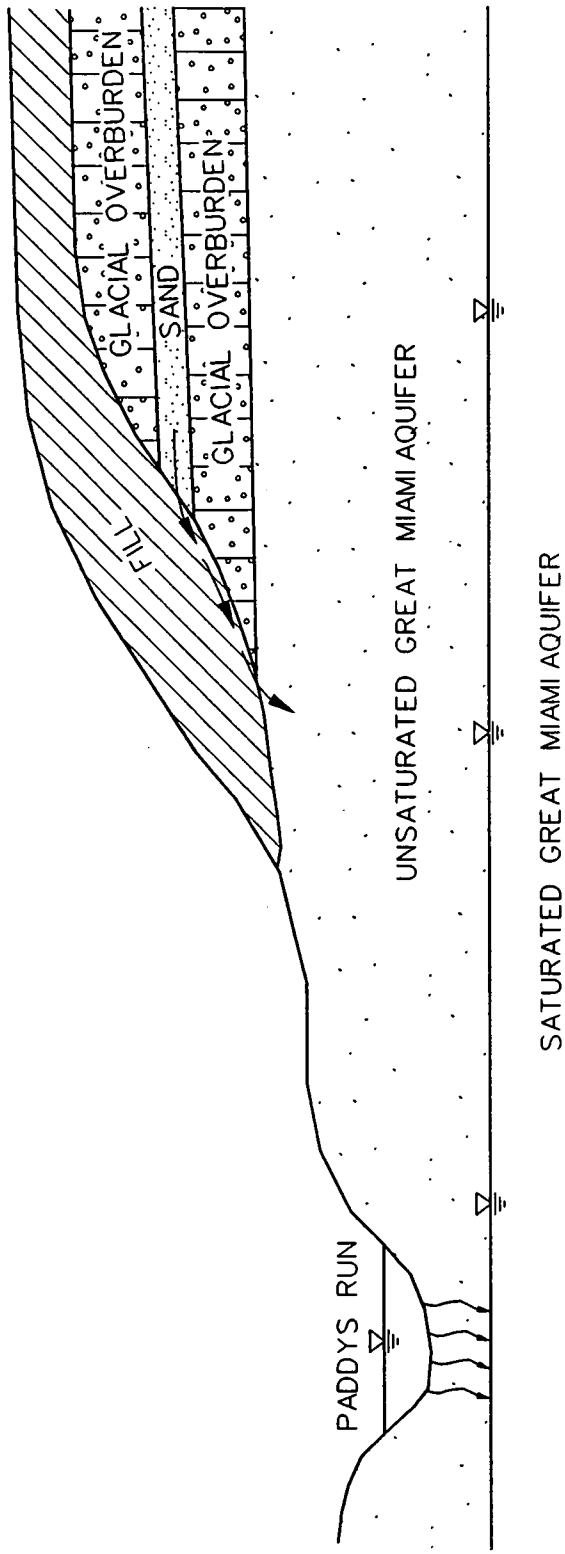

FIGURE 1-52
CONCEPTUAL MODEL FOR PERCHED WATER SUBSURFACE SEEPS

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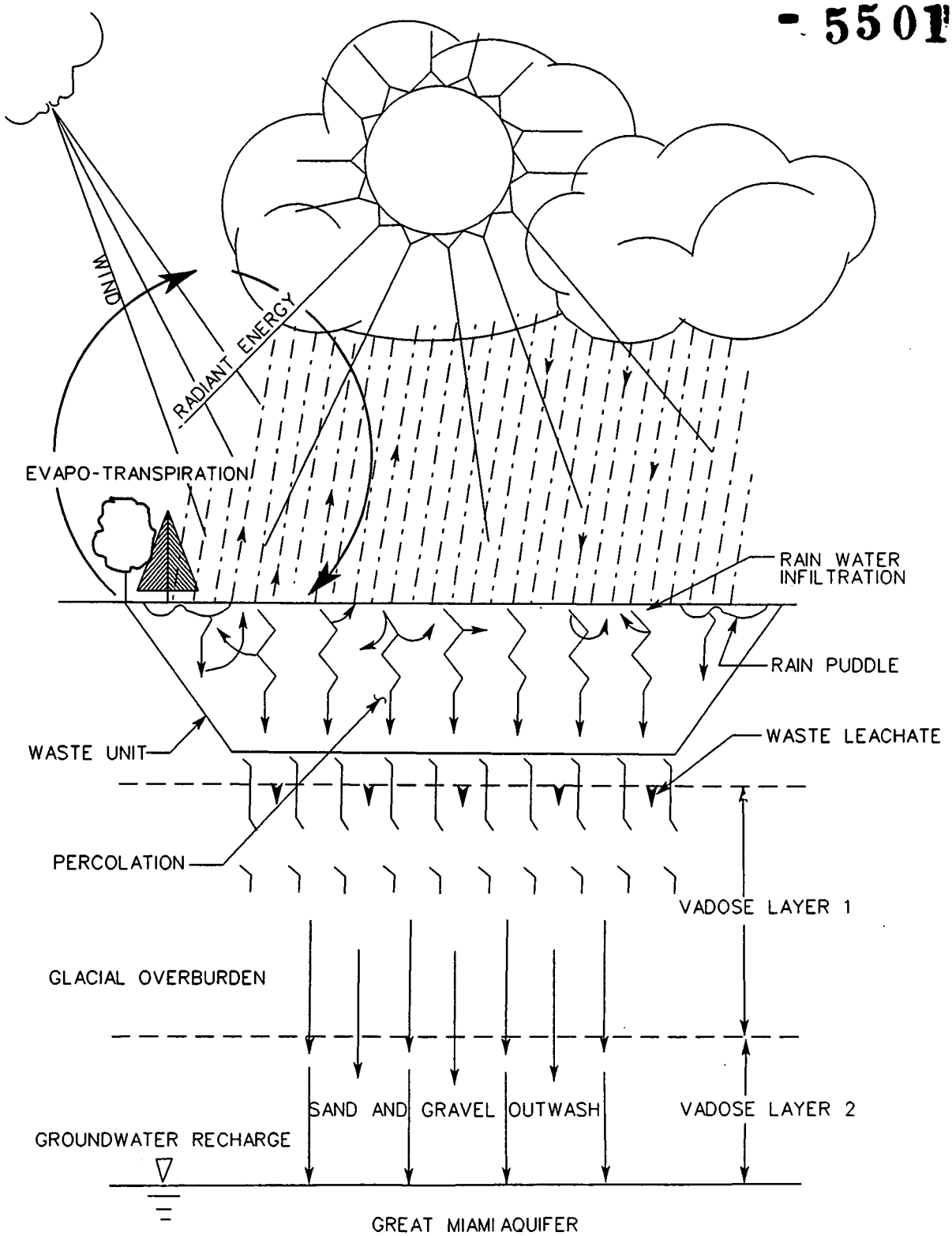

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FIGURE 1-53
CONCEPTUAL VADOSE ZONE MODEL

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 into an one-dimensional analytical solute transport (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 CPC concentration capable of producing 1×10^{-7} lifetime cancer risk for carcinogens or the concentration of the 0.1 Hazard Index (HI) for noncarcinogens was selected as a conservative screening level.

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 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 potentially 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, then 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 RAECOM model algorithms developed for the U.S. Nuclear Regulatory Commission (NRC 1984). 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.

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 three km 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 m) 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 four 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 5.9×10^{-2} and 7.1×10^{-5} pCi/L for Paddys Run and the Great Miami River, respectively. All inorganics and organics were predicted to remain below 5×10^{-3} μg/L in Paddys Run and 6×10^{-6} μg/L in the Great Miami River.

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.

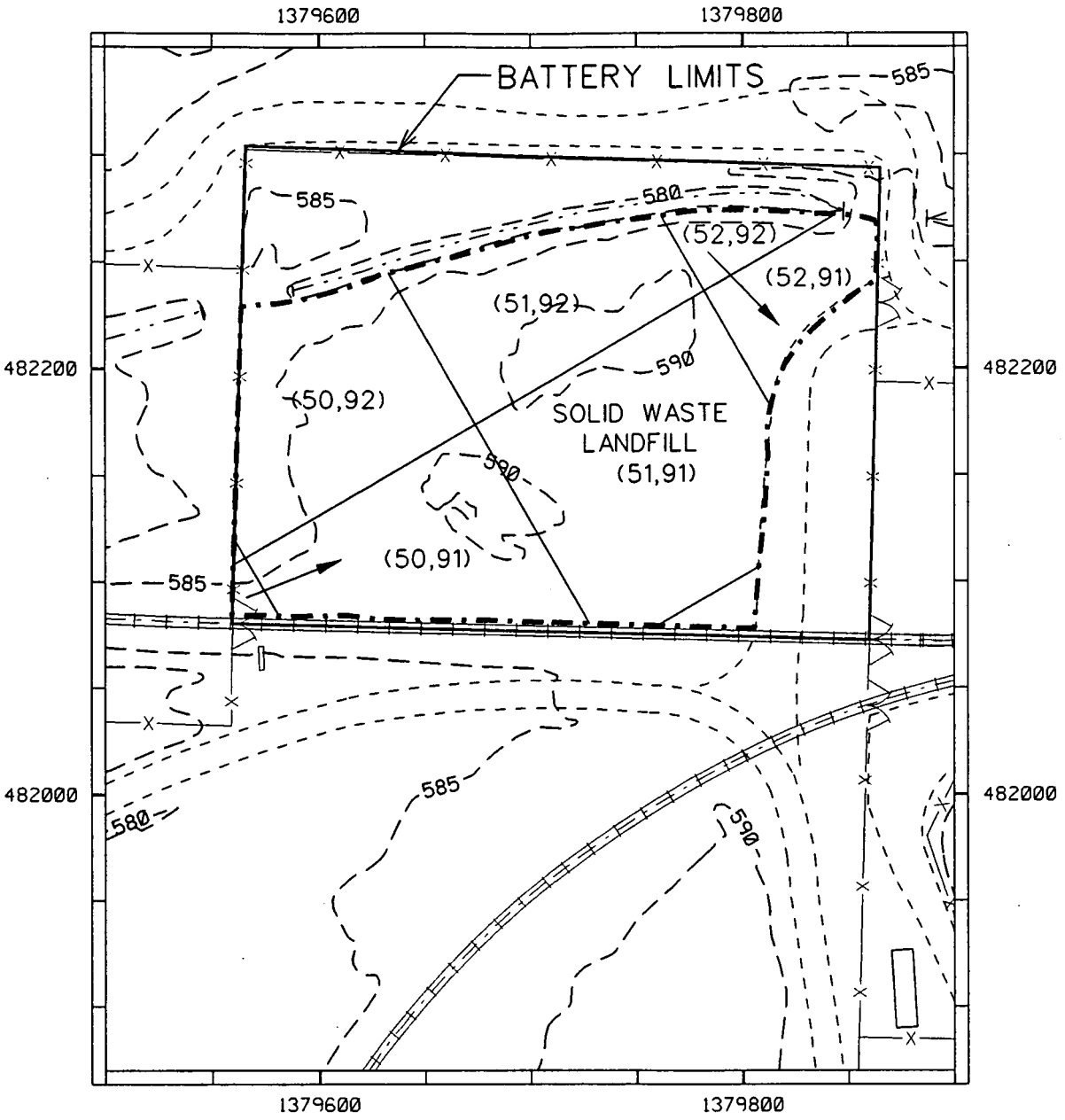
The groundwater fate and transport modeling results are summarized in Table 1-33 for technetium-99. The table presents the arrival time in the aquifer, the maximum loading concentration, the maximum predicted concentrations in the aquifer within 1,000 years, the time required to reach the maximum value, 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.

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 10^{-7} lifetime cancer risk level or 0.1 HI level. 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 since 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



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.

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 1-33

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)	10^{-7} Risk or 0.1 Hazard Index Screening Levels (pCi/L)
RADIONUCLIDES							
Technetium-99	28.5	10-20	60	0.61	70	0.054	0.27

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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

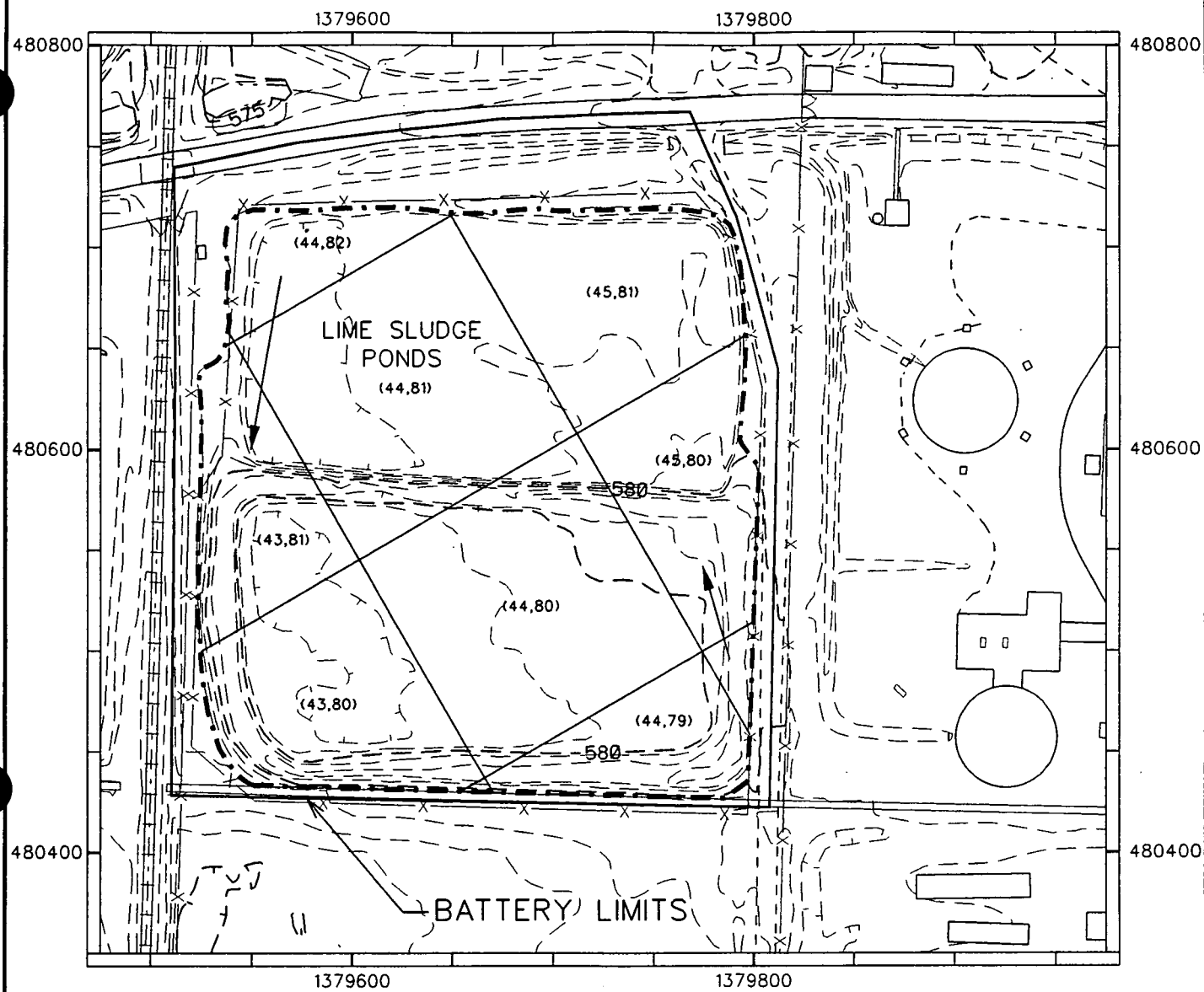
The Lime Sludge Ponds are contained within soil berms which isolate them from the surrounding soils and therefore, were not considered a source of contaminants to the surface waters. No surface water pathway modeling was conducted.

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 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 10^{-7} lifetime cancer risk level or 0.1 HI level.

The groundwater fate and transport modeling results are summarized in Table 1-34 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 10^{-7} lifetime cancer risk or 0.1 HI concentration levels. Maximum concentrations were 5.5 pCi/L, 1.9 pCi/L, 69.8 pCi/L, 0.015 μg/L, and 19.4 μg/L, respectively.



LEGEND

- ELEVATION CONTOURS (575)
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- WASTE FROM CELL IS INCLUDED IN OTHER CELL
- EXTENT OF WASTE
- SWIFT MODEL CELL (COLUMN, ROW) (44,80)

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

SCALE (FT)
0 50 100

SCALE (METER)
0 12 24

000265

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

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TABLE 1-34

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)	10^{-7} Risk or 0.1 Hazard Index Screening Levels (pCi/L)
RADIONUCLIDES							
Technetium-99	64.8	20-30	40	2.51	40	0.14	0.27

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 2.4×10^{-5} pCi/L for cesium-137 to a maximum of 0.66 pCi/L for uranium-238. Concentrations of radionuclides in the Great Miami River range from a low of 2.8×10^{-8} pCi/L for cesium-137 to a high of 8.0×10^{-4} pCi/L for uranium-238. All inorganics and organics were predicted to remain below 0.37 μg/L in Paddys Run and 4.5×10^{-4} μg/L in the Great Miami River.

Groundwater

Loading to the Great Miami Aquifer from Inactive Flyash Pile and the South Field were combined and modeled together because of close proximity of the Inactive Flyash 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 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, arsenic, and dibenzo(a,h)anthracene. The respective maximum annual average for these constituents were calculated to be 4.76 pCi/m^3, 6.21×10^{-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 1.7 x 10^{-4} pCi/L for cesium-137 to a high of 410 pCi/L for technetium-99. Concentrations of radionuclides in the Great Miami River ranged from 2.1 x 10^{-7} pCi/L for cesium-137 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 2.1 μg/L in Paddys Run and below 2.6 x 10^{-3} μg/L in the Great Miami River. All organics were predicted to be below 0.6 μg/L and 6.9 x 10^{-4} μg/L in Paddys Run and the Great Miami River, respectively.

Groundwater

Due to close proximity of the Inactive Flyash Pile and South Field, groundwater modeling for these two units were 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 1-35 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

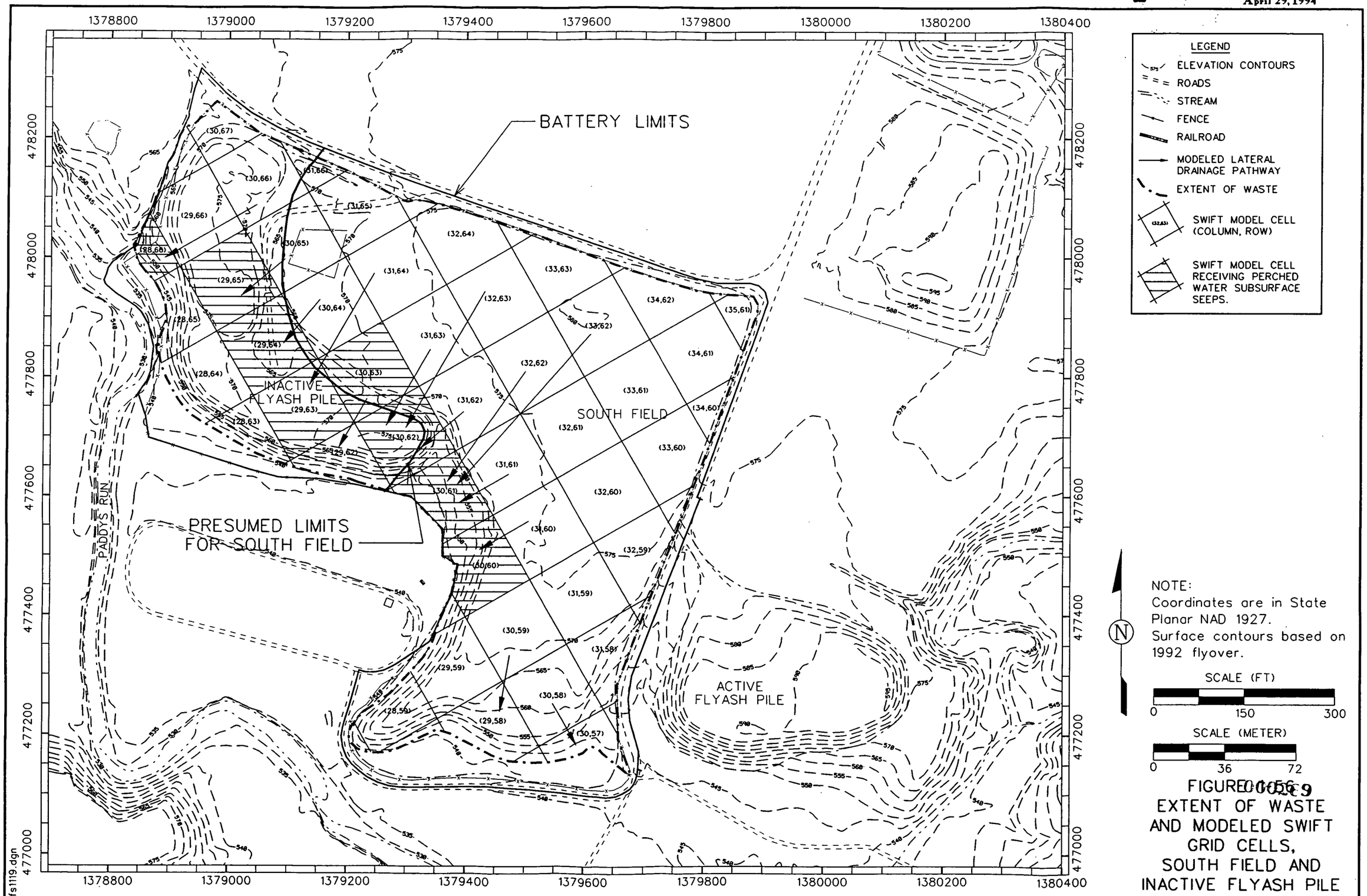

FIGURE 1-56
EXTENT OF WASTE AND MODELED SWIFT GRID CELLS, SOUTH FIELD AND INACTIVE FLYASH PILE

TABLE 1-35

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	Paddys Run Loading from Inactive Flyash Pile/ South Field Runoff
RADIONUCLIDES					
Neptunium-237	Yes	Yes	No	Yes	No
Radium-226	No	Yes	No	Yes	No
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	Yes
Uranium-238	Yes	Yes	Yes	Yes	Yes
Uranium - Total (non-RAD)	Yes	Yes	Yes	Yes	Yes
INORGANICS					
Antimony	Yes	No	No	Yes	No
Cadmium	Yes	No	No	Yes	No
Lead	Yes	No	No	Yes	No
Manganese	No	Yes	No	Yes	No
Molybdenum	Yes	No	No	Yes	No
Silver	No	No	No	Yes[c]	No

[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 Great Miami Aquifer, if applicable.
[c]Not modeled based on diluted Great Miami Aquifer concentration being approximately 4 percent greater than the screening concentration. Typical concentration reduction in the Great Miami Aquifer is approximately by a factor of 20.

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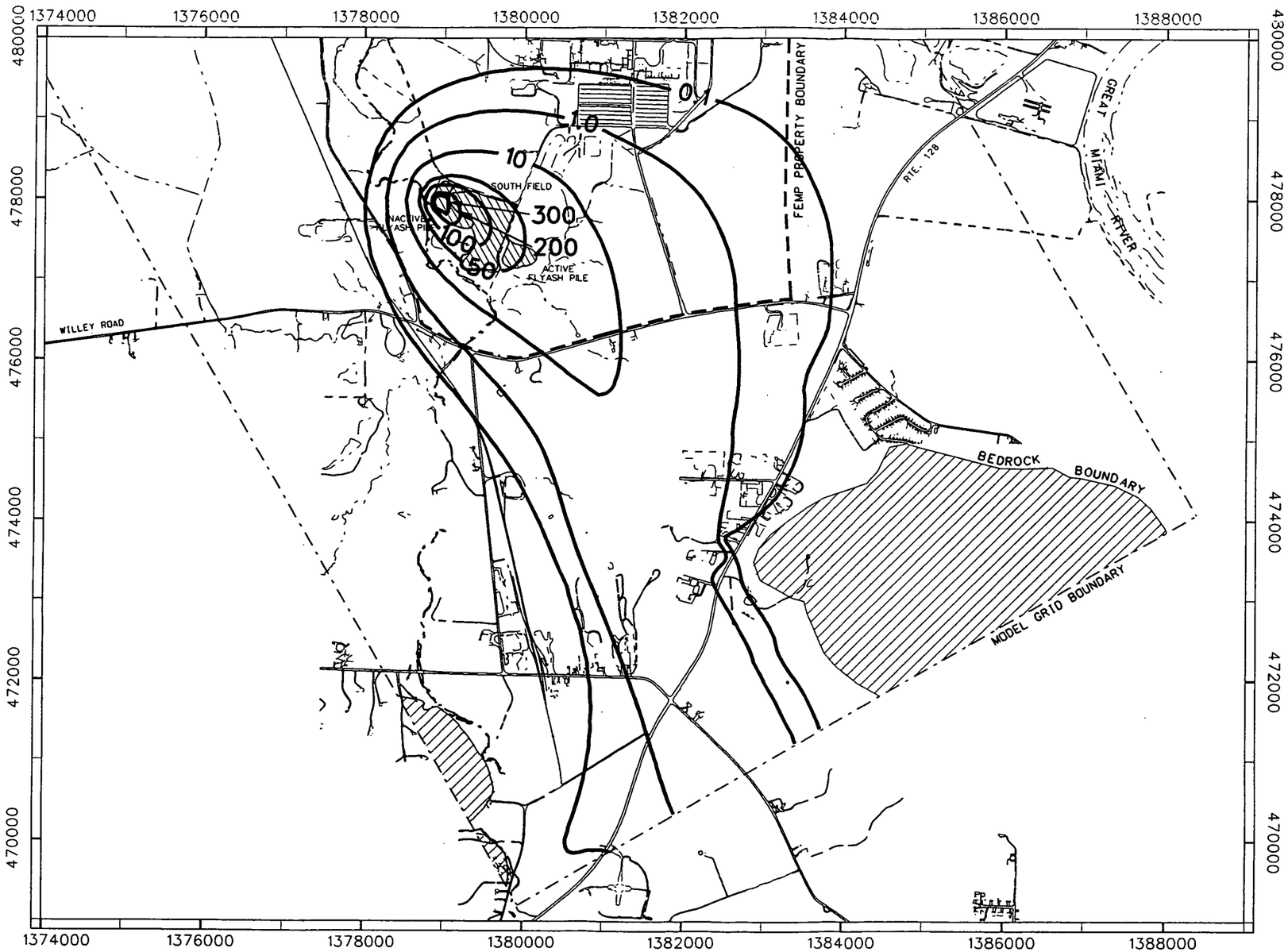
concentrations. The value of effective porosity used in the Operable Unit 2 RI SWIFT III model was 25 percent.

The groundwater fate and transport modeling results for the Inactive Flyash Pile and South Field are summarized in Table 1-36 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, molybdenum, and silver. 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 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:



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

N

SCALE (METER)
0 360 720

Other source loadings and background concentration not included.

000272

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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TABLE 1-36

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 FEMP Boundary (years)	Maximum Concentration at the FEMP Boundary (pCi/L RAD) (μg/L non-RAD)	10^{-7} Risk or 0.1 Hazard Index Screening Levels (pCi/L RAD) (μg/L non-RAD)
RADIONUCLIDES							
Neptunium-237	$1.73 \times 10^{+2}$	40	360	1.52×10^{0}	540	1.40×10^{-1}	2.20×10^{-2}
Radium-226	1.58×10^{-1}	760	1,000	8.90×10^{-3}	1,000	1.13×10^{-9}	4.00×10^{-2}
Strontium-90	6.32×10^{0}	60	140	8.54×10^{-2}	200	1.85×10^{-3}	1.30×10^{-1}
Techentium-99	$7.72 \times 10^{+2}$	60	40	$1.03 \times 10^{+1}$	40	2.86×10^{0}	2.70×10^{-1}
Uranium-234	$1.05 \times 10^{+4}$	20	160	$4.69 \times 10^{+2}$	220	$2.40 \times 10^{+1}$	3.00×10^{-1}
Uranium-235/236	$7.36 \times 10^{+2}$	20	160	$2.50 \times 10^{+1}$	220	1.28×10^{0}	3.00×10^{-1}
Uranium-238	$5.44 \times 10^{+5}$	20	160	$5.17 \times 10^{+2}$	220	$2.65 \times 10^{+1}$	1.70×10^{-1}
Uranium Total - (non-RAD)[a]	$3.79 \times 10^{+4}$	20	160	$1.84 \times 10^{+3}$	220	$9.45 \times 10^{+1}$	$1.00 \times 10^{+1}$
INORGANICS							
Antimony	$1.27 \times 10^{+1}$	280	530	8.61×10^{-1}	1,000	4.60×10^{-4}	1.50×10^{0}
Cadmium	$1.18 \times 10^{+1}$	60	980	7.51×10^{-1}	1,000	7.63×10^{-2}	1.80×10^{0}
Lead	$5.61 \times 10^{+1}$	200	1,000	4.86×10^{0}	1,000	5.94×10^{-3}	1.50×10^{0}
Manganese	$3.28 \times 10^{+3}$	240	560	$2.17 \times 10^{+2}$	1,000	5.98×10^{-2}	$1.80 \times 10^{+1}$
Molybdenum	$1.32 \times 10^{+3}$	60	660	$1.34 \times 10^{+1}$	1,000	1.26×10^{0}	$1.80 \times 10^{+1}$

[a]Results for uranium-234, uranium-235/236, and total uranium were established by using appropriate scaling ratios to uranium-238 results.

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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 these relationships 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 since 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 2.0×10^{-2} μg/L for thorium-232 to 51.4 pCi/L for uranium-234. The only

organic CPC for the surface soil was toluene. The predicted concentration of toluene in the Storm Sewer Outfall Ditch was 2.2 μg/L. For inorganic parameters, the predicted concentrations in the Storm Sewer Outfall Ditch ranged from 4.3 x 10^{-2} μg/L for thallium to 297 μg/L for barium.

The predicted concentrations of radionuclides in Paddys Run range from 2.5 x 10^{-4} pCi/L for thorium-232 to 0.64 pCi/L for uranium-234 or uranium-238. Radionuclide concentrations in the Great Miami River were predicted to range between 3.0 x 10^{-7} pCi/L for thorium-232 to 7.8 x 10^{-4} pCi/L for uranium-234 or uranium-238. For inorganics and organics, predicted concentrations in Paddys Run ranged from 5.2 x 10^{-4} μg/L for thallium to 3.7 μg/L for barium. Concentrations of all inorganics and organics in the Great Miami River were predicted to remain below 4.5 x $^{-0}$ 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 1-37 lists the constituents that survived the various screening processes and were simulated using the SWIFT III model for the Active Flyash Pile.

The groundwater fate and transport modeling results are summarized in Table 1-38 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, neptunium-237, strontium-90, arsenic, beryllium, cadmium, lead, and molybdenum. Out of these CPCs, uranium isotopes, neptunium-237, strontium-90, arsenic, lead, and molybdenum were expected to be above screening levels in the Great Miami Aquifer. Only neptunium-237, uranium isotopes, and molybdenum were expected to be above the 10^{-7} cancer risk or 0.1 HI 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 so 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 were estimated using the EPA 70-year rule. 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. Only cyanide is predicted to reach the Great Miami Aquifer at 1.1. x 10^{-3} μg/L concentration, which is approximately four orders of magnitude lower than the 10^{-7} risk or 0.1 HI concentration.

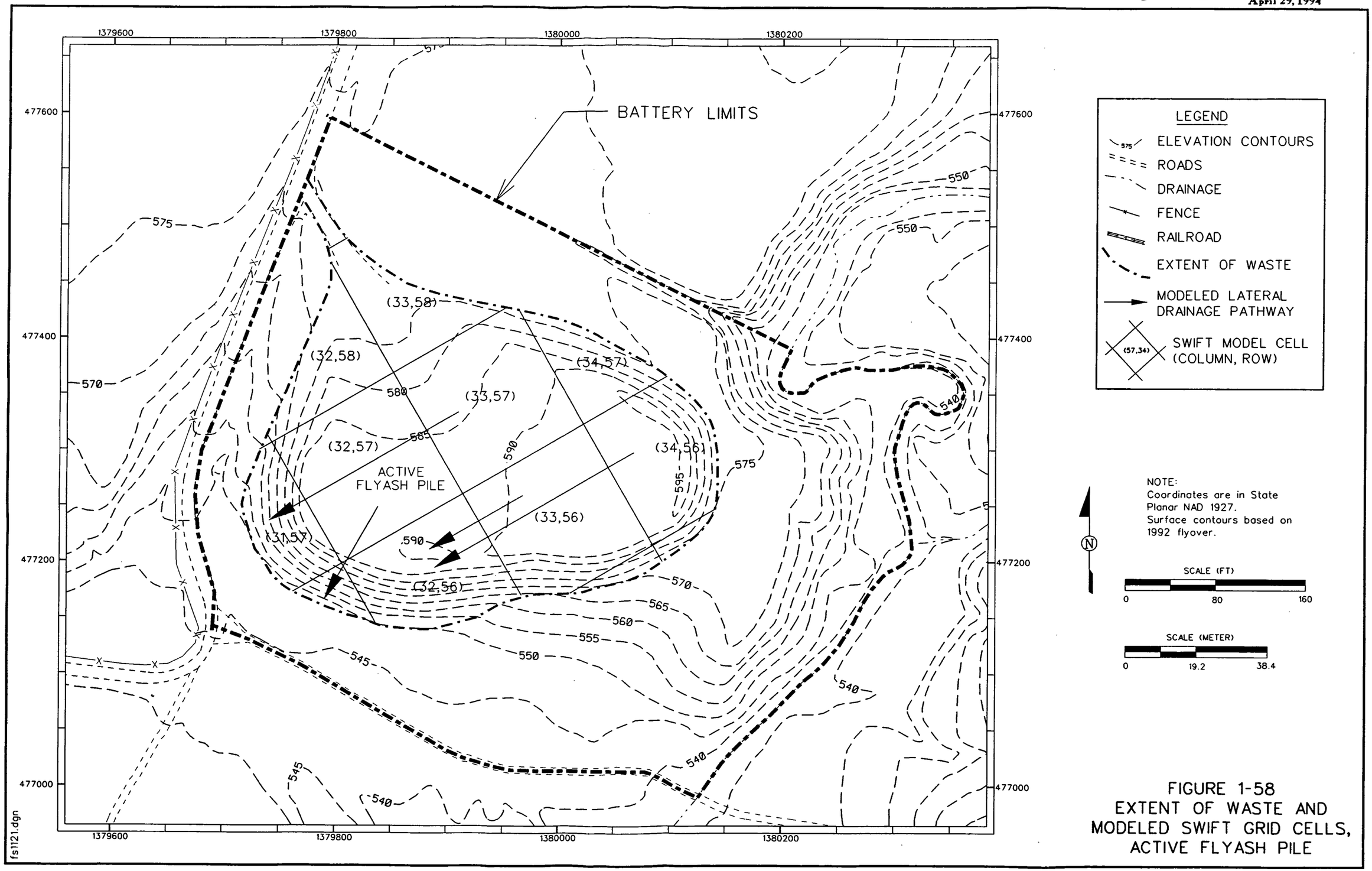
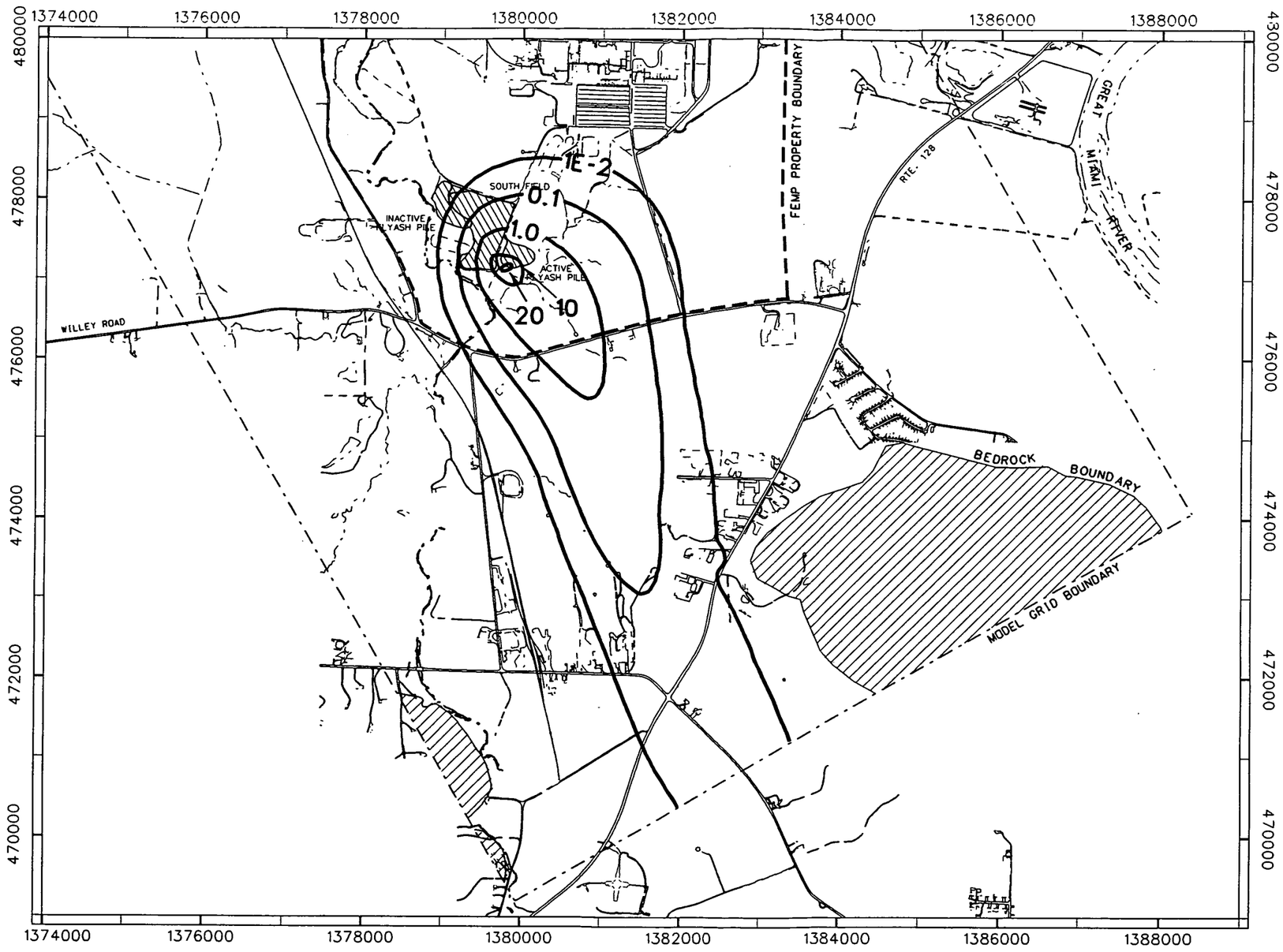


FIGURE 1-58
EXTENT OF WASTE AND MODELED SWIFT GRID CELLS, ACTIVE FLYASH PILE



LEGEND

- ROADS
- STREAM
- WASTE AREA
- RAILROAD
- FEMP PROPERTY BOUNDARY
- MODEL GRID BOUNDARY
- BEDROCK BOUNDARY
- 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.

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 1-37

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
Radium-226	No	Yes[c]
Radium-228	No	Yes[c]
Strontium-90	Yes	No
Uranium-234	Yes	Yes
Uranium-235/236	Yes	Yes
Uranium-238	Yes	Yes
Uranium Total	Yes	Yes
INORGANICS		
Arsenic	No	Yes
Beryllium	No	Yes
Cadmium	Yes	No
Lead	Yes	Yes
Molybdenum	Yes	No

[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 Great Miami Aquifer, if applicable.
[c]Not modeled based on diluted Great Miami Aquifer concentration less than 10^{-7} risk or 0.1 HI screening concentration.

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TABLE 1-38

SUMMARY OF SWIFT III 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)	10^{-7} Risk or 0.1 Hazard Index Screening Levels (pCi/L RAD) (μg/L non-RAD)
RADIONUCLIDES							
Neptunium-237	$3.28 \times 10^{+1}$	20	160	$1.52 \times 10^{+1}$	280	1.63×10^{-1}	2.20×10^{-2}
Radium-226[c]	NA[b]	0	-[c]	1.13×10^{-1}	-[c]	-[c]	4.00×10^{-2}
Radium-228[c]	NA	0	-[c]	7.83×10^{-2}	-[c]	-[c]	4.80×10^{-2}
Strontium-90	$1.79 \times 10^{+1}$	60	100	1.02×10^{0}	160	8.92×10^{-2}	1.30×10^{-1}
Uranium-234[a]	$8.54 \times 10^{+2}$	20	100	$1.98 \times 10^{+1}$	120	2.58×10^{0}	3.00×10^{-1}
Uranium-235/236[a]	$3.95 \times 10^{+2}$	20	100	1.05×10^{0}	120	1.38×10^{-1}	3.00×10^{-1}
Uranium-238	$4.87 \times 10^{+2}$	20	100	$2.18 \times 10^{+1}$	120	2.85×10^{0}	1.70×10^{-1}
Uranium - Total (non-RAD)[a]	$2.88 \times 10^{+3}$	20	100	$7.76 \times 10^{+1}$	120	$1.02 \times 10^{+1}$	$1.00 \times 10^{+1}$
INORGANICS							
Arsenic	NA	20	1,000	1.78×10^{-2}	1,000	4.55×10^{-3}	5.00×10^{-3}
Barium[c]	NA	0	-[c]	$2.2 \times 10^{+2}$	-[c]	-[c]	$2.60 \times 10^{+2}$
Beryllium	NA	20	1,000	6.87×10^{-4}	1,000	1.77×10^{-4}	2.00×10^{-3}
Cadmium	2.31×10^{0}	240	380	1.21×10^{0}	680	1.10×10^{-1}	1.80×10^{0}
Lead	$2.87 \times 10^{+1}$	20	1,000	1.64×10^{0}	1,000	3.47×10^{-2}	1.50×10^{0}
Molybdenum	$6.14 \times 10^{+2}$	20	300	$2.80 \times 10^{+1}$	520	$2.13 \times 10^{+0}$	$1.80 \times 10^{+1}$

[a]Uranium-234, uranium-235/236, and total uranium were modeled by applying ratios to uranium-238 results.
[b]Not applicable
[c]Barium, radium-226, and radium-228 were not modeled since concentrations in the Great Miami Aquifer fall below the 10^{-7} risk or 0.1 HI level after mixing in SWIFT III grid cell. Maximum predicted concentration based on the Storm Sewer Outfall Ditch width of 10 feet are reported as maximum on-site concentration.

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} risk or 0.1 HI concentration.

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} risk or 0.1 HI. For example, in grid cell (30,61), where lateral drainage was simulated, uranium isotopes, total uranium, strontium-90, barium, and cadmium concentrations exceed screening concentrations. In grid cell (29,65), which receives perched groundwater subsurface seep water, uranium isotopes, total uranium, radium-226, strontium-90, cadmium, chromium, lead, manganese, and nickel concentrations 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 certain CPCs exceed screening concentrations based on 10^{-7} risk or 0.1 HI. 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 Section B.2.0 of Appendix B to 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.

Future land use receptors assuming continued federal ownership include:

- an expanded trespasser.
- off-property resident farmer (adult and child).

Future land use receptors assuming private ownership include:

- the reasonable maximum exposure (RME) on-property 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).
- and 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 of the Operable Unit 2 RI report. Total carcinogenic risk and noncarcinogenic hazard for each of the receptors is summarized by subunit in Table 1-39.

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

1.7.3.1 Solid Waste Landfill

Table 1-40 summarizes risk and hazard associated with the Solid Waste Landfill for the future expanded trespasser and on- and off-property farmers. Total risk exceeded 1.0×10^{-6} for both future farmer receptors. Risks were mostly due to the estimated presence of beryllium and the naturally occurring radionuclides radium-228, thorium-228, and uranium-238 in soil. Risks exceeded 1.0×10^{-4} for the RME on-property farmer exposed to radium-226, uranium-238, thorium-228, and beryllium in surface soil via external radiation and dermal contact. Risk exceeded the 1.0×10^{-4} level for on-property residents ingesting produce or livestock products estimated to be contaminated with indeno(1,2,3-cd)pyrene. Risks to the expanded trespasser exceeded 1×10^{-5} due to these same compounds in soil. These estimates, however, are highly uncertain. Uncertainties are further discussed in Section B.4.0 of Appendix B of the Operable Unit 2 RI report. HIs ranged from 1.5 to 3.3 for future on-property receptors primarily due to the estimated presence of total uranium in soil.

1.7.3.2 Lime Sludge Ponds

Table 1-41 summarizes risks and hazards associated with Lime Sludge Ponds for the future expanded trespasser and the on- and off-property farmers. Risks due to groundwater did not exceed 1.0×10^{-6}. Risks associated with the expanded trespasser exceeded 1.0×10^{-6} due primarily to direct contact with

TABLE 1-39

BASELINE RISK ASSESSMENT SUMMARY

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	Expanded Trespasser	Off-Property Resident Farmer	Off-Property Resident Child
Solid Waste Landfill	Carcinogenic	$1.6x10^{-5}$	$2.4x10^{-5}$	$4.6x10^{-8}$	$6.2x10^{-9}$	$3.9x10^{-7}$	$4.4x10^{-5}$	$1.3x10^{-6}$	$1.5x10^{-7}$
	Noncarcinogenic	$3.9x10^{-1}$	$1.4x10^{-1}$	$5.5x10^{-6}$	$2.6x10^{-5}$	$6.1x10^{-5}$	$7.4x10^{-1}$	$1.3x10^{-4}$	$6.1x10^{-4}$
Lime Sludge Ponds	Carcinogenic	$2.8x10^{-5}$	$4.7x10^{-5}$	$2.3x10^{-7}$	$4.9x10^{-8}$	$5.5x10^{-6}$	$9.8x10^{-5}$	$2.4x10^{-7}$	$5.0x10^{-8}$
	Noncarcinogenic	$2.1x10^{-1}$	$1.4x10^{-1}$	$1.1x10^{-4}$	$2.0x10^{-4}$	$1.8x10^{-3}$	$6.3x10^{-1}$	$1.1x10^{-4}$	$2.0x10^{-4}$
Inactive Flyash Pile	Carcinogenic	$3.3x10^{-5}$	$5.0x10^{-5}$	$8.6x10^{-8}$	$8.3x10^{-9}$	$3.2x10^{-8}$	$1.2x10^{-4}$	$6.6x10^{-5}$	$3.2x10^{-6}$
	Noncarcinogenic	$1.2x1^{-1}$	$4.5x10^{-2}$	$3.1x10^{-5}$	$1.3x10^{-4}$	$7.2x10^{-5}$	$4.0x10^{-1}$	1.3	3.4
South Field	Carcinogenic	$8.0x10^{-5}$	$6.5x10^{-4}$	$7.0x10^{-7}$	$3.0x10^{-7}$	$4.2x10^{-6}$	$2.2x10^{-4}$	$8.1x10^{-5}$	$1.2x10^{-5}$
	Noncarcinogenic	$3.6x10^{-1}$	$4.1x10^{-2}$	$1.2x10^{-5}$	$4.9x10^{-5}$	$1.7x10^{-5}$	$3.8x10^{-1}$	1.1	2.7
Active Flyash Pile	Carcinogenic	$6.5x10^{-5}$	$9.2x10^{-5}$	$1.7x10^{-6}$	$5.0x10^{-7}$	$6.5x10^{-6}$	$2.4x10^{-4}$	$9.2x10^{-6}$	$8.7x10^{-7}$
	Noncarcinogenic	$1.1x10^{-1}$	$9.9x10^{-2}$	$4.2x10^{-3}$	$1.6x10^{-2}$	$4.7x10^{-2}$	$2.8x10^{-1}$	$1.9x10^{-1}$	$7.1x10^{-1}$

See footnotes at end of table

TABLE 1-39
(Continued)

Waste Subunit	Risk Type[a]	Future Land Use Assuming Private Ownership							
		On-Property Resident Farmer (RME)[b]	On-Property Resident Farmer (CT)[c]	On-Property Resident Child	Home Builder	Perched Groundwater User	Perched Groundwater Child	Great Miami River User (Adult)	Great Miami River User (Youth)
Solid Waste Landfill	Carcinogenic	$1.2x10^{-3}$	$8.8x10^{-5}$	$1.2x10^{-4}$	$5.1x10^{-6}$	$5.3x10^{-3}$	$1.1x10^{-3}$	$1.0x10^{-5}$	$4.2x10^{-6}$
	Noncarcinogenic	1.5	$3.0x10^{-1}$	3.3	1.9	NA[d]	NA	$1.4x10^{-1}$	$1.7x10^{-1}$
Lime Sludge Ponds	Carcinogenic	$1.9x10^{-3}$	$1.7x10^{-4}$	$2.1x10^{-4}$	NA	$7.7x10^{-7}$	$1.4x10^{-7}$	N/A	N/A
	Noncarcinogenic	$2.6x10^{-1}$	$1.4x10^{-1}$	1.3	NA	$6.0x10^{-3}$	$1.2x10^{-2}$	N/A	N/A
Inactive Flyash Pile	Carcinogenic	$3.2x10^{-3}$	$2.7x10^{-4}$	$3.3x10^{-4}$	NA	NA	NA	$2.5x10^{-5}$	$8.2x10^{-6}$
	Noncarcinogenic	$2.3x10^{+1}$	$1.3x10^{+1}$	$5.8x10^{+1}$	NA	NA	NA	$3.8x10^{-1}$	$2.4x10^{-2}$
South Field	Carcinogenic	$3.8x10^{-3}$	$3.1x10^{-4}$	$4.5x10^{-4}$	$2.7x10^{-7}$	NA	NA	$1.1x10^{-4}$	$6.3x10^{-5}$
	Noncarcinogenic	$2.2x10^{+1}$	$1.3x10^{+1}$	$5.7x10^{+1}$	0.1	NA	NA	$4.4x10^{-2}$	$6.3x10^{-2}$
Active Flyash Pile	Carcinogenic	$1.9x10^{-3}$	$1.7x10^{-4}$	$6.0x10^{-4}$	NA	NA	NA	$1.3x10^{-4}$	$6.5x10^{-5}$
	Noncarcinogenic	2.1	1.1	8.0	NA	NA	NA	0.2	0.2

[a]The carcinogenic risk value is the Incremental Lifetime Cancer Risk (ILCR) and the noncarcinogenic hazard value is the HI.

[b]RME = Reasonable Maximum Exposure.

[c]CT = Central Tendency.

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

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TABLE 1-40

FUTURE LAND USE
SOLID WASTE LANDFILL
SUMMARY OF TOTAL CARCINOGENIC RISK

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Soil						
Celsium-137	2.3E-07	0.58	8.8E-13	0.00	2.1E-05	1.85
Neptunium-237	2.5E-07	0.62	6.0E-09	0.45	2.3E-05	1.97
Plutonium-238	1.3E-08	0.03	5.2E-09	0.39	1.1E-06	0.09
Radium-226	1.3E-08	0.03	9.9E-10	0.07	1.5E-06	0.13
Radium-228	2.2E-06	5.49	2.0E-09	0.15	2.0E-04	17.59
Thorium-228	4.1E-06	10.36	2.2E-08	1.66	3.8E-04	32.89
Thorium-230	5.8E-08	0.15	3.3E-08	2.46	2.4E-06	0.20
Uranium-234	3.4E-07	0.86	1.9E-07	14.34	1.5E-05	1.26
Uranium-235/236	3.3E-07	0.82	1.2E-08	0.93	2.9E-05	2.53
Uranium-238	1.4E-06	3.52	7.0E-07	52.63	1.7E-04	14.47
Total Radiological Risk	8.9E-06	22.48	9.8E-07	73.68	8.4E-04	73.07
Arsenic	3.6E-07	0.91	9.8E-09	0.74	3.0E-05	2.63
Beryllium	2.8E-05	69.26	5.8E-10	0.04	2.4E-05	21.11
Chromium	1.5E-07	0.38	6.2E-08	4.64	3.7E-06	0.32
Benzo(a)pyrene	4.9E-08	0.12	2.0E-10	0.02	6.1E-06	0.53
Benzo(b)fluoranthene	1.3E-08	0.03	5.2E-11	0.00	1.6E-06	0.14
Dibenzo(a,h)anthracene	3.2E-08	0.08	1.3E-10	0.01	4.0E-06	0.35
Indeno(1,2,3-cd)pyrene	1.9E-08	0.05	7.9E-11	0.01	2.4E-06	0.21
Total Chemical Risk	1.2E-07	70.89	7.3E-08	5.46	1.5E-05	25.41
Total	9.1E-06	93.37	1.1E-06	79.14	8.6E-04	98.48
Homegrown Produce (Dust Affected)						
Arsenic	N/A[a]		1.0E-07	7.84	7.2E-06	0.62
Total Chemical Risk			1.2E-07	8.70	8.0E-06	0.69
Total			1.2E-07	9.24	8.5E-06	0.73

See footnote at end of table

TABLE 1-40
(Continued)

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Beef/Milk (Dust Affected)						
Indeno(1,2,3-cd)pyrene	N/A		1.2E-07	9.07	7.3E-06	0.63
Total Chemical Risk			1.5E-07	11.11	9.0E-06	0.78
Total			1.5E-07	11.21	9.0E-06	0.78
ALL MEDIA	4.0E-05		1.3E-06		1.2E-03	
CPCs	3.7E-05		1.3E-06		1.1E-03	

[a]Not Applicable

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TABLE 1-41

FUTURE LAND USE
LIME SLUDGE PONDS
SUMMARY OF CARCINOGENIC RISK

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	6.3E-07	0.71	2.7E-13	0.00	5.8E-05	3.14
Neptunium-237	1.4E-07	0.16	4.3E-10	0.18	1.4E-05	0.73
Radium-226	1.6E-08	0.02	1.2E-10	0.05	2.0E-06	0.11
Radium-228	2.1E-06	2.39	2.2E-11	0.01	2.0E-04	10.65
Thorium-228	7.3E-06	8.19	4.7E-09	1.94	6.8E-04	36.45
Thorium-230	7.9E-08	0.09	2.7E-08	11.08	4.9E-06	0.26
Uranium-234	3.5E-08	0.04	1.1E-08	4.66	2.5E-06	0.13
Uranium-235/236	1.9E-07	0.21	9.0E-10	0.37	1.8E-05	0.94
Uranium-238	1.3E-06	1.49	7.6E-08	31.57	1.2E-04	6.56
Total Radiological Risk	1.2E-05	13.30	1.2E-07	50.40	1.1E-03	59.05
Arsenic	3.7E-07	0.42	1.2E-09	0.52	3.2E-05	1.73
Beryllium	6.0E-05	67.17	1.5E-10	0.06	5.3E-04	28.51
Aroclor-1254	1.7E-05	18.76	0.0E+00	0.00	1.5E-04	8.30
Benzo(a)anthracene	2.0E-08	0.02	9.3E-12	0.00	2.5E-06	0.13
Benzo(a)pyrene	1.6E-07	0.18	7.7E-11	0.03	2.0E-05	1.07
Benzo(b)fluoranathene	1.8E-08	0.02	8.6E-12	0.00	2.2E-06	0.12
Dibenzo(a,h)anthracene	5.1E-08	0.06	2.5E-11	0.01	6.4E-06	0.34
Indeno(1,2,3-cd)pyrene	2.8E-08	0.03	1.4E-11	0.01	3.6E-06	0.19
Total	8.9E-05	100.00	1.2E-07	51.36	1.9E-03	99.50
Home Grown Produce (Dust Affected)						
Arsenic	N/A[a]		1.1E-08	4.77	1.0E-06	0.05
Total Chemical Risk			3.3E-08	13.63	2.9E-06	0.16
Total			3.9E-08	16.24	3.4E-06	0.19

See footnotes at end of table

TABLE 1-41
(Continued)

Medium/Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Beef/Milk (Dust Affected)						
Aroclor-1254	N/A		2.0E-08	8.33	1.8E-06	0.09
Benzo(a)pyrene	N/A		1.8E-08	7.69	1.6E-06	0.09
Total Chemical Risk			6.2E-08	25.62	5.4E-06	0.29
Total			6.3E-08	26.05	5.5E-06	0.30
ALL MEDIA	8.9E-05		2.4E-07		1.9E-03	
COCs	8.9E-05		1.7E-07		1.9E-03	

[a]N/A = Not Applicable

surface soil containing beryllium, Aroclor-1254, and thorium-228. Risks associated with the RME farmer receptors exceeded 1.0×10^{-4} due mostly to the presence of the same compounds in surface soil.

1.7.3.3 Inactive Flyash Pile

Table 1-42 summarizes the risks and hazards associated with the Inactive Flyash Pile for the future expanded trespasser and on- and off-property farmers.

The largest carcinogenic risk, which slightly exceeded 1.0×10^{-3} was associated with groundwater use by the RME farmer. Total risk for this receptor was 3.2×10^{-3} due mostly to thorium-228 and beryllium in soil. 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 also contributed significant risk. Exposure resulting in HIs greater than 1.0 was associated with ingestion of groundwater and homegrown produce contaminated with total uranium by the on-property residents.

1.7.3.4 South Field

Table 1-43 summarizes the risks associated with the South Field for the future expanded trespasser and on-property and off-property farmers. The greatest risk, which was 3.8×10^{-3}, was associated with the RME on-property farmer. Risks associated with groundwater use by this receptor were 3.9×10^{-4}; risks associated with homegrown produce and beef and milk for this receptor also exceeded 1.0×10^{-4}. Risks to the off-property farmer via contact with groundwater, beef, milk, and homegrown produce were in the 1.0×10^{-6} to 1.0×10^{-4} 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 farmer had major additional risk from the presence of radium-228, thorium-228, and PAHs in surface soil. Exposures resulting in HIs greater than 1.0 for on-property and off-property farm receptors were due to the estimated future presence of the total uranium in groundwater.

1.7.3.5 Active Flyash Pile

Table 1-44 summarizes carcinogenic and noncarcinogenic risks and hazard associated with the Active Flyash Pile for the future expanded trespasser and on- and off-property receptors. The largest risks

TABLE 1-42

FUTURE LAND USE
INACTIVE FLYASH PILE
SUMMARY OF CARCINOGENIC RISK

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	4.1E-07	0.40	3.7E-13	0.00	3.8E-05	1.18
Neptunium-237	1.6E-07	0.15	9.6E-10	0.00	1.5E-05	0.46
Radium-226	1.7E-08	0.02	2.5E-10	0.00	2.0E-06	0.06
Radium-228	2.9E-06	2.78	6.5E-11	0.00	2.7E-04	8.35
Thorium-228	6.8E-06	6.49	8.8E-09	0.01	6.3E-04	19.45
Uranium-235/236	4.6E-08	0.04	4.4E-10	0.00	4.2E-06	0.13
Uranium-238	1.6E-07	0.15	1.9E-08	0.03	1.5E-05	0.45
Total Radiological Risk	1.1E-05	10.05	4.5E-08	0.07	9.8E-04	30.14
Arsenic	1.7E-06	1.62	1.2E-08	0.02	1.5E-04	4.57
Beryllium	9.0E-05	85.67	4.5E-10	0.00	7.9E-04	24.47
Dibenzo(a,h)anthracene	3.5E-07	0.33	3.5E-10	0.00	4.4E-05	1.35
Total Chemical Risk	9.2E-05	87.64	2.4E-08	0.04	9.9E-04	30.40
Total	1.0E-04	97.68	6.9E-08	0.11	2.0E-03	60.54
Groundwater						
Uranium-234	N/A[a]		1.9E-05	28.63	3.7E-04	11.33
Uranium-235/236	N/A		1.0E-06	1.53	2.0E-05	0.60
Uranium-238	N/A		3.6E-05	55.32	7.1E-04	21.86
Total Radiological Risk			5.6E-05	85.58	1.1E-03	33.80
Home Grown Produce (Groundwater Affected)						
Uranium-234	N/A		2.8E-06	4.29	5.5E-05	1.70
Uranium-235/236	N/A		1.5E-07	0.23	2.9E-06	0.09
Uranium-238	N/A		5.4E-06	8.28	1.1E-04	3.27
Total Radiological Risk			8.4E-06	12.80	1.6E-04	5.06

See footnotes at end of table

TABLE 1-42
(Continued)

Medium/Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Beef/Milk (Groundwater Affected)						
Uranium-234	N/A		3.3E-07	0.50	6.4E-06	0.20
Uranium-238	N/A		6.3E-07	0.96	1.2E-05	0.38
Total Radiological Risk			9.8E-07	1.49	1.9E-05	0.59
ALL MEDIA	1.0E-04		6.6E-05		3.2E-03	
COCs	1.0E-04		6.6E-05		3.2E-03	

[a]N/A = Not Applicable

TABLE 1-43

FUTURE LAND USE
SOUTH FIELD
SUMMARY OF TOTAL CARCINOGENIC RISK

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Soil						
Celsium-137	4.5E-07	0.21	8.0E-13	0.00	4.1E-05	1.10
Neptunium-237	5.3E-08	0.02	5.6E-10	0.00	4.6E-06	0.12
Radium-226	3.6E-07	0.17	7.8E-09	0.01	3.5E-05	0.94
Radium-228	5.0E-06	2.35	2.2E-10	0.00	4.7E-04	12.46
Thorium-228	1.1E-05	5.34	2.9E-08	0.04	1.0E-03	27.64
Thorium-230	4.7E-07	0.22	3.4E-08	0.04	1.7E-05	0.46
Thorium-232	1.3E-07	0.06	9.5E-09	0.01	4.9E-06	0.13
Uranium-234	2.7E-07	0.12	1.9E-08	0.02	1.0E-05	0.26
Uranium-235/236	5.7E-08	0.03	8.9E-10	0.00	4.6E-06	0.12
Uranium-238	1.9E-07	0.09	4.1E-08	0.05	3.5E-05	0.93
Total Radiological Risk	1.9E-05	8.62	1.4E-07	0.18	1.7E-03	44.21
Arsenic	3.8E-07	0.18	5.2E-10	0.00	3.3E-05	0.87
Beryllium	3.7E-05	17.34	3.8E-10	0.00	3.3E-04	8.74
Chromium	5.3E-07	0.25	2.7E-08	0.03	1.3E-05	0.35
Benzo(a)anthracene	1.2E-07	0.06	2.3E-10	0.00	1.5E-05	0.40
Benzo(a)pyrene	1.4E-06	0.65	2.7E-09	0.00	1.7E-04	4.53
Benzo(b)fluoranthene	1.1E-07	0.05	2.2E-10	0.00	1.4E-05	0.37
Benzo(k)fluoranthene	5.6E-08	0.03	1.1E-10	0.00	6.9E-06	0.18
Dibenzo(a,h)anthracene	3.1E-07	0.15	6.1E-10	0.00	3.8E-05	1.02
Indeno(1,2,3-cd)pyrene	2.4E-07	0.11	4.8E-10	0.00	3.0E-05	0.79
Aroclor-1254	2.5E-06	1.18	0.0E+00	0.00	2.3E-05	0.62
Aroclor-1260	1.5E-06	0.69	0.0E+00	0.00	1.4E-05	0.36
Dieldrin	4.8E-07	0.22	7.6E-12	0.00	4.5E-06	0.12
Total Chemical Risk	4.5E-05	20.89	3.2E-08	0.04	6.9E-04	18.36
Total	6.3E-05	29.52	1.8E-07	0.22	2.4E-03	62.57

See footnote at end of table

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TABLE 1-43
(Continued)

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Sediment						
Radium-228	1.5E-06	0.69	N/A[a]		N/A	
Thorium-228	3.2E-06	1.47	N/A		N/A	
Total Radiological Risk	4.9E-06	2.29				
Arsenic	3.3E-06	1.52	N/A		N/A	
Beryllium	1.4E-04	66.39	N/A		N/A	
Total Chemical Risk	1.5E-04	67.39				
Total	1.5E-04	70.22				
Groundwater						
Uranium-234	N/A		1.9E-05	23.27	3.7E-04	9.76
Uranium-235/236	N/A		1.10E-06	1.24	2.0E-05	0.52
Uranium-238	N/A		3.6E-05	44.97	7.1E-04	18.83
Total Radiological Risk			2.0E-05	69.57	3.9E-04	29.13
Total						
Homegrown Produce (Dust Affected)						
Benzo(a)pyrene	N/A		5.1E-07	0.63	4.2E-06	0.11
Total Chemical Risk			9.6E-07	1.19	8.0E-06	0.21
Total			1.0E-06	1.28	8.6E-06	0.23
Homegrown Produce (Groundwater Affected)						
Uranium-234	N/A		2.8E-06	3.49	5.5E-05	1.46
Uranium-235	N/A		1.5E-07	0.19	2.9E-06	0.08
Uranium-238	N/A		5.4E-06	6.73	1.1E-04	2.82
Total Radiological Risk			8.4E-06	10.43	1.6E-04	4.36

See footnote at end of table

TABLE 1-43
(Continued)

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Beef/Milk (Dust Affected)						
Benzo(a)pyrene	N/A		1.3E-06	1.67	1.2E-05	0.31
Benzo(b)fluoranthene	N/A		4.3E-07	0.53	3.7E-06	0.10
Benzo(k)fluoranthene	N/A		4.3E-07	0.53	3.7E-06	0.10
Dibenzo(a,h)anthracene	N/A		3.0E-07	0.37	2.6E-06	0.07
Ideno(1,2,3-cd)pyrene	N/A		1.1E-05	13.99	9.8E-05	2.60
Total Chemical Risk			1.4E-05	17.23	1.2E-04	3.20
Total			1.4E-05	17.26	1.2E-04	3.20
Beef/Milk (Groundwater Affected)						
Uranium-234	N/A		3.3E-07	0.41	6.4E-06	0.17
Uranium-238	N/A		6.3E-07	0.78	1.2E-05	0.33
Total Radiological Risk			1.0E-06	1.24	1.9E-05	0.51
ALL MEDIA	2.1E-04		8.1E-05		3.8E-03	
CPCs	2.1E-04		8.0E-05		3.8E-03	

[a]Not Applicable

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TABLE 1-44

FUTURE LAND USE
ACTIVE FLYASH PILE
SUMMARY OF TOTAL CARCINOGENIC RISK

Medium/ Parameter	Expanded Trespasser	% Total Receptor Risk	Off-Property Resident Farmer	% Total Receptor Risk	On-Property Resident Farmer (RME)	% Total Receptor Risk
Soil						
Neptunium-237	1.1E-06	0.50	1.4E-08	0.15	1.0E-04	5.46
Radium-226	1.2E-05	5.71	1.2E-09	0.01	4.7E-06	0.25
Radium-228	4.1E-06	1.90	1.9E-10	0.00	3.8E-04	20.26
Thorium-228	9.6E-06	4.41	2.6E-08	0.28	8.9E-04	46.91
Uranium-235/236	1.7E-08	0.01	4.3E-10	0.00	1.6E-06	0.09
Uranium-238	6.7E-08	0.03	1.6E-08	0.18	6.0E-06	0.32
Total Radiological Risk	2.7E-05	12.57	8.5E-08	0.92	1.4E-03	73.42
Arsenic	4.6E-06	2.13	6.6E-08	0.72	4.0E-04	21.21
Beryllium	1.8E-04	85.03	1.9E-09	0.02	1.9E-08	0.00
Total Chemical Risk	1.9E-04	87.16	9.4E-09	1.03	4.0E-04	21.23
Total	2.2E-04	99.74	1.8E-07	1.95	1.8E-03	94.65
Groundwater						
Uranium-234	N/A[a]		2.0E-06	22.06	1.5E-05	0.82
Uranium-238	N/A		3.9E-06	42.59	3.0E-05	1.58
Total Radiological Risk			6.4E-06	69.77	4.7E-05	2.49
Total Chemical Risk			1.0E-09	0.01	2.4E-15	0.00
Total			6.4E-06	69.78	4.7E-05	2.49
Homegrown Produce (Dust Affected)						
Arsenic	N/A		1.1E-06	12.24	3.4E-05	1.80
Beryllium	N/A		1.4E-07	1.56	4.4E-06	0.23
Total Chemical Risk			1.3E-06	13.80	3.8E-05	2.03
Total			1.3E-06	14.22	4.0E-05	2.09

See footnote 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	On-Property Resident Farmer (RME)	% Total Receptor Risk
Homegrown Produce (Groundwater Affected)						
Uranium-234	N/A		3.0E-07	3.30	2.3E-06	0.12
Uranium-238	N/A		5.9E-07	6.38	4.5E-06	0.24
Total Radiological Risk			9.7E-07	10.52	7.1E-06	0.38
Total Chemical Risk			1.5E-10	0.00	3.6E-16	0.00
Total			9.7E-07	10.52	7.1E-06	0.38
Beef/Milk (Dust Affected)						
Arsenic	N/A		2.0E-07	2.17	6.1E-06	0.32
Total Chemical Risk			2.1E-07	2.30	6.4E-06	0.34
Total			2.1E-07	2.33	6.5E-06	0.34
ALL MEDIA	2.2E-04		9.2E-06		1.9E-03	
CPCs	2.2E-04		8.9E-06		1.9E-03	

[a]Not Applicable

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are from direct contact with soil or surface flyash material. Total estimated risks to the expanded trespasser slightly exceed the 1.0×10^{-4} level due mostly to the estimated presence of beryllium in flyash material.

Total estimated risk to the off-property farmer exceeded the 1.0×10^{-6} level due mostly to direct exposure to the estimated future concentration of uranium-234 and uranium-238 in groundwater. The estimated presence of arsenic in flyash material deposited on homegrown produce also contributed to the total risk to this receptor.

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 radium-228, thorium-228, and arsenic in surface flyash material. Risk due to direct contact with contaminants in groundwater is 4.7×10^{-5} to this receptor. Risks associated with homegrown produce, beef, and milk for the RME farmer receptor are inconsequential.

The only receptors associated with total HIs greater than 1.0 are the future on-property RME farmer and resident child. Total HI for the farmer is 2.1, due mostly to the presence of arsenic, beryllium, and toluene in surface flyash material. Total HI for the future on-property resident child is 8.0, again due mostly to the presence of arsenic, beryllium, and toluene in surface flyash material.

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 of HIs for these site-related concentrations are often greater than 1.0×10^{-4} and 1.0, respectively. Background contributions provide a useful point of comparison for subunit specific risk estimates. Therefore, risks and HIs were calculated for the RME on-property future 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 Operative Unit 2 RI Report.

1.8 OPERABLE UNIT 2 CERCLA ACTIONS

Removal Site Evaluations (RSE) 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) installation of a silt trap made from permeable geotextile fabric around the entire perimeter of the pile at the toe of the slope; (2) installation of a wind barrier made from high-density polyethylene around the top perimeter of the flyash pile; (3) alteration of the active working surface to minimize the noncompacted area and to prevent an increase in the maximum height of the existing pile; (4) minor regrading of the outer berm and compacting the nonworking top surfaces of the flyash pile; (5) application of water, foam, and binding-type dust-control agents on side slopes and top; and (6) periodic inspection and necessary maintenance identified during inspection. 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 the installation of 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 provide bank stabilization 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, interim slope improvement was performed with the installation of 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.

2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

2.1 INTRODUCTION

The purpose of this section is to develop Remedial Action Objectives (RAOs) for the Operable Unit 2 FSO. Development of RAOs is a key step in the FS process. The RAOs are medium-specific goals that define the objective of taking remedial actions to protect human health and the environment. The RAOs specify the contaminants of concern (COCs), the exposure routes and receptors, and an acceptable contaminant level or range of levels for each exposure route (preliminary remediation goals). It is important to identify contaminant levels and exposure routes because protectiveness can be achieved by reducing exposure routes as well as by reducing contaminant levels.

These 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 which will be developed into preliminary remedial alternatives.

The development of Operable Unit 2 RAOs is presented in three steps: 1) the ARARs are identified; 2) the COCs, by media, are identified with respect to exposure routes and receptors, this information is then used to establish preliminary remediation goals for the environmental media; 3) these data are used to develop RAOs.

In this section, the following three actions of the FS process are discussed:

- Identify ARARs (Section 2.2).
- Develop preliminary remediation goals (Section 2.3).
- Establish remedial action objectives (Section 2.5).

2.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED CRITERIA

CERCLA §121(d)(2) directs that for wastes left on-site, remedial actions must comply with Federal and State environmental laws that are legally applicable or relevant and appropriate under the circumstances of the release or potential release. Off-site actions must comply with all requirements that are legally applicable. This section discusses the applicable or relevant and appropriate requirements (ARARs) for Operable Unit 2.

The definitions of ARARs are:

- 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 criteria (TBCs) are a category created by EPA 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 laws and regulations, Ohio regulations, DOE Orders, and OEPA guidance that address the site-specific circumstances in Operable Unit 2.

The National Oil and Hazardous Substances Pollution Contingency Plan (called the National Contingency Plan) has identified 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].

- Location-specific ARARs restrict actions or contaminant concentrations in certain environmentally sensitive areas. Examples of areas regulated under various Federal laws include floodplains, wetlands, and locations where endangered species or historically significant cultural resources are present.

- Action-specific ARARs are usually technology- or activity-based requirements, limitations on actions, or conditions involving special substances.

Under CERCLA §121(d)(4), EPA may waive compliance with an ARAR if one of the following conditions can be demonstrated:

- 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 is not directly applicable to the project. However, cost is still a criteria for the evaluation of identified alternatives.)

At this time, it not expected that Operable Unit 2 will require a waiver from any ARAR.

The initial Operable Unit 2 list of potential ARARs was submitted to EPA and OEPA on October 12, 1990. On February 7, 1991, EPA acknowledged receipt of the potential list and commented that their review would be an iterative process with their final approval given at the time of remedy selection.

During the Operable Unit 2 RI, sufficient data was developed to make initial judgements 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 (U.S. DOE 1994).

The Operable Unit 2 ARARs will be finalized with the selection of the preferred remedial alternative for each subunit. The Record of Decision (ROD) will contain the final list of ARARs that will govern the remedial design and remedial action of the chosen alternatives.

The proposed Operable Unit 2 ARARs are identified in Appendix B. A discussion of major ARARs is presented in this section.

2.2.1 Chemical-Specific ARARs

The Baseline Risk Assessment process identified the contaminants of concern (COCs) for Operable Unit 2. Table 2-1 presents the COCs for soil and the subset of COCs in the contaminated material that are predicted to pose a future adverse impact to groundwater from each subunit. These groundwater COCs have been determined to have the potential to leach from the contaminated material to the groundwater at concentrations which would result in unacceptable risk to a future groundwater user.

The chemical-specific ARARs for these contaminants of concern are arranged in this section according to the following categories:

- ARARs and TBC Criteria for Drinking Water and Groundwater
- ARARs and TBC Criteria for Surface Water
- ARARs and TBC Criteria for Air Emissions
- ARARS and TBC Criteria for Radiation
- As Low As Reasonably Achievable (ALARA) Requirements

2.2.1.1 ARARs and TBC Criteria for Drinking Water and Groundwater

The chemical-specific requirements for drinking water and groundwater are relevant and appropriate for Operable Unit 2 remedial actions. 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 Maximum Contaminant Levels (MCLs) are considered to be relevant and appropriate for any aquifer that is a potential drinking water source. The Great Miami Aquifer beneath the site is a potential drinking water source.

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 standard would not be relevant and appropriate (U.S. EPA 1990a).

The relevant and appropriate or TBC (proposed) MCLG and MCL values for the Operable Unit 2 COCs are provided in Appendix B-1.

TABLE 2-1

OPERABLE UNIT 2 CONTAMINANTS OF CONCERN (COCs)

Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
SOIL				
cesium-137 neptunium-237 radium-226 radium-228 thorium-228 thorium-230 technetium-99 plutonium-238 uranium-234 uranium-235/236 uranium-238 arsenic beryllium chromium benzo(a)pyrene benzo(b)fluoranthene carbazole 4,4-DDE dibenzo(a,h)anthracene indeno(1,2,3-cd)pyrene	cesium-137 neptunium-237 radium-226 radium-228 thorium-228 thorium-230 uranium-234 uranium-235/236 uranium-238 arsenic beryllium Aroclor-1254 benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene dibenzo(a,h)anthracene indeno(1,2,3-cd)pyrene	cesium-137 neptunium-237 radium-226 radium-228 thorium-228 uranium-234 uranium-235/236 uranium-238 arsenic beryllium dibenzo(a,h)anthracene	cesium-137 neptunium-237 radium-226 radium-228 thorium-228 thorium-230 thorium-232 uranium-234 uranium-235/236 uranium-238 arsenic beryllium chromium Aroclor-1254 Aroclor-1260 benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene benzo(k)fluoranthene dibeno(a,h)anthracene dieldrin indeno(1,2,3-cd)pyrene	neptunium-237 radium-226 radium-228 thorium-228 uranium-234 uranium-235/236 uranium-238 arsenic beryllium
GROUNDWATER				
no COCs	no COCs	uranium-234 uranium-235/236 uranium-238	uranium-234 uranium-235/236 uranium-238	uranium-234 uranium-238
PERCHED GROUNDWATER				
technetium-99 carbazole	no COCs	no COCs	no COCs	no COCs

2.2.1.2 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):

- warm water aquatic life habitat
- agricultural and industrial water supply
- primary contact recreational use

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

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.

The definitions of all water designation terms are presented in the Ohio Administrative Code (OAC) 3745-1-07.

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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 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.

2.2.1.3 ARARs and TBC Criteria for Air Emissions

EPA regulations for National Emission Standards for Hazardous Air Pollutants (NESHAP) provides 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 per year. 40 CFR §192.02, Subpart A, requires that reasonable assurance be provided that releases of radon-222 from residual radioactive material to the atmosphere will not:

- exceed an average release rate of 20 pCi/m^{2s} (averaged over the entire surface of the disposal site and over at least one 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 each of our subunits contains radium-226 in the soil, an element that decays into radon-222.

The National Ambient Air Quality Standards (NAAQS) would be applicable for remedial treatment units (e.g., vitrification, dryer) because they may release airborne pollutants. The remedial treatment units for Operable Unit 2, in addition to the FEMP's emissions during remedial action, will be designed to maintain the NAAQs standards for carbon monoxide, nitrogen dioxide, particulate matter (PM_{10}), ozone, and sulfur oxides. These standards are provided in Appendix B.

For the same reason as the NAAWS are applicable, 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 this policy, a health impact/risk assessment study on the carcinogen will be performed 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 concentration (MAGLC) 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 or MAGLC would be exceeded. Operable Unit 2 emissions, in conjunction with all FEMP emissions, will be verified during remedial design.

2.2.1.4 ARARS and TBC Criteria for Radiation

Atomic Energy Act (AEA) requirements for DOE's low-level radioactive waste management are incorporated into DOE Order 5820.2A, developed under DOE's AEA authority. The Order is generally consistent with and typically includes equivalent Nuclear Regulatory Commission (NRC) 10 DOE Order 5820.2A requirements are TBC requirements, which 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 a 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 mrems.

The relevant and appropriate EPA regulation is 40 CFR §192.20 that 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 is present in each Operable Unit 2 subunit.

2.2.1.5 As Low As Reasonably Achievable (ALARA)

Regulations 40 CFR §§ 192.21(f) and 192.22(b), considered relevant and appropriate, require that reasonable measures be made to maintain releases of radioactivity in effluents 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.

2.2.2 Action-Specific ARARs

The principal action-specific requirements for Operable Unit 2 are based upon the regulatory definitions and classifications of the wastes in each of the subunits. This section describes the waste classifications and indicates the action-specific requirements associated with each waste. One principal action-specific requirement, called the corrective action management unit (CAMU) rule, is relevant and appropriate for the waste. In addition to the waste-specific requirements contained in Operable Unit 2, this section also describes the uses of the CAMU and the associated temporary unit (TU).

2.2.2.1 Corrective Action Management Units (40 CFR §264.552)

This rule supports treatment and consolidation of waste material from a portion of the site or from the total site, without invoking disposal restrictions. The decisions for designation of CAMUs are related to the function and purpose of managing remediation wastes during cleanup, rather than to the aerial extent and the contiguousness of the contamination prior to cleanup. Placement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes or trigger minimum technology requirements.

Remediation wastes means all solid and hazardous waste and all media (including groundwater, surface water, soils, sediments and debris) which contain listed hazardous wastes or which themselves exhibit a hazardous waste characteristic, that are managed for the purpose of implementing corrective, or remedial action requirements.

The CAMU rule also created a temporary unit (TU) that can be used for treatment or storage of remediation wastes during remedial activities. TUs can be located inside or outside the physical boundaries of a CAMU, however, they must be located at the facility. The rule specifies that only tanks and container storage units will be eligible for designation as TUs. These TUs are also not

subject to land disposal restrictions and minimum technology requirements. There is a maximum one-year time limit on the use of the TU which can only be extended if the wastes had to remain in the unit due to "unforeseen, temporary, and uncontrollable" circumstances.

Although, with the exception of the material in the South Field Firing Range, the wastes in Operable Unit 2 are not considered to be hazardous wastes, the substantive requirements of the CAMU rule are considered to be relevant and appropriate because this rule addresses situations sufficiently similar to those encountered in the remediation of Operable Unit 2. Consolidation and/or treatment of Operable Unit 2 remediation wastes and contaminated media in the area of contamination or at the FEMP facility will not be considered as new placement or disposal of wastes.

2.2.2.2 Regulatory Definition of Wastes

Operable Unit 2 subunits contain a mixture of waste classifications that will direct pertinent action-specific ARAR and TBC criteria for in situ containment, on-site disposal, and/or off-site disposal. The different types of wastes are:

- Low-level radioactive waste/Residual radioactive material
- Solid waste
- Non-toxic wastes and wastes exempt from the OEPA definition of solid waste
  - Flyash/bottom ash
  - Lime sludge
  - Construction debris
- Infectious waste
- Hazardous waste
- Other material not considered waste
  - Soils below the Proposed Remediation Levels (PRLs)
  - Residual radioactive material below PRLs

The mixture of waste classifications associated with each Operable Unit 2 subunit is identified in Table 2-2.

The remedial actions will be required to meet the most stringent requirements of rules governing each type of wastes being managed together.

A specific discussion of each classification of Operable Unit 2 wastes is presented in this section. Detailed definitions and the technical requirements for in situ capping or disposal of each of these wastes are provided in Appendix B.

TABLE 2-2

OPERABLE UNIT 2 SUBUNIT WASTE CLASSIFICATIONS

Waste Type	Solid Waste Landfill	Lime Sludge Ponds	Inactive Flyash Pile	South Field	Active Flyash Pile
Low-Level Radioactive Wastes/ Residual Radioactive Material	X	X	X	X	-
Solid Waste	X	-	X	X	-
Exempted Waste	-	X	X	-	X
Infectious Waste	X	-	-	-	-
Hazardous Waste	-	-	-	X	-
Soils and Residual Radioactive Material Below the PRLs	X	X	X	X	X

2.2.2.2.1 Low-Level Radioactive Waste/Residual Radioactive Material

The term low-level radioactive wastes is defined broadly as a radioactive material that is not high level wastes, spent nuclear fuel, transuranic wastes, or byproduct material [Atomic Energy Act; 42 U.S.C. §2014(e)(2)]. DOE has established a more specific definition for residual radioactive material. Residual radioactive material is defined as residual concentrations of radionuclides in soil, debris, surface contamination, air emissions and water discharges (DOE Order 5400.5). Residual radioactive material can be free released from federal control (not considered a waste) if concentration levels can be shown to be below the functional definition of 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.

2.2.2.2.2 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 by product material, as defined by the Atomic Energy Act of 1954 as amended, is not solid waste under the federal definition (40 CFR §257).

The OEPA's definition of solid waste is any unwanted residual solid or semi-solid material resulting from industrial, commercial, agricultural, and community operations. Several exemptions to this definition and OEPA requirements for solid waste, are provided that will be discussed in the next waste category (OAC 3745-27-03).

2.2.2.2.3 Non-Toxic Exempted Waste

The following wastes are considered exempted waste (from the OEPA Solid Waste Regulations OAC 3745-27-03):

- Non-toxic flyash/bottom ash - These wastes are considered non-toxic if its leachate (from the EP Toxicity test) does not exceed 30 times the Ohio Drinking Water Standard [OAC 3745-81-11(B)] for arsenic, barium, cadmium, chromium, lead, mercury and selenium (Table 2-3), the flyash in Operable Unit 2 will meet both the 30 times Ohio Drinking Water Standard and the OEPA Hazardous Waste Toxic Criteria. OEPA Policy 4.07 provides requirements for disposal facilities for exempted wastes.

TABLE 2-3

NONTOXIC FLYASH LIMITS

Parameter	Ohio Drinking Water Standards 3745-81-11(B) mg/L	30 X Ohio Drinking Water Standard mg/L	OEPA Hazardous Waste Toxic Criteria mg/L
Arsenic	0.05	1.5	5.0
Barium	1.0	30.0	100.0
Cadmium	0.01	0.3	1.0
Chromium	0.05	1.5	5.0
Lead	0.05	1.5	5.0
Mercury	0.002	0.06	0.02
Selenium	0.01	0.3	1.0

- Lime sludge - Lime sludge and other material resulting from the treatment of a water supply for drinking or industrial purposes are not required to meet the OEPA solid waste regulations [OAC 3745-27-03(H)(2)].

- Construction debris - Construction wastes and debris are not required to meet the OEPA solid waste regulations. OEPA has proposed separate regulation of construction debris. These proposed regulations state that a construction debris disposal facility at its final elevation (i.e., no more material will be added to the facility) at the time of the rule's promulgation is not subject to the regulations. Construction or demolition debris that is stored for less than two years for recycling into usable construction material is exempt from the definition of construction debris waste (Proposed OAC 3745-29-01).

For the purposes of the Operable Unit 2 FS, the technical requirements provided in OEPA Policy 4.07 for disposal of non-toxic flyash, bottom ash, foundry sands, and other exempted solid waste, will be the minimum TBC criteria for the remedial actions for flyash, lime sludge, and construction debris.

2.2.2.2.4 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 wastes per month who do not hold a certificate of registration may transport and dispose of infectious wastes in the same manner as solid wastes. The FEMP, with approximately 2,500 employees and subcontractors, has just exceeded the 50 pounds per month level. This regulation is not applicable nor relevant and appropriate 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.

2.2.2.2.5 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 listed wastes were disposed in Operable Unit 2 subunits. TCLP analyses taken in these units showed that the Operable Unit 2 subunits are not characteristically toxic. Therefore, RCRA subtitle C requirements will not be considered applicable or relevant and appropriate.

One exception will be during the remediation of the firing range in the South Field. While the bullets are not considered waste, they will be managed as a hazardous waste subject to 40 CFR §262 requirements when they are actively managed for disposal off site.

2.2.2.2.6 Residual Radioactive Material and Soils Below the PRLs

Residual Radioactive materials and soils below PRLs determined through the CERCLA process are protective of human health and are therefore not considered to be a waste.

This is consistent with the Division of Solid and Infectious Waste Management (DSIWM) Policy PP 01 03 200 for petroleum-contaminated soil (March 25, 1991). This policy references the RCRA Subtitle C "contained in" policy for environmental media. The "contained in" policy does not consider environmental media to be a waste material. The result of the policy is that if the waste constituents can be removed, the environmental media is no longer a hazardous waste. The OEPA policy applied this concept to petroleum-contaminated soils by stating that the soils containing a petroleum hydrocarbon would not need to be managed as a solid waste if the contaminants are removed.

2.2.3 Location-Specific ARARs

The most significant location-specific ARAR is the determination by the Region V, EPA (53 CFR 25670) that the buried valley aquifer system of the Great Miami/Little Miami rivers of Southwestern Ohio is the sole or principal source of drinking water and that this aquifer, if contaminated, would create a significant hazard to the public health. The determination was effective as of 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 the sole source of drinking water. OEPA has established solid waste siting criteria that prohibit locating a solid waste landfill over a sole source

aquifer unless it is demonstrated to the Director that human health and the environment will be protected.

For waste exempted from an OEPA definition of solid waste, the regulations and guidance state that disposal units may not be normally located over a sole source aquifer, but allows demonstrations of adequate protection. A specific discussion of the location-specific requirements for each type of waste in Operable Unit 2 is presented in this section.

2.2.3.1 Residual Radioactive Material and Soil Below the PRLs

As discussed in Section 2.2.2.2.5, the soils in this group are not considered to be a waste. These soils will be protective of human health and the environment without any additional engineering or hydrogeologic controls. For residual radioactive material and soil with levels below the PRLs, OEPA location-specific ARARs would, therefore, not be considered applicable or relevant and appropriate.

2.2.3.2 Non-Toxic Exempted Wastes

OEPA Policy 4.07, effective August 1, 1988, provides design criteria for the disposal of non-toxic flyash, bottom ash, foundry sands, and other exempted solid wastes. Because lime sludge and construction debris are exempted from the OEPA solid waste regulations, this policy will apply to the disposal of these materials.

This policy states that any exempted waste disposal facility shall not normally be located above a federally declared sole source aquifer. The policy also states that supporting documentation and evidence must be submitted if the identified pollution control measures, such as siting criteria or landfill design requirements, are not planned to be utilized. Therefore, if non-toxic flyash and other exempted wastes will be separated from other remedial wastes contained and disposed on-site, documentation and evidence will be provided through the CERCLA process to demonstrate that the containment or disposal of these non-toxic and exempted wastes above a sole source aquifer is protective of human health and the environment.

2.2.3.3 Solid Wastes from the Solid Waste Landfill

OEPA Solid Waste Regulations [OAC 3745-27-09(Y)] state that, upon every tenth anniversary of the effective date of the permit to install that approved the initial construction of the facility, the permittee shall submit to the director an analysis demonstrating that the design, construction, and final closure

plan of the sanitary landfill facility continues to constitute the best available technology. If the director determines that the design is no longer consistent with best available technology as being applied to the sanitary landfill industry in the State of Ohio, the permittee may be required to submit a permit to install application for necessary modifications to the landfill facilities. If a permit to install is required, the Director shall not apply the siting criteria outlined in paragraph (B) of OAC 3745-27-07, when considering the application.

If the current design of the Solid Waste Landfill does not adequately protect human health and the environment, the decision to upgrade the existing facility will be based on the comparison of the detailed alternatives in the FS and will be identified as the preferred leading remedial alternative in the Proposed Plan. The upgrade may consist of additional capping measures, segregation of wastes, compacting, and/or providing a liner containment system for increased protection of the groundwater. While the Solid Waste Landfill has not received a permit to install from OEPA due to its age, the substantive requirements of OAC 3745 -27-09(Y) will be relevant and appropriate for any upgrade to the existing Solid Waste Landfill at the FEMP.

2.2.3.4 Other Wastes Resulting From CERCLA Remedial Actions

The consolidation of existing waste materials into a disposal unit(s) will not invoke the OEPA siting criteria. EPA guidance states that consolidation of waste material during a CERCLA remedial action does not constitute placement that would invoke requirements such as RCRA land disposal restrictions. This direction has been further expanded by the RCRA CAMU rule that supports treatment and consolidation of waste material from a portion of the total remedial site, without invoking disposal restrictions (see Section 2.2.2.1 for detail about the CAMU rule). This action was implemented to encourage treatment of wastes for more effective long term solutions. The OEPA regulation OAC 3745-27-09(Y) supports this concept by waiving the siting criteria contained in paragraph (B) of OAC 3745-27-07 when actions are taken to improve an existing solid waste disposal facility to better protect human health and the environment.

2.2.3.5 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 using the U.S. Army Corps of Engineers standard HEC2 water surface profile analysis program in October 1993. The 100-year flood

elevations reach the western 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 U.S. Army Corps of Engineers Wetland Delineation Manual was completed in March 1993. A small area of wetlands were identified north of the Solid Waste Landfill. EPA and DOE regulations (40 CFR §6.302 and 10 CFR §1022) require that impacts to wetlands and floodplains be avoided when a practicable alternative to the impact exists. OEPA regulations prohibit the siting of a new solid waste disposal facility in a floodplain or within 200 feet of a wetland. If it is necessary to adversely impact wetlands during remediation, Operable Unit 2 will comply with the substantive permitting requirements for impacts to wetlands under the Clean Water Act (33 CFR §§ 323-330).

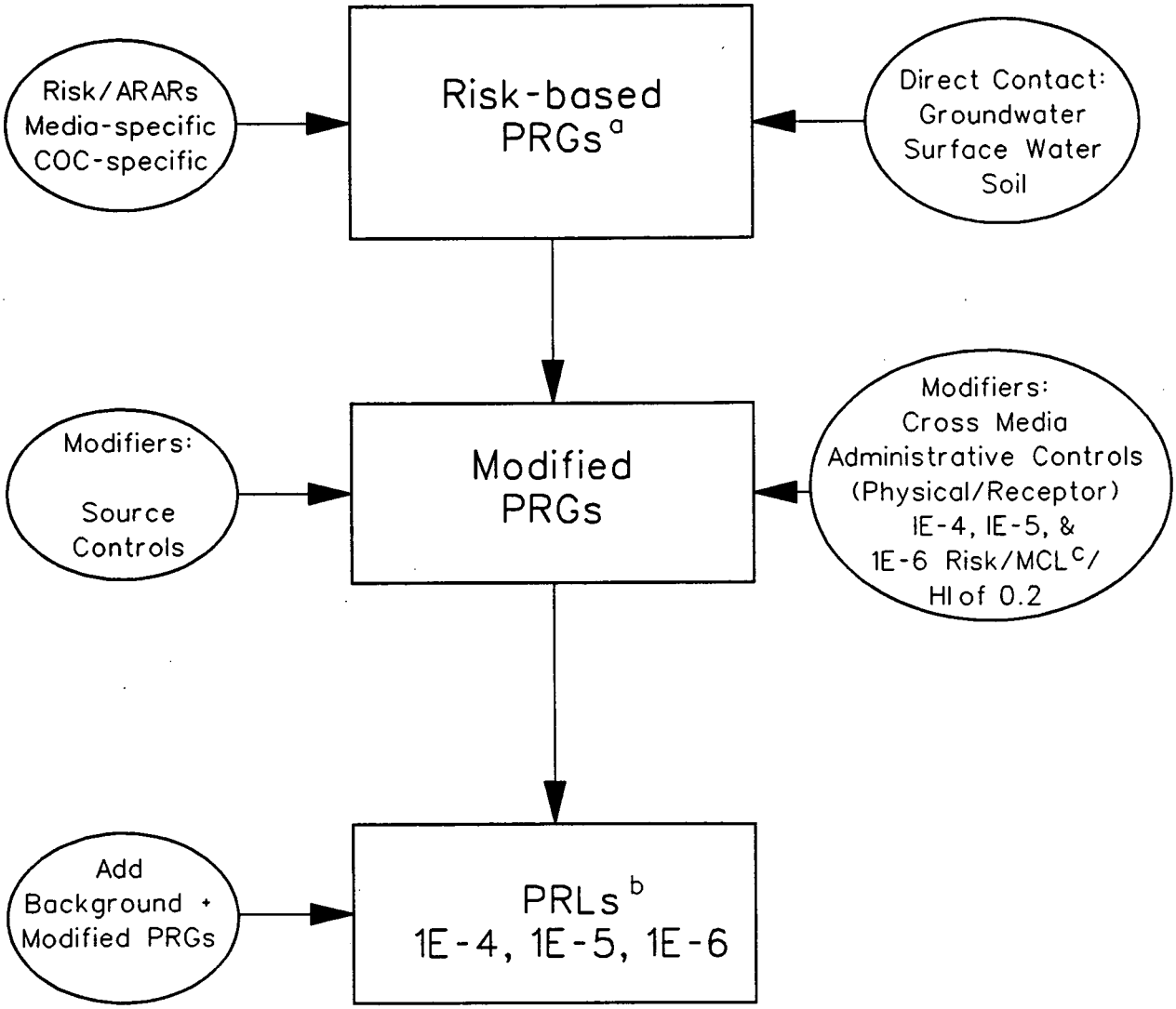
2.3 DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS AND PRELIMINARY REMEDIATION LEVELS

The protection of human health is one of the two threshold criteria identified in the NCP to evaluate FS alternatives. A multi-step process, shown in Figure 2-1, will be followed to determine remediation levels in media that will be protective of human health. This process begins with the development of risk-based Preliminary Remediation Goals (PRGs) and is completed by establishing Proposed Remediation Levels (PRLs) for the Operable Unit 2 Record of Decision (ROD) that will direct the remedial actions in Operable Unit 2.

The PRLs will differ from PRGs because of modifications resulting from consideration of various uncertainties, technical and exposure factors, as well as all nine. Selection-of-Remedy criteria outlined in NCP. In support of this process and to allow for more accurate estimates of volumes and costs, a variety of modified PRGs and PRLs will be calculated in this section and will be used in the feasibility study process.

Through the CERCLA process, DOE is responsible for the remediation of the site to allow no additional risk to a receptor than the acceptable exposure level that represent an excess upper bound lifetime cancer risk to an individual between 1.0×10^{-4} to 1.0×10^{-6}. The PRG represents the incremental concentration level above background that represents this ILCR. PRLs, therefore, will be calculated as the sum of the acceptable incremental risk as represented by the modified PRGs and background.

5501



a - Preliminary Remedial Goal
b - Preliminary Remedial Level
c - Maximum Concentration Level

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FIGURE 2-1
PROCESS FOR DEVELOPING PROPOSED REMEDIAL LEVELS (PRLs)

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Risk-based PRGs are developed from the ILCRs and are used as initial guidelines. Risk-based PRGs are based on the following:

- For chemical toxicants, an HI = 0.2
- For chemical and radiation carcinogens, an ILCR = 1.0×10^{-6}
- Dose limits applicable or relevant and appropriate requirements (ARARs) and to be considered (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 and does not consider cross-media impacts.

Contaminants of concern (COCs) are those contaminants which remain a concern at the end of the baseline risk assessment process. The baseline risk assessment evaluates the risk to future receptors if no remedial action is taken a the Operable Unit 2 subunit. These contaminants were determined to potentially pose an unacceptable risk to human health under the certain condition of exposure for the on-property farmer, off-property farmer, and expanded trespasser. The point of departure from the acceptable risk levels for COCs are associated with a risk greater than 1.0×10^{-6} or an HI greater than 0.2.

The risk-based PRGs can be 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 have been evaluated in this report:

- Administrative controls
  - administratively and physically limiting access to potential receptors through federal continued ownership and fencing of impacted areas.
- Cross media
  - potential for soil to impact groundwater

- Source control assumptions
  - lateral control of water movement in perched water within the glacial overburden
  - reduced infiltration/exposure barrier

Source control assumptions were added as modifiers to allow additional alternatives to be considered. This step was added because cross media modified soil PRGs are below background levels.

PRGs that are modified must still meet the threshold of (1) protection of human health and (2) compliance with ARARs.

Certain media associated with Operable Unit 2 (i.e., groundwater and surface water) are outside the scope of remedial actions being considered under this FS and will be addressed in Operable Unit 5. However, risk-based PRGs are provided for groundwater, because groundwater serves as a environmental receptor and pathway for the uptake of COCs from contaminated material located in Operable Unit 2.

2.3.1 Risk-Based PRGs

Risk-based PRGs for surface soil and groundwater were calculated using the on-property (RME) farmer exposure scenario, intake equations, and exposure parameter values consistent with those utilized in the baseline risk assessment for Operable Unit 2. The on-property (RME) farmer is used to calculated the risk-based PRGs because it is a reasonably maximized exposure scenario where an individual has unlimited access to the operable unit to farm, live, and do other activities.

Risk-based PRGs are calculated from the results of the baseline risk assessment based on a linear interpolation between concentration of the COC "i" in the source medium (either soil, surface water, or groundwater) and the total risk from all direct and indirect exposure pathways resulting from that source medium, based on the equation:

$$PRG_i = \frac{(ILCR)(C_{si})}{\Sigma risk_i} \qquad (2\text{-}1)$$

where:

PRG_i = Preliminary remediation goal for constituent "i" in source medium

ILCR = Target risk level 10^{-4} to 10^{-6} for carcinogens; or HI < =0.2

Σ $risk_i$ = Sum of risk from all direct and indirect exposure pathways

C_{si} = Concentration of COC "i" in source medium.

Note that the concentration of the COC in the above equation is the source medium concentration and not an individual exposure medium pathway concentration since the risk to a particular source includes exposure to all direct and indirect exposure pathways. Table 2-4 presents the minimum soil risk-based PRGs developed for Operable Unit 2 subunits.

Table 2-5 presents the groundwater risk-based PRGs developed for Operable Unit 2. The subunits which contain COCs in the GMA include the South Field, Active Flyash Pile, and Inactive Flyash Pile. COCs were not identified in the GMA for the Solid Waste Landfill and Lime Sludge Ponds.

Perched water as a potential drinking water source was evaluated for the Lime Sludge Ponds and the Solid Waste Landfill. COCs were identified for the Solid Waste Landfill. Perched water was not considered a potential drinking water source for the Inactive Flyash Pile, South Field and the Active Flyash Pile subunits due to the low potential for water yield from perched water in these subunits and the nearness of the Great Miami Aquifer.

The baseline risk assessment identified no COCs in surface water for the Operable Unit 2 subunits.

2.3.2 Modified Soil PRGs Development

Risk-based soil PRGs are modified by application of influencing conditions which can include administrative controls, cross-media migration, and source controls. Modified soil PRGs that consider intermedia migration of contamination are developed using a fate and transport model to simulate the migration of contaminants from soils into groundwater.

Risk-based PRGs may be reduced or increased based on the modification considered. 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/PRLs considered for Operable Unit 2. Figure 2-2 also shows the receptor that requires the lowest PRG/PRL to be protective. Only

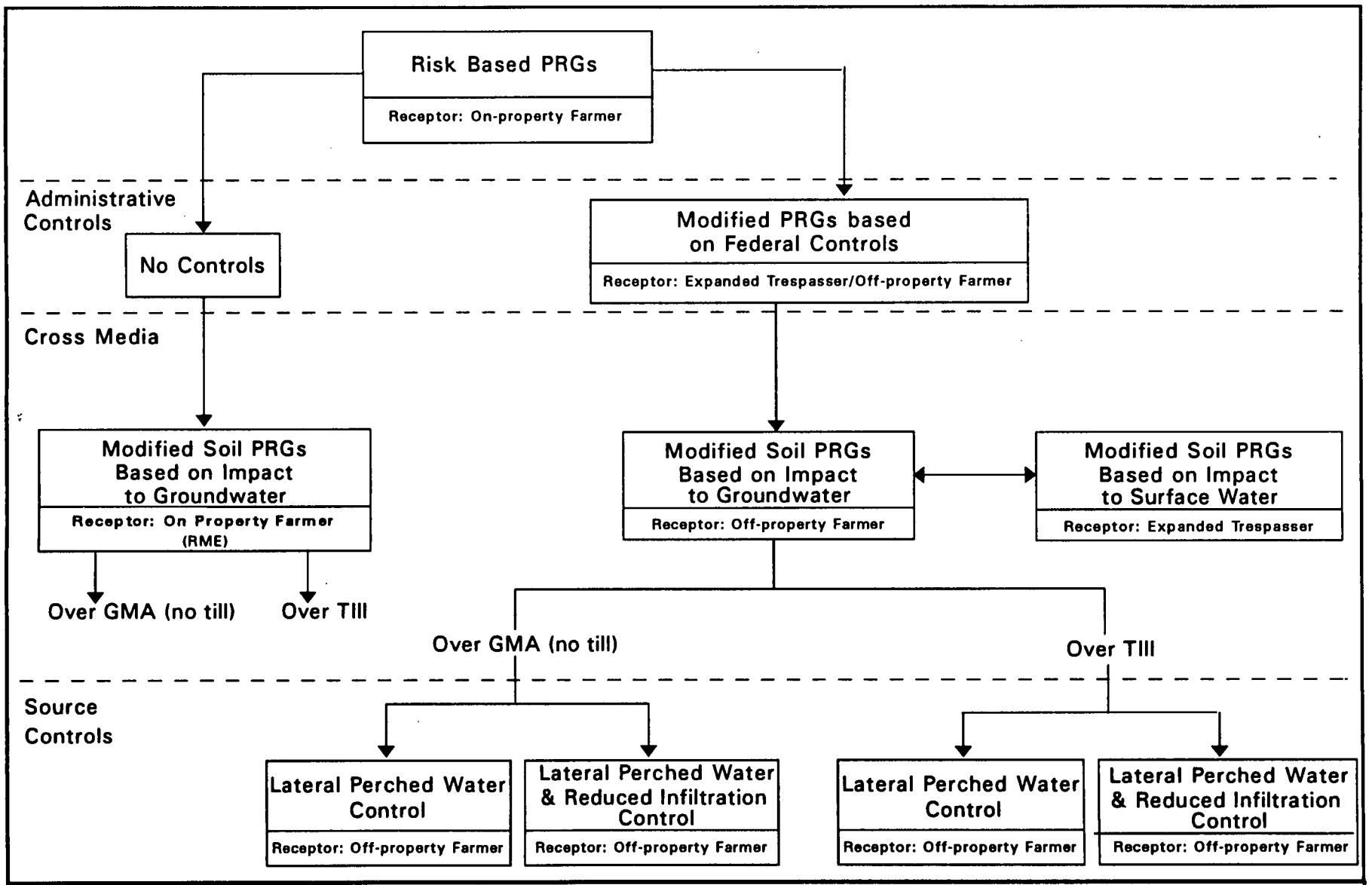

Figure 2-2 Operable Unit 2 PRG/PRL Development

TABLE 2-4

SUMMARY OF CONTAMINANTS OF CONCERN AND RISK-BASED SOIL PRELIMINARY REMEDIAL GOALS (PRGs)[a]

COC	NO ADMINISTRATIVE CONTROLS On-Property Farmer (RME)[b] PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	10^{-4} ILCR[c]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	1.2	0.12	1.2E-2		0.849
Neptunium-237	5.2	0.52	5.2E-2		0.0
Plutonium-238	91	9.1	0.91		0.0
Radium-226	94	9.4	0.94	5[d]	1.47
Radium-228	0.83	8.3E-2	8.3E-3	5[d]	1.170
Thorium-228	0.43	4.3E-2	4.3E-3		1.341
Thorium-230	310	31	3.1	5[e]	1.897
Thorium-232	320	32	3.2	5[e]	1.269
Uranium-234	320	32	3.2		1.307
Uranium-235/236	9.7	0.97	9.7E-2		0.142
Uranium-238	48	4.8	0.48		1.122
Arsenic	22	2.2	0.22		9.704
Beryllium	3.9	0.39	3.9E-2		0.6
Chromium	480	48	4.8		17.057
Benzo(a)anthracene	36	3.6	0.36		0.0
Benzo(a)pyrene	5.4	0.54	5.4E-2		0.0
Benzo(b)fluoranthene	43	4.3	0.43		0.0
Benzo(k)fluoranthene	96	9.6	0.96		0.0
Dibenzo(a,h)anthracene	3.4	0.34	3.4E-2		0.0
Indeno(1,2,3-cd)pyrene	16	1.6	0.16		0.0
Aroclor-1254	0.38	3.8E-2	3.8E-3		0.0
Aroclor-1260	0.38	3.8E-2	3.8E-3		0.0
Dieldrin	0.21	2.1E-2	2.1E-3		0.0

TABLE 2-4
(Continued)

Parameter	NO ADMINISTRATIVE CONTROLS On-Property Farmer (RM)[a] PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	HI[f] = 0.1	HI = 0.2	HI = 1.0		
NONCARCINOGNIC					
Arsenic	11.8	23	118		
Uranium-Total		37000			

[a]Risk-based PRGs in this table respresent the minimum PRGs for any of the Operable Unit 2 subunits. Specific subunit risk-based PRGs for the on-property farmer are presented in Appendix C.

[b]RM - Reasonable Maximum xposure

[c]ILCR - Incremental Lifetime Cancer Risk

[d]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 5 progeny.

[e]First 15 cm (i.e., 6 inches) depth [DO Order 5400.5 Chapter IX (4)(a)(2), (3)]

[f]HI - Hazard Index

TABLE 2-5

SUMMARY OF CONTAMINANTS OF CONCERN AND RISK-BASED GROUNDWATER PRELIMINARY REMEDIAL GOALS (PRGs)

COC	NO ADMINSTRATIVE CONTROLS				ARAR/ TBC	Background 95th %
	On-Property Farmer (RME)[a] PRG (pCi/g or mg/kg)					
	HI[e] = 0.2	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		
Uranium-234		110	11	1.1		0.187
Uranium-235/236		110	11	1.1		0.0169
Uranium-238		62	6.2	0.62		0.240
Uranium-Total	1.7E-2	--[c]	--	--	20 ug/L[d]	

[a]RME - Reasonable Maximium Exposure

[b]ILCR - Incremental Lifetime Cancer Risk

[c]-- Carcinogenic risk not applicable to this parameter

[d]56 Federal Register 33050 (July 18, 1991) TBC

[e]HI - Hazard Index

the COC whose PRG would be affected by the modification is presented in the modified PRG/PRL tables provided in the following sections.

The risk-based PRGs for all COCs would be increased by the modification the administrative control of restricting the use of the Operable Unit 2 subunits. Conversely, when considering the effect of cross media migration of contaminants from the soil to groundwater, the risk-based PRGs for the contaminants identified in the Baseline risk assessment to be a concern for that pathway would be reduced. These COCs are identified in Table 2-1 for each subunit under the headings of groundwater and perched groundwater.

The source control modifications would increase the PRGs by reducing the contaminant migration. The two cases considered in this Operable Unit 2 FS are lateral control of perched water and reduced infiltration. The reduced infiltration source control would also provide a barrier to the receptor exposure thereby eliminating the direct exposure pathway. It is assumed that the use of any source control can only be considered in conjunction with the administrative control through federal ownership.

Additionally, each modified soil PRG to consider cross-media migration was developed for different geologic 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 by the glacial overburden. Figure 2-3 shows the face of glacial overburden terrace. One set of modified soil PRGs were developed for source soils on top of the glacial overburden and another set of modified soil PRGs were developed for source soils directly underlain by the Great Miami Aquifer and the terrace face.

2.3.3 Modified Soil PRGs for Administrative Controls

Administrative controls physically limit access, movement, and activities of potential receptors. The administrative control considered in the Operable Unit 2 FS is one where Federal ownership of the property continues, thereby allowing control of the future uses of the Operable Unit 2 subunit area. Under the federal ownership scenario, it is assumed that the Operable Unit 2 area has restricted access controlled through fencing. The modified PRGs for this scenario have been developed to protect a trespasser that would make repeated unauthorized entry to the Operable Unit 2 area. This receptor is referred to as an expanded trespasser and is consistent with the trespasser considered in the Operable Unit 2 Baseline Risk Assessment. Modified PRGs for the protection of the expanded

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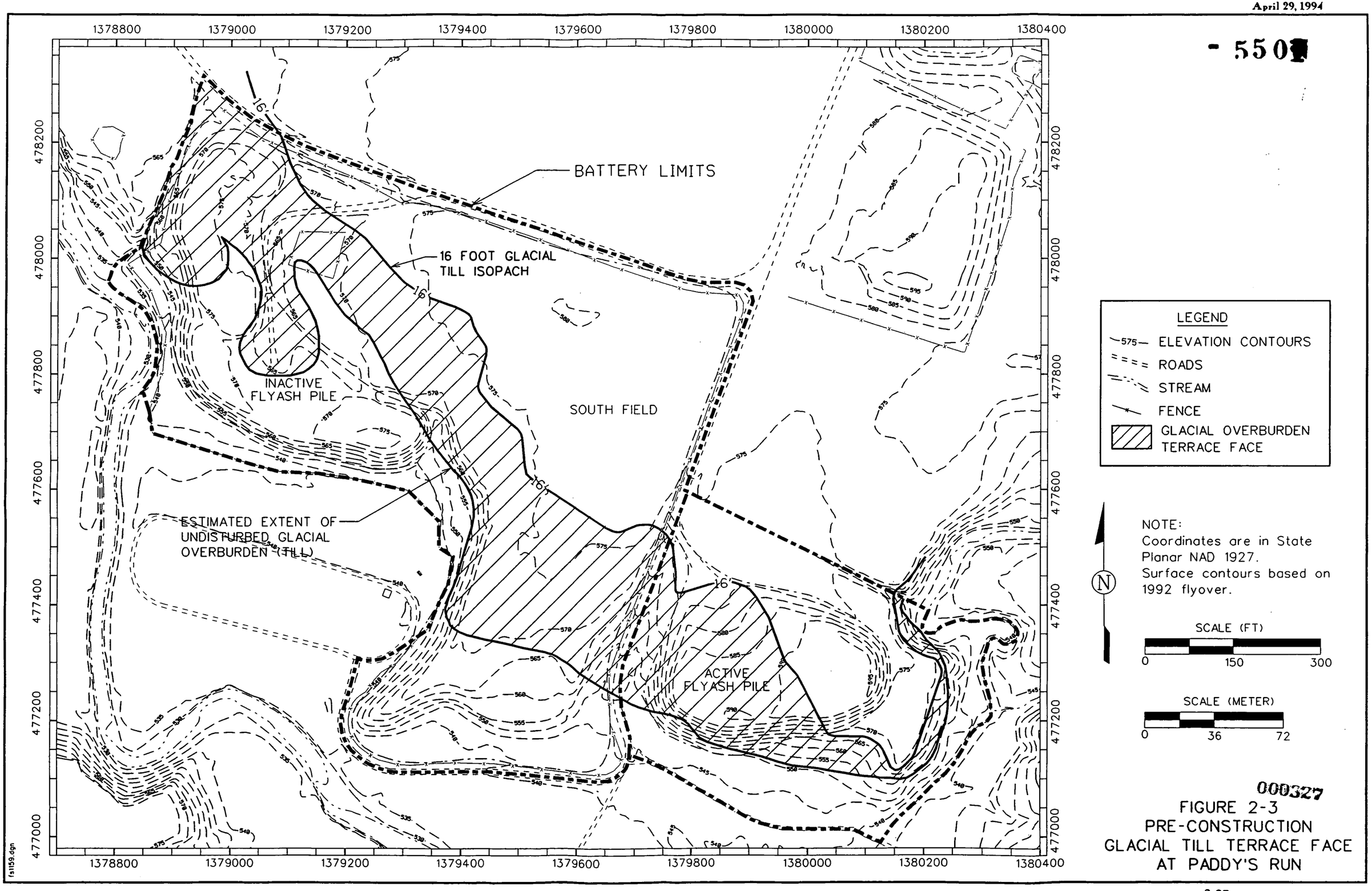

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FIGURE 2-3
PRE-CONSTRUCTION
GLACIAL TILL TERRACE FACE
AT PADDY'S RUN

trespasser must also be protective for the use of the property surrounding the Fernald site. Therefore, the modified PRGs protective of the expanded trespasser are adjusted, as needed, to also be protective of an off-property farmer. Table 2-6 presents the modified soil PRGs for the expanded trespasser. This table represents the minimum modified soil PRGs for any of the Operable Unit 2 subunits.

Tables 2-7 through 2-11 present the modified soil PRGs for the off-property farmer. Several factors contributed to the variation of modified soil PRGs developed for the off-property farmer from subunit-to-subunit. Such factors included air and groundwater modeling, and location of the off-property farmer in reference to the subunit. Modified soil PRGs developed for the South Field that would be protective of the off-property farmer in the presence of administrative controls were the lowest of the five subunits. For example, the modified soil PRG for uranium-238 in the South Field is 220 pCi/g while the other subunits modified soil PRG ranged from 410 pCi/g in the Active Flyash Pile to 3500 pCi/g in the Lime Sludge Ponds.

The PRG/PRLs presented in Table 2-6 determined to be protective of the expanded trespasser are lower than the levels determined to be protective of the off-property farmer. These PRGs/PRLs in Table 2-6 will, at a minimum, need to be met if no additional modifier is deemed to be more restrictive or if a source control reduces the exposure pathway to the expanded trespasser.

2.3.4 Modified Soil PRGs and PRLs for Cross Media Without Engineering Controls

Cross media contamination is the potential for contaminants in the soil to impact groundwater via migration. Modified soil PRGs evaluating cross-media migration were developed for receptors of both federal (administrative controls) and private (no administrative controls) ownership. Cross media modified soil PRGs were developed for soil impacting perched water and groundwater. This modified soil PRG (cross media) is the concentration of a contaminant in soil that will not create a groundwater concentration that exceeds a selected risk-based water criteria at the exposure point. Groundwater risk-based PRGs or MCLs are typically used as the criteria at the selected exposure point for the development of modified soil PRGs.

The following sections outline the approach 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 is presented in Appendix D.1.

TABLE 2-6

SUMMARY OF OPERABLE UNIT 2 MODIFIED SOIL PRELIMINARY REMEDIAL GOALS (PRGs)[a] FOR THE EXPANDED TRESPASSER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Expanded Trespasser (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	1.1E+2	1.1E+1	1.1		0.849
Neptunium-237	5.0E+2	5.0E+1	5.0		0.0
Plutonium-238	1.8E+4	1.8E+3	1.8E+2		0.0
Radium-226	1.2E+4	1.2E+3	1.2E+2	5[c]	1.47
Radium-228	77	7.7E+0	7.7E-1	5[c]	1.170
Thorium-228	39	3.9E+0	3.9E-1		1.341
Thorium-230	1.1E+5	1.1E+4	1.1E+3	5[d]	1.897
Thorium-232	1.1E+5	1.1E+4	1.1E+3	5[d]	1.269
Uranium-234	1.1E+5	1.1E+4	1.1E+3		1.037
Uranium-235/236	9.1E+2	9.1E+1	9.1		0.142
Uranium-238	5.6E+3	5.6E+2	5.6E+1		1.122
Arsenic	1.9E+3	1.9E+2	1.9E+1		9.704
Beryllium	4.8E+2	4.8E+1	4.8		0.6
Chromium	1.5E+5	1.5E+4	1.5E+3		17.057
Benzo(a)anthracene	4.7E+3	4.7E+2	4.7E+1		0.0
Benzo(a)pyrene	7.0E+2	7.0E+1	7.0		0.0
Benzo(b)fluoranthene	5.7E+3	5.7E+2	5.7E+1		0.0
Benzo(k)fluoranthene	1.3E+4	1.3E+3	1.3E+2		0.0
Dibenzo(a,h)anthracene	6.3E+2	6.3E+1	6.3		0.0
Indeno(1,2,3-cd)pyrene	2.6E+3	2.6E+2	2.6E+1		0.0
Aroclor-1254	3.5	3.5E-1	3.5E-2		0.0
Aroclor-1260	3.5	3.5E-1	3.5E-2		0.0
Dieldrin	7.6E+3	7.6E+2	7.6E+1		0.0

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See footnotes at end of table

TABLE 2-6
(Continued)

COC	ADMINISTRATIVE CONTROLS Expanded Trespasser (pCi/g or mg/kg) HI[e] = 0.1	HI = 0.2	HI = 1.0	ARAR/ TBC	Background 95th %
CARCINOGENIC					
Arsenic	2.0E+2	4.1E+2	2.0E+3		5.78
Uranium - Total	3.8E+1	7.7E+1	3.8E+3		2.54 mg/kg

[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 C.

[b]ILCR - Incremental Lifetime Cancer Risk

[c]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.

[d]First 15 cm (i.e., 6 inches) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC.

[e]HI - Hazard Index

TABLE 2-7

SUMMARY OF SOLID WASTE LANDFILL MODIFIED SOIL PRELIMINARY REMEDIAL GOALS (PRGs) FOR THE OFF-PROPERTY FARMER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	5.3E+5	5.3E+4	5.3E+3		0.849
Neptunium-237	4.0E+5	4.0E+4	4.0E+3		0.0
Plutonium-238	3.1E+5	3.1E+4	3.1E+3		0.0
Radium-226	2.3E+6	2.3E+5	2.3E+4	5[b]	1.47
Radium-228	4.8E+6	4.8E+5	4.8E+4	5[b]	1.170
Thorium-228	1.7E+3	1.7E+4	1.7E+3		1.341
Thorium-230	4.6E+5	4.6E+4	4.6E+3	5[c]	1.897
Uranium-234	5.0E+5	5.0E+4	5.0E+3		1.037
Uranium-235/236	5.2E+5	5.2E+4	5.2E+3		0.142
Uranium-238	2.5E+5	2.5E+4	2.5E+3		1.122
Arsenic	8.0E+4	8.0E+3	8.0E+2		9.704
Beryllium	1.4E+5	1.4E+4	1.4E+3		0.6
Chromium	5.8E+5	5.8E+4	5.8E+3		17.057
Benzo(a)pyrene	5.3E+4	5.3E+3	5.3E+2		0.0
Benzo(b)fluoranthene	1.3E+5	1.3E+4	1.3E+3		0.0
Dibenzo(a,h)anthracene	4.8E+4	4.8E+3	4.8E+2		0.0
Indeno(1,2,3-cd)pyrene	5.3E+3	5.3E+2	5.3E+1		0.0

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	HI[d] = 0.1	HI = 0.2	HI = 1.0		
NONCARCINOGENIC					
Arsenic	3.3E+5	6.6E+5	3.3E+6		5.78
Uranium - Total	3.3E+5	6.6E+6	3.3E=6		2.54 mg/kg

[a]ILCR - Incremental Lifetime Cancer Risk
[b]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.
[c]First 15 cm (i.e., 6 inches) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC.
[d]HI - Hazard Index

TABLE 2-8

SUMMARY OF LIME SLUDGE PONDS MODIFIED SOIL PRELIMINARY REMEDIAL GOALS (PRGs) FOR THE OFF-PROPERTY FARMER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	3.0E+7	3.0E+6	3.0E+5		0.849
Neptunium-237	6.0E+5	6.0E+4	6.0E+3		0.0
Radium-226	5.0E+6	5.0E+5	5.0E+4	5[b]	1.47
Radium-228	1.6E+7	1.6E+6	1.6E+5	5[b]	1.170
Thorium-228	2.3E+5	2.3E+4	2.3E+3		1.341
Thorium-230	6.2E+5	6.2E+4	6.2E+3	5[c]	1.897
Uranium-234	6.9E+5	6.9E+4	6.9E+3		1.037
Uranium-235/236	7.2E+5	7.2E+4	7.2E+3		0.142
Uranium-238	3.5E+5	3.5E+4	3.5E+3		1.122
Arsenic	1.3E+6	1.3E+5	1.3E+4		9.704
Beryllium	1.1E+6	1.1E+5	1.1E+4		0.6
Benzo(a)pyrene	2.7E+5	2.7E+4	2.7E+3		0.0
Benzo(b)fluoranthene	7.4E+5	7.4E+4	7.4E+3		0.0
Dibenzo(a,h)anthracene	2.5E+5	2.5E+4	2.5E+3		0.0
Indeno(1,2,3-cd)pyrene	1.9E+7	1.9E+6	1.9E+5		0.0
Aroclor-1254	1.6E+5	1.6E+4	1.6E+3		0.0

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	HI[d] = 0.1	HI = 0.2	HI = 1.0		
NONCARCINOGENIC					
Uranium - Total	1.85E+7	3.7E+7	1.85E		2.54 mg/kg

[a]ILCR - Incremental Lifetime Cancer Risk
[b]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.
[c]First 15 cm (i.e., 6 inches) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC.
[d]HI - Hazard Index

TABLE 2-9

SUMMARY OF INACTIVE FLYASH PILE MODIFIED SOIL PRELIMINARY REMEDIAL GOALS (PRGs) FOR THE OFF-PROPERTY FARMER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	5.1E+6	5.1E+5	5.1E+4		0.849
Neptunium-237	8.9E+4	8.9E+3	8.9E+2		0.0
Radium-226	7.6E+5	7.6E+4	7.6E+3	5[b]	1.47
Radium-228	2.4E+6	2.4E+5	2.4E+9	5[b]	1.170
Thorium-228	3.4E+4	3.4E+3	3.4E+2		1.341
Uranium-235/236	1.1E+5	1.1E+4	1.1E+3		0.142
Uranium-238	4.7E+4	4.7E+3	4.7E+2		1.122
Arsenic	2.1E+5	2.1E+4	2.1E+3		9.704
Beryllium	1.9E+5	1.9E+4	1.9E+3		0.6
Dibenzo(a,h)anthracene	7.0E+5	7.0E+4	7.0E+3		0.0

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	HI = 0.1	HI = 0.2	HI = 1.0		
NONCARCINOGENIC					
Uranium - Total	1.6E-1	3.2E-1	1.6E+0		2.54 mg/kg

[a]ILCR - Incremental Lifetime Cancer Risk

[b]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.

[c]HI - Hazard Index

TABLE 2-10

SUMMARY OF SOUTH FIELD MODIFIED SOIL PRELIMINARY REMEDIAL GOALS (PRGs) FOR THE OFF-PROPERTY FARMER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Cesium-137	5.4E+5	5.4E+4	5.4E+3		0.849
Neptunium-237	3.5E+4	3.5E+3	3.5E+2		0.0
Radium-226	2.2E+5	2.2E+4	2.2E+3	5[b]	1.47
Radium-228	4.7E+5	4.7E+4	4.7E+3	5[b]	1.170
Thorium-228	1.5E+4	1.5E+3	1.5E+2		1.341
Thorium-230	4.0E+4	4.0E+3	4.0E+2	5[c]	1.897
Thorium-232	4.1E+4	4.1E+3	4.1E+2	5[c]	1.269
Uranium-234	4.4E+4	4.4E+3	4.4E+2		1.037
Uranium-235/236	4.6E+4	4.6E+3	4.6E+2		0.142
Uranium-238	2.2E+4	2.2E+3	2.2E+2		1.122
Arsenic	6.1E+4	6.1E+3	6.1E+2		9.704
Beryllium	1.5E+5	1.5E+4	1.5E+3		0.6
Chromium	5.0E+4	5.0E+3	5.0E+2		17.057
Benzo(a)anthracene	5.8E+4	5.8E+3	5.8E+2		0.0
Benzo(a)pyrene	5.1E+3	5.1E+2	5.1E+1		0.0
Benzo(b)fluoranthene	1.8E+4	1.8E+3	1.8E+2		0.0
Benzo(k)fluoranthene	1.6E+4	1.6E+3	1.6E+2		0.0
Dibenzo(a,h)anthracene	2.0E+2	2.0E+1	2.0E+0		0.0
Indeno(1,2,3-cd)pyrene	1.2E+6	1.2E+5	1.2E+4		0.0
Aroclor-1254	2.8E+3	2.8E+2	2.8E+1		0.0
Aroclor-1260	2.5E+3	2.5E+2	2.5E+1		0.0
Dieldrin	7.6E+3	7.6E+2	7.6E+1		0.0

See footnotes at end of table

TABLE 2-10
(Continued)

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	HI[d] = 0.1	HI = 0.2	HI = 1.0		
NONCARCINOGENIC					
Arsenic	3.35E+4	6.7E+4	3.35E+5		
Uranium - Total	3.1E+5	6.2E+5	3.1E+6		2.54 mg/kg

[a]ILCR - Incremental Lifetime Cancer Risk

[b]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.

[c]First 15 cm (i.e., 6 inches) depth [DOE Order 5400.5 Chapter IV (4)(a)(2),(3)] TBC.

[d]HI - Hazard Index

TABLE 2-11

SUMMARY OF ACTIVE FLYASH PILE MODIFIED SOIL PRELIMINARY REMEDIAL GOALS (PRGs) FOR THE OFF-PROPERTY FARMER WITH ADMINISTRATIVE CONTROLS

COC	ADMINISTRATIVE CONTROLS Off-Property Farmer PRG (pCi/g or mg/kg)			ARAR/ TBC	Background 95th %
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Neptunium-237	6.5E4	6.5E+3	6.5E+2		0.0
Radium-226	4.3E+5	4.3E+4	4.3E+3	5[b]	1.47
Radium-228	9.1E+5	9.1E+4	9.1E+3	5[b]	1.170
Thorium-228	2.7E+4	2.7E+3	2.7E+2		1.341
Uranium-235/236	8.5E+4	8.5E+3	8.5E+2		0.142
Uranium-238	4.1E+4	4.1E+3	4.1E+2		1.122
Arsenic	8.5E+4	8.5E+3	8.5E+2		9.704
Beryllium	4.7E+4	4.7E+3	4.7E+2		0.6

[a]ILCR - Incremental Lifetime Cancer Risk

[b]First 15 cm (i.e., 6 inches) depth (40 CFR 192) for radium-226 + 5 progeny.

2.3.4.1 Technical Approach

Figure 2-4 shows the technical approach used in development of modified soil PRGs based on cross-media contamination. Based on geophysical model and site-specific data, fate and transport models are used to predict future concentration at the receptor points. These concentrations are then used in the baseline risk assessment to calculate baseline risk and define COCs. Results of these are presented in the RI report for the Operable Unit 2. Fate and transport models are then used to develop COC soil concentrations that are protective for the risk level range of 10^{-4} to 10^{-6} ILCR.

The approach to the fate and transport modeling in developing modified soil PRG was to use the ECTran model, a screening model, to evaluate numerous conditions in a time efficient manner. The modified soil PRGs determined from the cross-media impacts using the ECTran Model were confirmed using a more complex fate and transport model, ODAST/improved SWIFT. A discussion on the confirmation modeling performed for the Operable Unit 2 FS fate and transport modeling is presented in Appendix D.3.

Similar to the Operable Unit 2 RI, the Operable Unit 2 FS quantities the local vertical migration and the lateral migration of groundwater toward the edge of till in or near the South Field and Inactive Flyash Pile subunits where the glacial till pinches out and the perched groundwater can vertically migrate into the Great Miami Aquifer (Figures 2-5 and 2-6). The 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 three media; source/fill, glacial till, and Great Miami Aquifer sands and gravels. These three media were evaluated because loading in each media impacts the receptor risk individually. The Modified PRGs for the glacial till and sand and gravel was reviewed on the basis of whether or not remediation of the media was required. The modified PRGs for source/fill materials are reported in this section.

2.3.4.2 Modified PRG and PRL Results

Modified soil PRGs were required for the Solid Waste Landfill, Inactive Flyash Pile, South Field, and Active Flyash Pile subunits since each of these subunits had COCs which had the potential to adversely impact groundwater. The Lime Sludge Ponds had no COCs which impacted groundwater, therefore, no modified soil PRGs were necessary for this Operable Unit 2 subunit.

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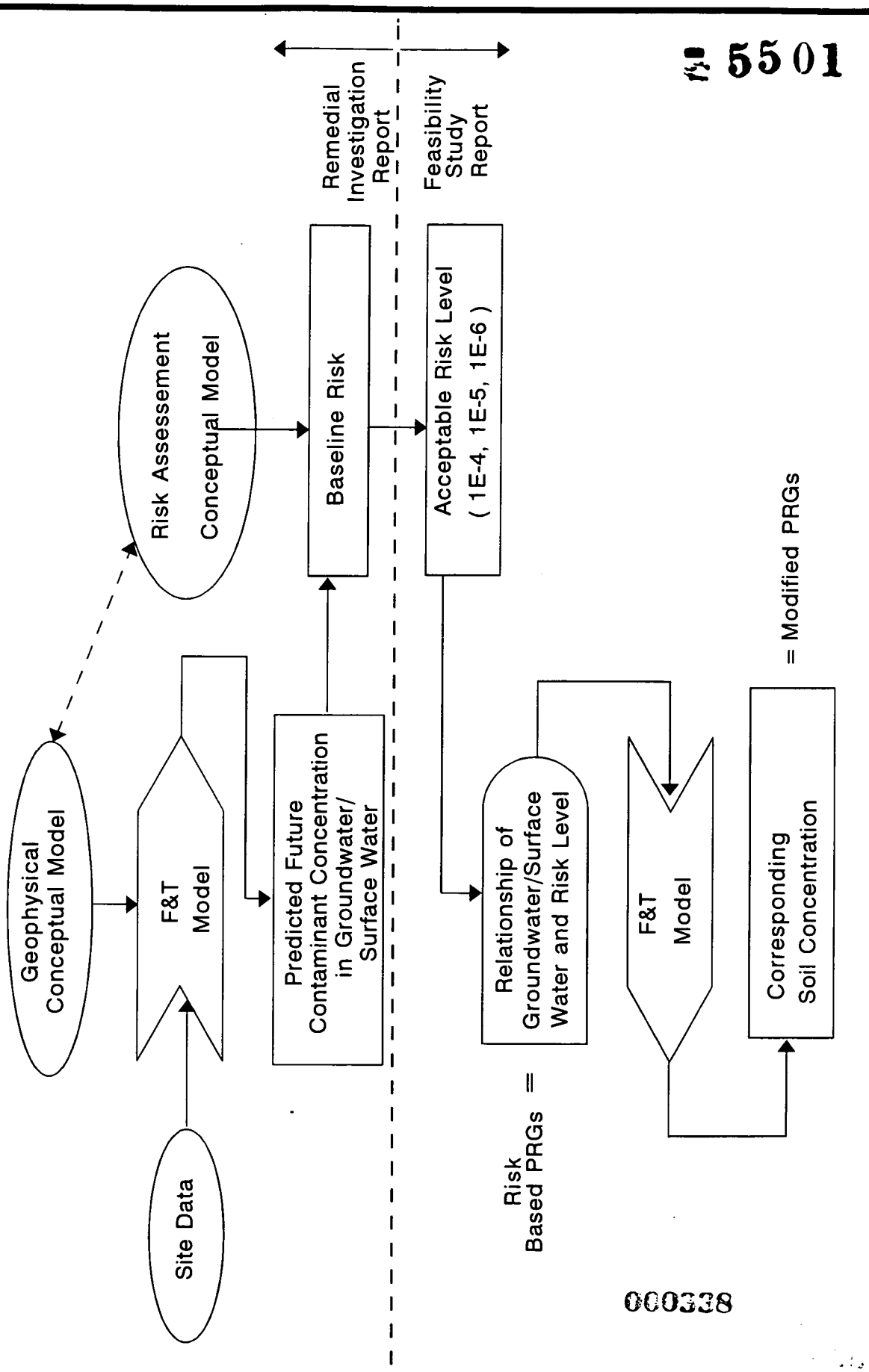

Figure 2-4
Development of Modified PRGs from the Baseline Risk Assessment based on Cross Media Contamination

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FEMP-OU02-4 DRAFT
April 29, 1994

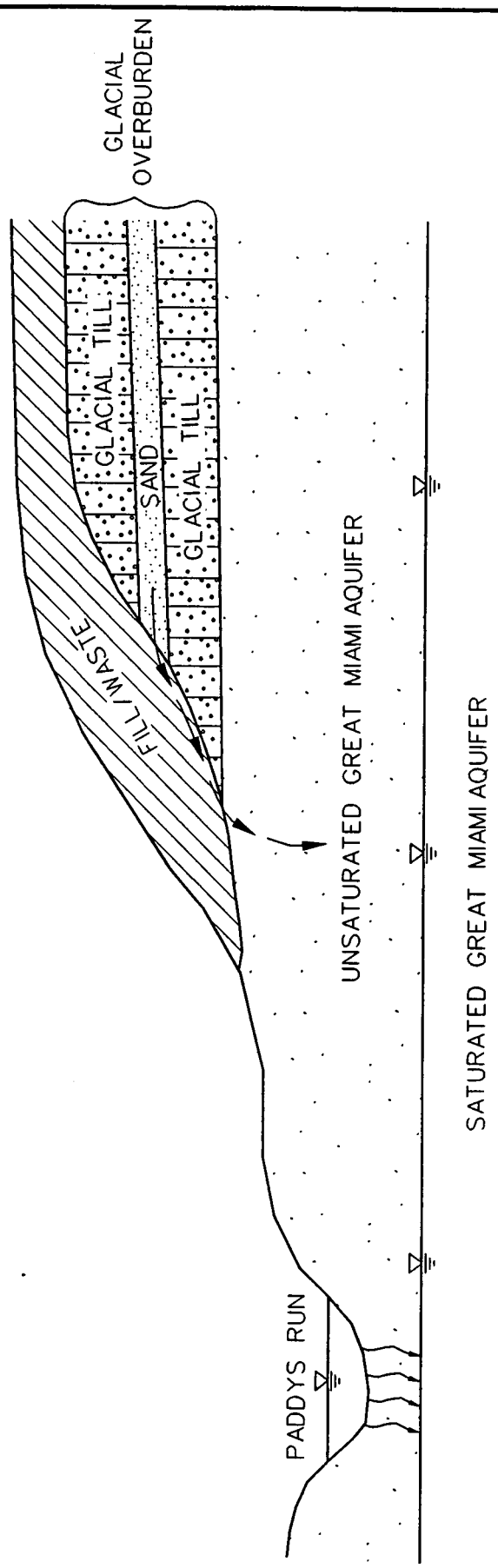

FIGURE 2-5
CONCEPTUAL MODEL FOR PERCHED WATER SUBSURFACE SEEPS

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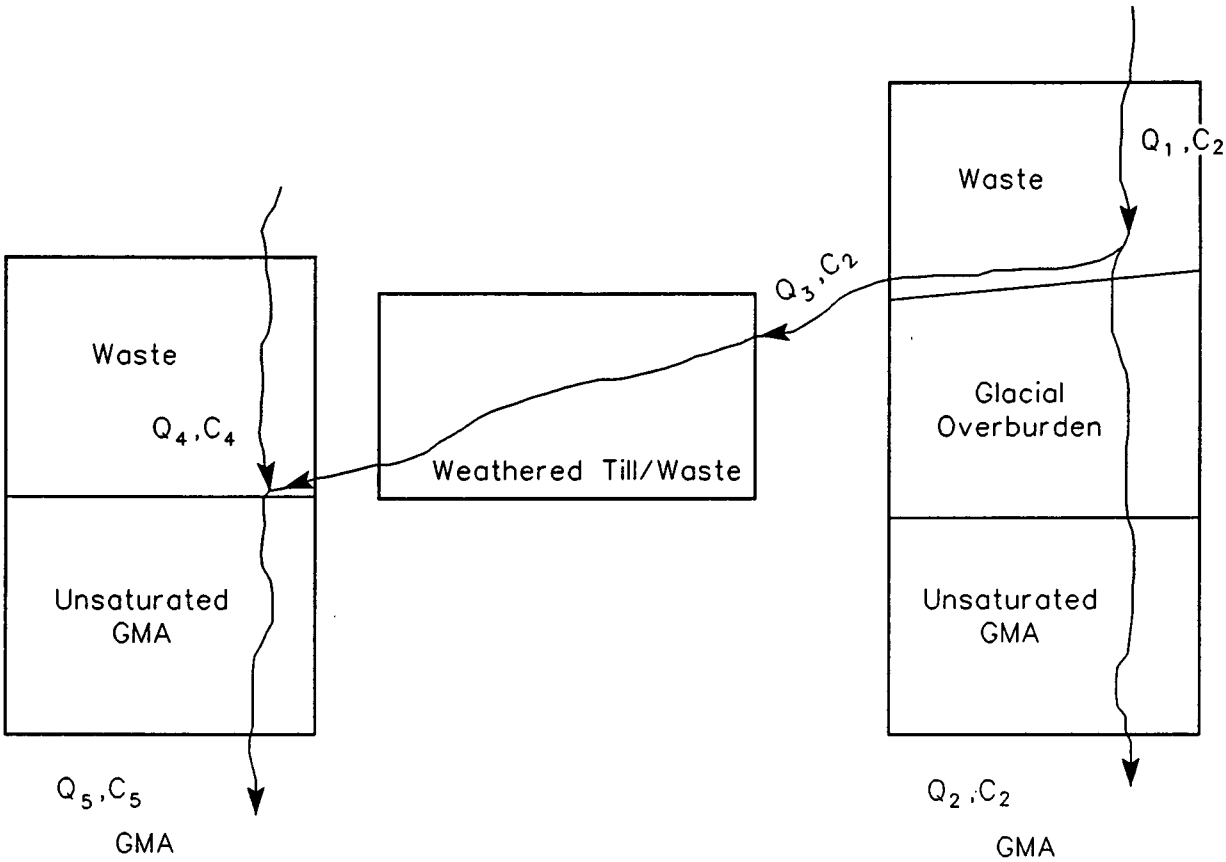

$$Q_1 = Q_2 + Q_3$$

$$Q_5 = Q_3 + Q_4$$

$$C_5 = \frac{Q_3 C_2 + Q_4 C_4}{Q_3 + Q_4}$$

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.

FIGURE 2-6
CONCEPTUAL MODEL FOR LATERAL DRAINAGE INFILTRATING TO THE UNSATURATED GREAT MIAMI AQUIFER FOR THE OPERABLE UNIT 2 WASTE SUB-UNITS

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The COCs which impacted groundwater were determined based on a screening procedure. These COCs are listed in the baseline risk assessment, Section 6.3 of the Operable Unit 2 RI and summarized in Table 2-1. The Solid Waste Landfill had COCs which impacted the perched water while the Inactive Flyash Pile, South Field, and Active Flyash Pile had COCs which impacted the GMA. The Solid Waste Landfill COCs included technetium-99 and carbazole. Uranium-234, uranium-235/236, and uranium-238 are the COCs for the Inactive Flyash Pile and the South Field and uranium-234 and uranium-238 were the Active Flyash Pile COCs.

Solid Waste Landfill

The perched groundwater is typically discontinuous under the Solid Waste Landfill and downgradient transport of contaminants was not considered. Due to the discontinuous nature of the perched groundwater zone, the only applicable perched water exposure point for modified soil PRG development was the perched water directly below the site. The potential receptor for the perched water was the on-property farmer. For modified soil PRG development, this is a conservative approach since the closest exposure point, the perched groundwater under the source, will result in the lowest modified soil PRGs.

The general hydraulic parameters and physical dimensions of the Solid Waste Landfill are summarized in Appendix D.1. The physical dimensions and soil media parameters of the site were taken from the Operable Unit 2 RI and the layer thicknesses presented are for the appropriate SWIFT grid block. Hydrogeologic and geologic data from a SWIFT grid block, which is a three-dimensional finite difference cell in SWIFT that has its own hydrogeologic and contaminant transport parameters assigned to it, was used to represent the Solid Waste Landfill. The actual Solid Waste Landfill source area was used for modified soil PRG modeling. Table 2-12 shows modified PRGs for the Solid Waste Landfill. Since the background concentration for technetium-99 and carbazole is zero, the modified soil PRGs are also PRLs.

Inactive Flyash Pile/South Field/Active Flyash Pile

Section 5.0 and Appendix A.2 of the Operable Unit 2 RI discuss the conceptual models used for the RI modeling for the Inactive Flyash Pile, South Field, and Active Flyash Pile. These models were also used to conceptualize the Operable Unit 2 subunits for modified soil PRG development modeling.

TABLE 2-12

SOLID WASTE LANDFILL
CROSS MEDIA MODIFIED SOIL PRELIMINARY REMEDIAL GOALS (PRGs)
PROTECTIVE OF PERCHED WATER

COCs Impacting Perched Water	NO ADMINISTRATIVE CONTROLS			Current Concentration	Background
	On-Property Farmer (RME)[a] PRG (pCi/g or mg/kg)				
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		
CARCINOGENIC					
Technetium-99	5.4E-4	5.4E-5	5.4E-6	7.5E-1	0
Carbazole	9.0E-2	9.0E-3	9.0E-4	4.2E+0	0

[a]RME - Reasonable Maximum Exposure

[b]ILCR - Incremental Lifetime Cancer Risk

The two types of exposure points used for modeling included the Great Miami Aquifer under the source and the Great Miami Aquifer at FEMP fenceline. The selection of groundwater exposure points for modified soil PRG development was based on the potential for two future ownership of the site, namely a private or 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 and off-property 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 farmer with an exposure point to the Great Miami Aquifer groundwater under the subunits (Great Miami Aquifer under subunit). However, unlike private ownership, federal ownership would implement administrative controls to limit access to the Great Miami Aquifer under the waste units and the only groundwater exposure point is the Great Miami Aquifer at FEMP fenceline (i.e., off-property farmer).

Modified soil PRGs were developed using the ECTran model for a typical worst case in each subunit. To be conservative, the grid blocks chosen had the maximum infiltration rates. Site-specific distribution coefficients were used. Details of the site-specific distribution coefficient study are included in Appendix D-4. Based on ODAST/SWIFT calibration, 1.78 mL/g was used as distribution coefficient for the Great Miami Aquifer (see Appendix D-3). The hydraulic gradients and flow distances along the path lines to the FEMP fenceline used for modified soil PRG development were determined from 2000-series monitoring well groundwater contour maps for the months of April 1988 to December 1989. Based on these maps, an average hydraulic gradient was calculated and the minimum flow distance along the pathlines to the FEMP fenceline was estimated for each subunit. The mixing depth concept was used to determine the appropriate thickness of the Great Miami Aquifer which was used for mixing/dilution of the infiltrating leachate. This concept and its governing equation are discussed in the ECTran reference presented in Attachment D.1.1 of Appendix D. Other hydrogeological information, such as vertical and horizontal hydraulic conductivity, porosity, soil density, and saturation was taken from the Operable Unit 2 RI. Values for all area-specific hydrogeological information used for modified soil PRG development are presented in Appendix D.1.

Tables 2-13, 2-14, and 2-15 shows the modified soil PRGs and PRLs for the Inactive Flyash Pile, South Field, and Active Flyash Pile, respectively. These modified soil PRGs were developed assuming that no source controls will be used. These modified soil PRGs assume that at the Inactive Flyash Pile and South Field, perched water lateral movement will not be controlled. Tables 2-13

TABLE 2-13

INACTIVE FLYASH PILE
CROSS MEDIA MODIFIED SOIL PRGS AND PRLS
PROTECTIVE OF THE GREAT MIAMI AQUIFER
WITHOUT ENGINEERING CONTROLS

COCs Impacting Groundwater	No Administrative Controls On-Property Resident Farmer PRG-Carcinogenic Risk Based (pCi/g)			Administrative Controls Off-Property Resident Farmer PRG-Carcinogenic Risk Based (pCi/g)			Background (pCi/g)	No Administrative Controls PRLs [PRG+Background (pCi/g)]			Administrative Controls PRLs [PRG+Background (pCi/g)]		
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER													
Uranium-234	0.62	0.0620	0.00609	16.4	1.63	0.00294	1.04	1.66	1.10	1.04	17.4	2.7	1.04
Uranium-235/236	0.62	0.0620	0.00620	16.3	1.63	0.163	0.14	0.76	0.20	0.15	16.4	1.77	0.30
Uranium-238	0.35	0.0349	0.00338	9.24	0.0108	9.93E-4	1.12	1.47	1.15	1.12	10.4	1.13	1.12
SOURCE MATERIAL ON THE TOP OF THE TERRACE (GLACIAL TILL)													
Uranium-234	9.05	0.905	0.0889	238	23.8	0.0429	1.04	10.1	1.94	1.13	239	24.8	1.08
Uranium-235/236	9.07	0.907	0.0907	237	23.7	2.37	0.14	9.2	1.05	0.23	237	23.8	2.51
Uranium-238	5.12	0.509	0.0493	135	0.159	0.0145	1.12	6.2	1.63	1.17	136	1.28	1.13

[a]ILCR Incremental Lifetime Cancer Risk

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TABLE 2-14

SOUTH FIELD
CROSS MEDIA MODIFIED SOIL PRGS AND PRLS
PROTECTIVE OF THE GREAT MIAMI AQUIFER
WITHOUT ENGINEERING CONTROLS

COCs Impacting Groundwater	No Administrative Controls On-Property Resident Farmer PRG-Carcinogenic Risk Based (pCi/g)			Administrative Controls Off-Property Resident Farmer PRG-Carcinogenic Risk Based (pCi/g)			Background (pCi/g)	No Administrative Controls PRLs [PRG+Background (pCi/g)]			Administrative Controls PRLs [PRG+Background (pCi/g)]		
	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER AND ON THE TERRACE FACE													
Uranium-234	27	2.70	0.209	1130	113	8.24E-5	1.04	28	3.7	1.20	1130	114	1.0
Uranium-235/236	27	2.70	0.270	1140	114	11.4	0.14	27	2.8	0.41	1140	114	11.5
Uranium-238	15.2	1.47	0.0678	642	64.3	3.17E-5	1.12	16	2.6	1.19	643	65	1.1
SOURCE MATERIAL ON THE TOP OF THE TERRACE (GLACIAL TILL)													
Uranium-234	74.8	7.48	0.579	3140	314	2.28E-4	1.04	76	8.5	1.62	3140	315	1.05
Uranium-235/236	74.9	7.49	0.749	3150	315	31.5	0.14	75	7.6	0.89	3150	315	31.5
Uranium-238	42.2	4.07	0.188	1780	178	8.80E-5	1.12	43	5.2	1.31	1780	179	1.1

[a]ILCR - Incremental Lifetime Cancer Risk

TABLE 2-15

ACTIVE FLYASH PILE
CROSS MEDIA MODIFIED SOIL PRGS AND PRLS
PROTECTIVE OF THE GREAT MIAMI AQUIFER
WITHOUT ENGINEERING CONTROLS

COCs Impacting Groundwater	No Administrative Controls On-Property Resident Farmer PRG-Carcinogenic Risk Based (pCi/g)			Administrative Controls Off-Property Resident Farmer PRG-Carcinogenic Risk Based (pCi/g)			Background (pCi/g)	No Administrative Controls PRLS [PRG+Background (pCi/g)]			Administrative Controls PRLs [PRG+Background (pCi/g)]		
	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	10^{-4} ILCR[a]	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR	10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER AND ON THE TERRACE FACE													
Uranium-234	17.5	1.75	0.17	247	24.7	0.025	1.04	18.5	2.8	1.2	248	25.7	1.1
Uranium-238	9.9	0.98	0.09	52.2	3.48	0.021	1.12	11.0	2.1	1.2	53.3	4.6	1.1
SOURCE MATERIAL ON THE TOP OF THE TERRACE (GLACIAL TILL)													
Uranium-234	29.4	2.94	0.27	415	41.5	0.039	1.04	30.4	4.0	1.3	416	43	1.08
Uranium-238	16.6	1.65	0.14	52	20.4	0.033	1.12	17.7	2.8	1.3	53	22	1.15

[a]ILCR - Incremental Lifetime Cancer Risk

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and 2-14 indicate that without source controls of the lateral movement of the perched water, modified soil PRGs are very low. This was also confirmed by the ODAST/SWIFT model where only the perched water subsurface seep pathway (Figure 2-5) was simulated. Model calculations show that this pathway alone can result in uranium-238 concentrations in the Great Miami Aquifer at the fenceline to be 15.6 pCi/L. This concentration exceeds the 10^{-5} ILCR concentration for uranium-238. The 10^{-5} ILCR groundwater concentration for uranium-238 is comparable to the uranium-238 portion of the proposed MCL for total uranium (30 pCi/L). For the purpose of the Operable Unit 2 FS, the uranium-238 PRG/PRLs determined to be protective for the 10^{-5} ILCR from groundwater will be considered comparable to meeting the MCL for total uranium.

2.3.5 Modified Soil PRGs and PRLs for Cross Media with Source Controls

Two potential Operable Unit 2 source controls were evaluated for the Inactive Flyash Pile, South Field, and Active Flyash Pile for modified soil PRG development. The first source control evaluates preventing lateral migration of the perched water. This source control will prevent contaminants from migrating directly from the perched water to the Great Miami Aquifer. The second control also prevents lateral flow is also used to impede infiltration through the remediated subunits and provides a barrier to a receptor and direct soil contact. These source controls assume federal ownership, therefore requiring only the exposure to the Great Miami Aquifer at the FEMP fenceline to be investigated.

Inactive Flyash Pile

Table 2-16 shows modified soil PRGs and PRLs protective for exposure to the Great Miami Aquifer using source controls for preventing lateral migration of the perched water. At 10^{-6} ILCR, uranium-238 PRL for source material directly overlying the Great Miami Aquifer soils or on the glacial overburden terrace face is 6 pCi/g. Table 2-17 shows modified soil PRGs and PRLs protective of the Great Miami Aquifer using source controls to prevent lateral migration of the perched water and reduced infiltration. At 10^{-6} ILCR, uranium-238 PRL for the source material directly overlying the Great Miami Aquifer soils was 9 pCi/g and for the source material on the glacial overburden terrace face was 1210 pCi/g.

South Field

Tables 2-18 and 2-19 show modified soil PRGs and PRLs protective of the Great Miami Aquifer using source controls for preventing lateral migration of the perched water alone and with a reduced

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TABLE 2-16

INACTIVE FLYASH PILE
MODIFIED SOIL PRGS AND PRLS
PROTECTIVE OF THE GREAT MIAMI AQUIFER USING
ENGINEERING CONTROLS FOR PERCHED WATER

COCs Impacting Groundwater	Modified Soil PRG-Carcinogenic Risk Based[a] (pCi/g)			Background (pCi/g)	PRLs[a] [PRG+Background (pCi/g)]		
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER							
Uranium-234	711	71	4.5[c]	1.04	712	72	5.6
Uranium-235/236	712	71	7.12	0.14	712	72	7.26
Uranium-238	402	40	5[c]	1.12	403	41	6.12[c]
SOURCE MATERIAL ON THE TERRACE FACE							
Uranium-234	1290	129	4.5[c]	1.04	1290	130	5.6[c]
Uranium-235/236	1280	128	12.8	0.14	1280	128	13
Uranium-238	726	73	5[c]	1.12	727	74	6.12[c]

[a]Modified soil PRGs and PRLs are given for off-property farmer.

[b]ILCR - Incremental Lifetime Cancer Risk

[c]Modified soil PRG is based on ODAST/SWIFT modeling.

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TABLE 2-17

INACTIVE FLYASH PILE
MODIFIED SOIL PRGS AND PRLS
PROTECTIVE OF THE GREAT MIAMI AQUIFER USING A CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

COCs Impacting Groundwater	Modified Soil PRG-Carcinogenic Risk Based[a] (pCi/g)			Background (pCi/g)	PRLs[a] [PRG+Background (pCi/g)]		
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
Incremental Lifetime Cancer Risk							
Uranium-234	16500	1640	155	1.04	16500	1640	156
Uranium-235/236	16500	1640	164	0.14	16500	1640	164
Uranium-238	9290	919	8.23	1.12	9290	920	9
SOURCE MATERIAL ON THE TERRACE FACE							
Uranium-234	254000	25200	2330	1.04	254000	25200	2330
Uranium-235/236	255000	25400	2540	0.14	255000	25400	2540
Uranium-238	144000	14100	1210	1.12	144000	14100	1210

[a]Modified soil PRGs and PRLs are given for off-property farmer.

[b]Incremental Lifetime Cancer Risk

TABLE 2-18

SOUTH FIELD
MODIFIED SOIL PRGS AND PRLS
PROTECTIVE OF THE GREAT MIAMI AQUIFER USING
ENGINEERING CONTROLS FOR PERCHED WATER

COCs Impacting Groundwater	Modified Soil PRG-Carcinogenic Risk Based[a] (pCi/g)			Background (pCi/g)	PRLs[a] [PRG+Background (pCi/g)]		
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER AND ON THE TERRACE FACE							
Uranium-234	3630	363	4.5	1.04	3630	364	5.5
Uranium-235/236	3630	363	35.9	0.14	3630	363	36
Uranium-238	2050	205	5[c]	1.12	2050	206	6.1
SOURCE MATERIAL ON THE TOP OF THE TERRACE (GLACIAL TILL)							
Uranium-234	337000	33600	3240	1.04	337000	33600	3240
Uranium-235/236	336000	33600	3360	0.14	336000	33600	3360
Uranium-238	190000	18900	1740	1.12	190000	18900	1740

[a]Modified soil PRGs and PRLs are given for off-property farmer.

[b]ILCR - Incremental Lifetime Cancer Risk

[c]Modified soil PRG is based on ODAST/SWIFT modeling and assumes lateral groundwater flow is prevented with engineering controls.

TABLE 2-19

SOUTH FIELD
MODIFIED SOIL PRGS AND PRLS
PROTECTIVE OF THE GREAT MIAMI AQUIFER USING A CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

COCs Impacting Groundwater	Modified Soil PRG-Carcinogenic Risk Based[a] (pCi/g)			Background (pCi/g)	PRLs[a] [PRG+Background (pCi/g)]		
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER AND ON THE TERRACE FACE							
Uranium-234	68400	6810	667	1.04	68400	6810	668
Uranium-235/236	68100	6810	681	0.14	68100	6810	681
Uranium-238	38500	3840	367	1.12	38500	3840	368
SOURCE MATERIAL ON THE TOP OF THE TERRACE (GLACIAL TILL)							
Uranium-234	4120000	418000	40300	1.04	4120000	418000	40300
Uranium-235/236	4170000	417000	41700	0.14	4170000	417000	41700
Uranium-238	2350000	235000	21800	1.12	2350000	235000	21800

[a]Modified soil PRGs and PRLs are given for off-property farmer.

[b]ILCR - Incremental Lifetime Cancer Risk

infiltration, respectively. Without reduced infiltration, uranium-238 PRLs for 10^{-6} ILCR for source material overlying the Great Miami Aquifer and on the terrace face was 6 pCi/g. With reduced infiltration, the uranium-238 PRL increases to 368 pCi/g. For the source material on the top of the terrace, the uranium-238 PRLs with prevention of lateral perched water migration alone and reduced infiltration at 10^{-6} ILCR are 1,740 pCi/g and 21,800 pCi/g, respectively. These PRLs are higher than the maximum uranium-238 concentration measured in soil samples at the South Field. Therefore, if perched water lateral migration is controlled, the waste on the top of the terrace at the South Field will be protective of the Great Miami Aquifer at the fenceline.

Active Flyash Pile

Perched water subsurface seep pathway is not applicable 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 was not evaluated. Table 2-20 shows modified soil PRGs and PRLs protective of the Great Miami Aquifer at the fenceline using reduced infiltration. At 10^{-6} ILCR, the uranium-238 PRLs is 55 pCi/g for the source material overlying the Great Miami Aquifer and on the terrace face. The uranium-238 PRL at 10^{-6} ILCR for the source material on the top of the terrace is 1930 pCi/g. The uranium-238 PRLs are higher than the maximum uranium-238 concentration detected in the Active Flyash Pile.

2.4 MODELING WITH ODAST/SWIFT

Modeling was conducted using the ODAST/SWIFT Model to verify that the Great Miami Aquifer is not adversely impacted above the designated risk based criteria from PRLs. Results of this modeling are provided in Appendix D.3. Modeling was conducted for the South Field/Inactive Flyash Pile area. The results are shown in Table 2-21. This modeling evaluated removing all contaminated material from the area directly on the Great Miami Aquifer and on the sloping face of the glacial overburden (terrace face) and left all contaminated material on the top of the terrace. The results of this evaluation indicated that the maximum uranium-238 concentration in the Great Miami Aquifer is predicted to be 1.6×10^{-48} pCi/L. The predicted result is significantly less than 10^{-6} criteria for uranium-238 which is 0.62 pCi/L. Based on the ECTran model 1,740 pCi/g of uranium-238 can be left on top of the terrace and not exceed the 0.62 pCi/L risk criteria at the top of the fenceline.

Additional ODAST/SWIFT modeling was conducted to evaluate the concentration of uranium-238 which could be left in the South Field/Inactive Flyash Pile, and be protective of the Great Miami

TABLE 2-20

ACTIVE FLYASH PILE MODIFIED SOIL PRGS AND PRLS PROTECTIVE OF THE GREAT MIAMI AQUIFER USING A CAP

COCs Impacting Groundwater	Modified Soil PRG-Carcinogenic Risk Based[a] (pCi/g)			Background (pCi/g)	PRLs[a] [PRG+Background (pCi/g)]		
	10^{-4} ILCR[b]	10^{-5} ILCR	10^{-6} ILCR		10^{-4} ILCR	10^{-5} ILCR	10^{-6} ILCR
SOURCE MATERIAL OVER THE GREAT MIAMI AQUIFER AND ON THE TERRACE FACE							
Uranium-234	11000	1090	99.8	1.04	11000	1090	100.8
Uranium-238	6190	611	53.7	1.12	6190	612	54.8
SOURCE MATERIAL ON THE TOP OF THE TERRACE (GLACIAL TILL)							
Uranium-234	404000	40100	3620	1.04	404000	40100	3620
Uranium-238	228000	22400	1930	1.12	228000	22400	1930

[a]Modified soil PRGs and PRLs are given for off-property farmer.

[b]ILCR - Incremental Lifetime Cancer Risk

TABLE 2-21

SUMMARY OF MODELING RESULTS FOR OPERABLE UNIT 2

Subunit or Disposal Area	Alterative	COC[a]	Concentration Unit	Maximum Loading Concentration to GMA	On-Site Maximum		FEMP Fenceline Maximum		Maximum Concentration at 1000 years
					Time (Years)	Concentration	Time (Years)	Concentration	
South Field/Inactive Flyash Pile	Removal to 60 pCi/g on terrace and to background elsewhere	Uranium-234	pCi/L	1.5E-48	-	-	-	-	-
		Uranium-235/236	pCi/L	7.8E-50	-	-	-	-	-
		Uranium-238	pCi/L	1.6E-48	-	-	-	-	-
		Uranium-total	ug/L	4.9E-48	-	-	-	-	-
South Field/Inactive Flyash Pile	No removal on terrace and removal to background elsewhere	Uranium-234	pCi/L	1.5E-48	-	-	-	-	-
		Uranium-235/236	pCi/L	7.8E-50	-	-	-	-	-
		Uranium-238	pCi/L	1.6E-48	-	-	-	-	-
		Uranium-total	ug/L	4.9E-48	-	-	-	-	-
South Field/Inactive Flyash Pile	Removal to 60 pCi/g on terrace and to 5 pCi/g elsewhere (on-site disposal alternatives)	Uranium-234	pCi/L	22.8	460	0.87	460	0.14	0.79
		Uranium-235/236	pCi/L	1.2	460	0.05	460	0.01	0.04
		Uranium-238	pCi/L	25.1	460	0.96	460	0.15	0.86
		Uranium-total	ug/L	75.2	460	2.87	460	0.46	2.59

[a]COC - Containment of Concern

[b]NB - No breakthrough

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Aquifer. This evaluation assumes that lateral groundwater migration is prevented with source controls. A concentration of 5 pCi/g of uranium-238 was evaluated for the area directly above the Great Miami Aquifer or on the terrace face and 60 pCi/g of uranium-238 was evaluated for the top of the terrace. The results of this analysis indicated that the 60 pCi/g concentration on the top of the terrace resulted in a maximum concentration of 1.6×10^{-48} pCi/L in the Great Miami Aquifer, which is considered negligible. The 5 pCi/g concentration directly on the GMA resulted in a maximum uranium-238 concentration at the FEMP fenceline of 0.153 pCi/L, which is less than the 0.62 pCi/L risk criteria for the off-property farmer.

2.5 PRG/PRL DEVELOPMENT SUMMARY

Figure 2-7 summarizes the development pathway for uranium-238 soil PRGs at a 10^{-6} ILCR in the South Field. The process begins with the development of a risk based PRG as described in Section 2.3.1. The administrative controls are 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 for both administrative and no administrative controls. Cross media impacts are altered by geologic conditions, so the cross media modified soil PRGs are also evaluated for source material over the Great Miami Aquifer and source material over a layer of glacial till. PRGs were developed for these two geologic conditions because the risk due to source material lying over the aquifer is significantly greater than the risk due to source material over the glacial overburden.

Figure 2-7 indicates the cross media modified soil PRGs for the two administrative controls cases and the two geologic conditions. The asterisk and footnote on Figure 2-7 relating to the cross media modified soil PRGs indicate that source material in the glacial till and Great Miami Aquifer also impact groundwater risk and PRGs for these materials were developed. A completed discussion of glacial till and Great Miami Aquifer material PRGs is provided in Appendix D. By considering the cross-media effect, the PRGs decrease considerably. This means that current source concentrations will impact the groundwater in the future, and therefore the amount of source must be decreased to maintain the current level of risk. As a result of the cross media PRG evaluation, it was determined that source controls should be evaluated to allow additional alternatives to be considered.

Source controls considered are; perched water lateral migration controls and reduced infiltration. The PRGs developed when considering source controls are significantly higher than the cross media

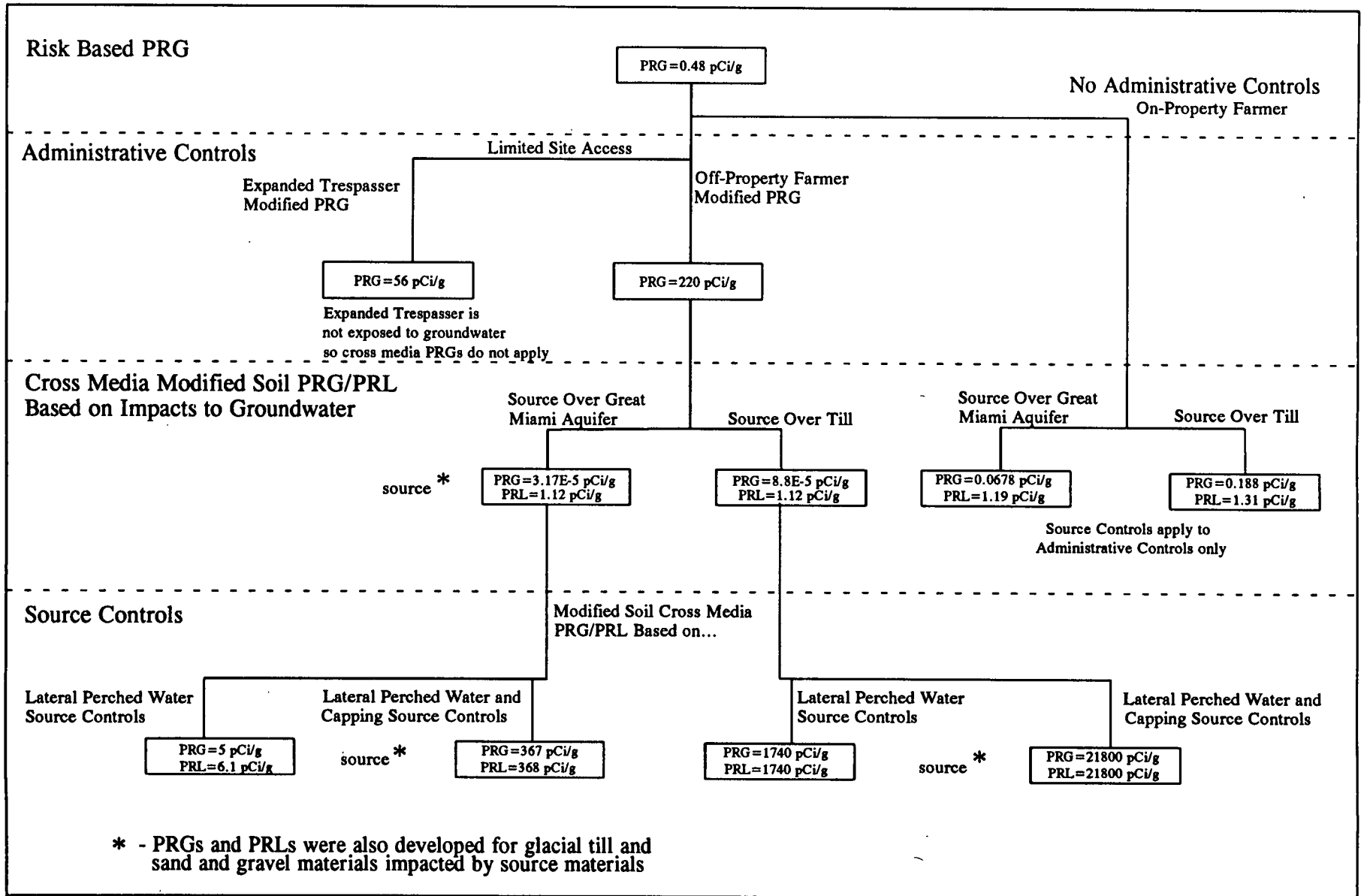

FIGURE 2-7 SUMMARY OF SOIL PRG/PRL AT 10^{-6} ILCR FOR URANIUM 238 IN THE SOUTH FIELD

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PRGs. Figure 2-7 shows that the modified soil PRGs increase significantly with the implementation of source controls. Modified soil PRGs considering source controls were evaluated for the glacial till and sand and gravel materials as well and are discussed in Appendix D.

2.6 REMEDIAL ACTION OBJECTIVES

The RAOs for Operable Unit 2 are based on site-specific contaminants and the various exposure pathways. The RAOs establish goals for protecting human health and the environment for each medium of interest in Operable Unit 2.

The goals for protecting human health and the environment are dependent on the media which are contaminated and the exposure pathways. The exposure pathways are very dependent on the future land use designated for the FEMP site. As described in Section 2.3, there are exposure scenarios which range from the FEMP continuing to maintain access controls with a security fence and security guards to the site being used by a resident farmer. Because of this wide range in future land uses, each contaminant of concern will have a range for the corresponding PRL, depending on each exposure scenario, as described in Section 2.3.

Potential risks associated with exposures related to Operable Unit 2 contamination were assessed in detail in Section 6 and Appendix B of the RI Report for Operable Unit 2 (DOE 1994) to identify those media that should be addressed to achieve RAOs. From this assessment, contaminated media contained in Operable Unit 2 were identified as follows:

- The contents of the Solid Waste Landfill, including the debris, cover soil, and base soil.
- The contents of the Lime Sludge Ponds, including the lime sludge and berm soils.
- The contents of the Inactive Flyash Pile, including the flyash, cover soil, and other waste material.
- The contents of the South Field, including soil and other waste material.
- The contents of the Active Flyash Pile, including flyash and base soil.
- Perched groundwater beneath the Solid Waste Landfill, the Lime Sludge Ponds, the Inactive Flyash Pile, the South Field, and the Active Flyash Pile.
- Construction water, which includes surface water, perched groundwater encountered during remediation of the subunits, and residual process water.

Tables 2-22 through 2-26 indicate the primary exposure pathway for each COC with regard to the exposure scenarios and each subunit. Tables 2-22 through 2-26 were prepared by evaluating the associated risk with each pathway to determine which contaminants exceeded an ILCR of 10^{-6} or an HI of 0.2.

The primary exposure pathway for the COCs at the Solid Waste Landfill and the Lime Sludge Ponds is through direct contact with the soil. The South Field, Active Flyash Pile, and the Inactive Flyash Pile have COCs which are a concern for direct contact with soils and groundwater. Indirect contact with soils from the subunits also contribute risk, but to a lesser degree. In addition, indirect contact pathways for groundwater also contribute minimal unacceptable risk for the South Field, Active Flyash Pile, and the Inactive Flyash Pile. Remediation of the Operable Unit 2 subunits can be accomplished by either excavating and treating the media contaminated at concentrations above the PRLs or by removing the potential for a receptor to be exposed to a COC through a particular exposure pathway.

In general, all of the exposure pathways provided in Section 2.3 can be controlled by preventing contact with the contaminated media (i.e., soil or groundwater). By preventing contact with the media of concern, risks form indirect pathways such as those associated with livestock and produce will also be controlled to within acceptable criteria.

Below are the remedial action objectives developed for the Operable Unit 2 FS:

- Prevent exposure to the contaminants of concern that are carcinogens at concentrations that would exceed an excess carcinogenic risk of 10^{-6} for all potential exposure pathways.
- Prevent exposure to the contaminants of concern that are non-carcinogens at concentrations that would result in the Hazard Index exceeding 0.2 for each individual chemical in all potential exposure pathways.
- Prevent exposure to contaminants of concern that are at concentrations which exceed ARAR-based levels (i.e., radiation levels, MCLs, etc.) for all potential exposure pathways.
- Prevent further degradation of the environment and/or resources in the Operable Unit 2 waste areas.
- Provide a degree of remediation and a design that are suitable for the designated future land use.
- Achieve remediation goals for ALARA considerations when practicable.

TABLE 2-22

SOLID WASTE LANDFILL
SUMMARY OF COCs AND EXPOSURE PATHWAYS

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure	COC for Exposure Pathway
Private Ownership	Future On-Property Resident Farmer	plants (homegrown produce)	ingestion	Arsenic
		livestock (grazing on property)	ingestion milk beef	Indeno(1,2,3-cd)pyrene
		groundwater	ingestion dermal contact inhalation	No COCs
		perched groundwater	ingestion dermal contact inhalation	Carbazole and Technetium-99
		soil	ingestion dermal contact external radiation inhalation	Cesium 137, Neptunium-237, Plutonium-238, Radium-226, Radium-228, Thorium-228, Thorium-230, Uranium-234, Uranium-235/236, Uranium-238, Arsenic, Beryllium, Benzo(a)pyrene, Benzo(b)-fluoranthene, Chromium, Dibenzo (a,h)-anthracene, Indeno(1,2,3-cd)pyrene
Federal Ownership	Future Off-Property Farmer	air	inhalation particulates	No COCs
		plants (homegrown produce)	ingestion	No COCs
		livestock (grazing on property)	ingestion milk beef	No COCs
		groundwater	ingestion dermal contact inhalation	No COCs
	Expanded Trespasser	surface water	ingestion dermal contact	No COCs
		sediment	ingestion dermal contact	Radium-228, Thorium-228, Arsenic
		soil	ingestion dermal contact external radiation inhalation	Radium-228, Thorium-228, Uranium-238, Beryllium

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TABLE 2-23

LIME SLUDGE PONDS
SUMMARY OF COCs AND EXPOSURE PATHWAYS

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure	COC for Exposure Pathway
Private Ownership	Future On-Property Resident Farmer	plants (homegrown produce)	ingestion	Arsenic
		livestock (grazing on property)	ingestion milk beef	Aroclor-1254, Benzo(a)pyrene
		groundwater	ingestion dermal contact inhalation	No COCs
		soil	ingestion dermal contact external radiation inhalation	Cesium 137, Neptunium-237, Radium-226, Radium-228, Thorium-228, Thorium-230, Uranium-234, Uranium-235/236, Uranium-238, Aroclor-1254, Arsenic, Beryllium, Benzo(a)pyrene, Benzo(b)-fluoranthene, Benzo(a)-anthracene, Chromium, Dibenzo(a,h)-anthracene, Indeno(1,2,3-cd) pyrene
Federal Ownership	Future Off-Property Farmer	air	inhalation particulates	No COCs
		plants (homegrown produce)	ingestion	No COCs
		livestock (grazing on property)	ingestion milk beef	No COCs
		groundwater	ingestion dermal contact inhalation	No COCs
	Expanded Trespasser	soil	ingestion dermal contact external radiation inhalation	Radium-228, Thorium-228, Uranium-238, Beryllium, Aroclor-1254

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TABLE 2-24

INACTIVE FLYASH PILE
SUMMARY OF COCs AND EXPOSURE PATHWAYS

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure	COC for Exposure Pathway
Private Ownership	Future On-Property Resident Farmer	plants (homegrown produce)	ingestion	Uranium-234 Uranium-235 Uranium-238
		livestock (grazing on property)	ingestion milk beef	Uranium-234 Uranium-238
		groundwater	ingestion dermal contact inhalation	Uranium-234 Uranium-235/236 Uranium-238
		soil	ingestion dermal contact external radiation inhalation	Cesium 137, Neptunium-237, Radium-226, Radium-228, Thorium-228, Uranium-235/236, Uranium-238, Arsenic, Beryllium, Dibenzo (a,h)-anthracene
Federal Ownership	Future Off-Property Farmer	air	inhalation particulates	No COCs
		plants (homegrown produce)	ingestion	Uranium-234 Uranium-238
		livestock (grazing on property)	ingestion milk beef	No COCs
		groundwater	ingestion dermal contact inhalation	Uranium-234 Uranium-235/236 Uranium-238
	Expanded Trespasser	sediment	ingestion dermal contact	No COCs
		soil	ingestion dermal contact external radiation inhalation	Radium-228, Thorium-228, Arsenic, Beryllium
		surface water	ingestion dermal contact	No COCs

TABLE 2-25

SOUTH FIELD
SUMMARY OF COCs AND EXPOSURE PATHWAYS

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure	COC for Exposure Pathway
Private Ownership	Future On-Property Resident Farmer	plants (homegrown produce)	ingestion	Benzo(a)pyrene, Uranium-234, Uranium-235, Uranium-238
		livestock (grazing on property)	ingestion milk beef	Uranium-234, Uranium-238, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Dibenzo(a,h)fluoranthene, Ideno(1,2,3-cd)pyrene
		groundwater	ingestion dermal contact inhalation	Uranium-234 Uranium-235/236 Uranium-238
		soil	ingestion dermal contact external radiation inhalation	Cesium 137, Neptunium-237, Radium-226, Radium-228, Thorium-228, Thorium-230, Thorium-232, Uranium-234, Uranium-235/236, Uranium-238, Arsenic, Beryllium, Chromium, Benzo(a)-anthracene, Benzo(a)pyrene, Benzo(b)-fluoranthene, Benzo(k)-fluoranthene, Dibenzo (a,h)-anthracene, Indeno(1,2,3-cd)pyrene, Aroclor-1254, Aroclor-1260, Dieldrin
Federal Ownership	Future Off-Property Farmer	air	inhalation particulates	Thorium-228, Thorium-230, Uranium-238
		plants (homegrown produce)	ingestion	Uranium-234 Uranium-238
		livestock (grazing on property)	ingestion milk beef	Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene
		groundwater	ingestion dermal contact inhalation	Uranium-234 Uranium-235/236 Uranium-238
	Expanded Trespasser	surface water	ingestion dermal contact	No COCs
		sediment	ingestion dermal contact	Radium-228, Thorium-228, Arsenic, Beryllium
		soil	ingestion dermal contact external radiation inhalation	Radium-228, Thorium-228, Arsenic, Beryllium, Benzo(a)pyrene

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TABLE 2-26

ACTIVE FLYASH PILE
SUMMARY OF COCs AND EXPOSURE PATHWAYS

Future Land Use	Receptor	Direct Contact Medium	Route of Exposure	COC for Exposure Pathway
Private Ownership	Future On-Property Resident Farmer	plants (homegrown produce)	ingestion	Arsenic, Beryllium, Uranium-234, Uranium-238
		livestock (grazing on property)	ingestion milk beef	Arsenic
		groundwater	ingestion dermal contact inhalation	Uranium-234, Uranium-238
		soil	ingestion dermal contact external radiation inhalation	Neptunium-237, Radium-226, Radium-228, Thorium-228, Uranium-235/236, Uranium-238, Arsenic
Federal Ownership	Future Off-Property Farmer	air	inhalation particulates	No COCs
		plants (homegrown produce)	ingestion	Arsenic
		livestock (grazing on property)	ingestion milk beef	No COCs
		groundwater	ingestion dermal contact inhalation	Uranium-234, Uranium-238
	Expanded Trespasser	surface water	ingestion dermal contact	No COCs
		soil	ingestion dermal contact external radiation inhalation	Radium-226, Radium-228, Thorium-228, Arsenic, Beryllium

3.0 GENERAL RESPONSE ACTIONS AND INITIAL SCREENING OF REMEDIAL ACTION TECHNOLOGIES

3.1 INTRODUCTION

In this section the following six items are discussed:

- Estimated volumes of contamination for each subunit (Section 3.2).
- Identification of GRAs to meet remedial objectives, including No Action (Section 3.3).
- Initial screening of technologies and process options (Section 3.4).
- Descriptions of technologies and process options remaining after the initial screening (Sections 3.5 and 3.6).
- Evaluation of technologies for each subunit with regard to effectiveness, implementability and cost (Section 3.7 and 3.8).
- Selection of representative technologies (Section 3.9).

3.2 VOLUMES OF CONTAMINATION

The volumes of contamination 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
- Refinement of results for use in computer modelling
- Determination of contaminant concentrations in a block model of each subunit by kriging, and determination of volumes based on kriging results

During the remedial investigation, the geology of the subunits was defined. The topography was based on 1992 aerial 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 have been segregated according to material type at each subunit.

An analysis of the topography, geology, and sample analysis results indicated several material types at each subunit. These material types contained varying degrees of contaminant concentrations.

Uranium-238 was identified as the most widespread contaminant, and was therefore chosen as the parameter to model for contaminant volumes.

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 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.

The three-dimensional block modeling was also used as the basis for establishing volumes of material contaminated with uranium-238. Uranium-238 concentrations in the blocks were calculated by kriging for each media using analytical results associated with that specific medium. The kriging procedure itself consists first of establishing a radius 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 of the contamination allows determination of contaminant volumes at various levels of contamination based on the number of blocks at any specified concentration level.

Upon completion of the input to the block model, comparisons of uranium-238 PRLs to modeled contaminant concentrations were conducted to determine remediation volumes for the Operable Unit 2 subunits. These volumes were determined by comparing contamination levels to the appropriate PRLs for a particular land use scenario. Following evaluation of the material with respect to uranium-238, other contaminants, as well as ARAR specified concentration levels, were then evaluated. Remediation volumes for each subunit were generally based on two land use scenarios; one scenario assumes private ownership and the second scenario assumes federal control. Under the private ownership scenario, the PRLs are those associated with a resident farmer receptor and an off-property farmer receptor. For the federal ownership scenario, the PRLs are those associated with the expanded trespasser receptor and the off-property farmer receptor. The PRLs used to determine the remediation volumes are based on the more conservative values for the two associated receptors for a given land use scenario.

The PRLs will differ based on the use of source controls. As an example, contaminated material contained using source controls would have a higher PRL than for material with no source controls. The volumes that will require remediation will also vary dependent on the PRLs selected for a given land use scenario and associated receptor.

Because the PRLs associated with private ownership are based on the receptor being an on-property resident farmer, pre-industrial conditions will be required to achieve protection of human health. Essentially, the PRLs associated with the on-property resident farmer receptor will require a clean closure for each subunit. The remediation volumes associated with the future land use scenario with federal ownership are typically less than those associated with the private ownership scenario because of the less stringent health-based PRLs. Appendix E contains the volume calculations which utilize the results of the block modeling. As shown in Appendix E, the volumes of material requiring remediation are dependent upon the PRLs which are determined by the specific land use scenario and receptor. The PRLs are established for remediation of COCs to a 1.0×10^{-6} ILCR and/or a 0.20 HI.

Additional details concerning land use scenarios and associated PRLs used to determine remediation volumes are discussed in the following sections for each individual subunit.

3.2.1 Solid Waste Landfill

The total area of the Solid Waste Landfill, within the battery limits, is 0.6 ha (1.5 acres). The area actually used for disposal of waste is slightly more than 0.32 ha (one acre). Based on three-dimensional block modeling, the Solid Waste Landfill contains approximately 11,600 cu m (15,200 cu yd) of fill. Of this volume, approximately 4,100 cu m (5,300 cu yd) consists of debris. The maximum fill depth observed at the landfill was in a geotechnical boring G2-106 in the southeast corner where the fill was about 6.7 m (22 ft) deep. However, typical fill depths range between about 1.5 and 4.6 m (five and 15 ft).

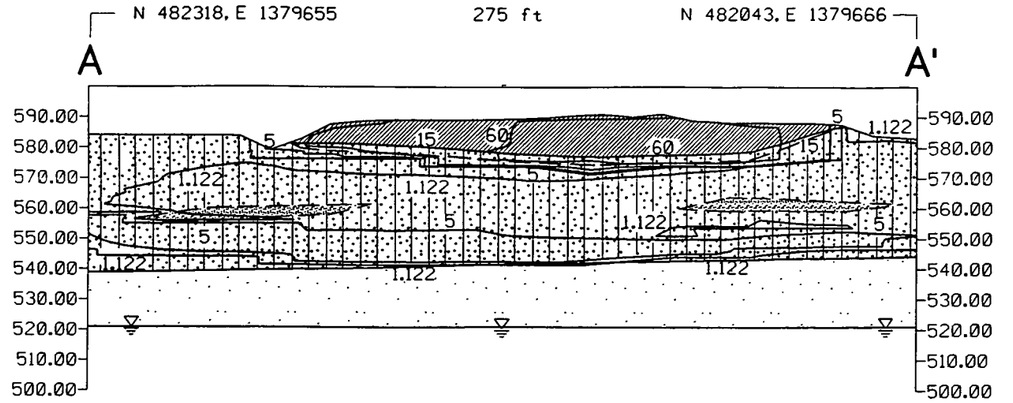
The volumes of material to be remediated at the Solid Waste Landfill are determined by comparing the PRLs to volumes determined by block modeling. Figure 3-1 provides a cross section of the Solid Waste Landfill with regard to concentrations of uranium-238 at various depths determined by kriging. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238 for four material types at the Solid Waste Landfill. These material types include fill, impacted till, remaining till, and unsaturated Great Miami Aquifer material. The

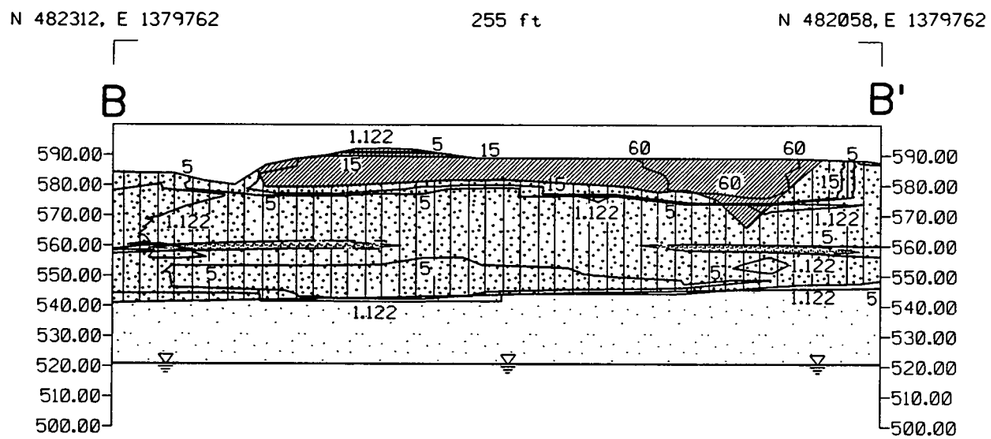
fill is the soil/debris/waste; the impacted till is the top 0.75 m (2.5 ft) of natural till that contains excessive concentrations of uranium as compared to the remaining till; and the remaining till and the unsaturated Great Miami Aquifer material are natural soils existing below the Solid Waste Landfill subunit. In addition to these four 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 for radionuclide contamination was evaluated to determine if PRLs, based on ARAR specified levels, were exceeded.

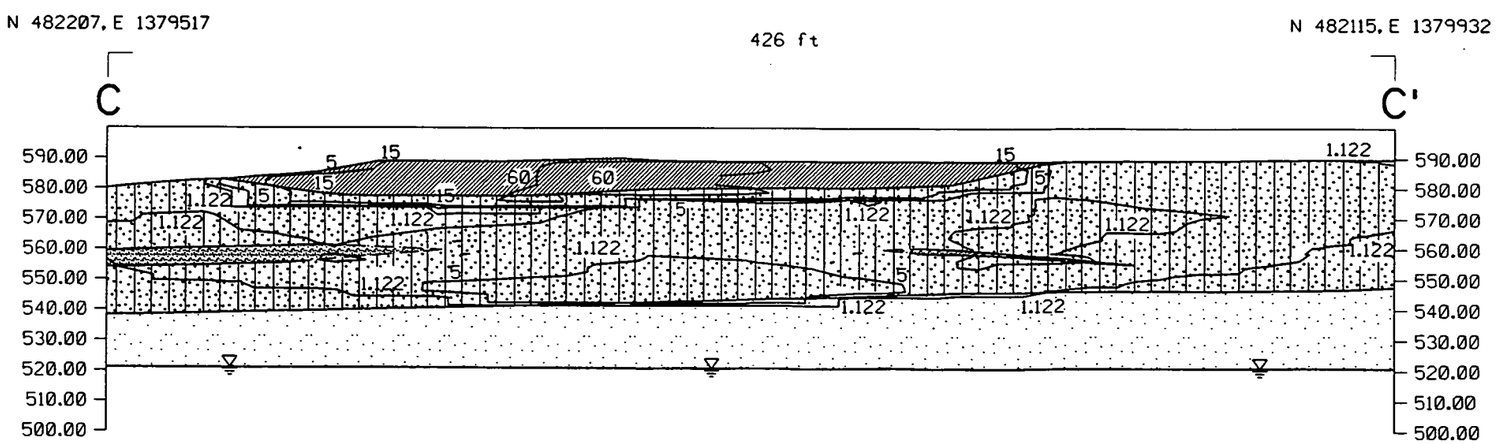
The remediation volumes developed for the Solid Waste Landfill will be based on a future land use of the FEMP with private ownership or with federal ownership. The remediation volumes for the private ownership are based on PRLs developed for surface pathways and for protection of perched groundwater. For the federal ownership scenario only PRLs associated with dermal/ingestion/fugitive dust emissions will be considered to determine remediation volumes. No PRLs for protection of the Great Miami Aquifer were developed based on the RI determination that the existing contamination in the Solid Waste Landfill will not impact the Great Miami Aquifer at concentrations which result in an unacceptable threats to human health and the environment.

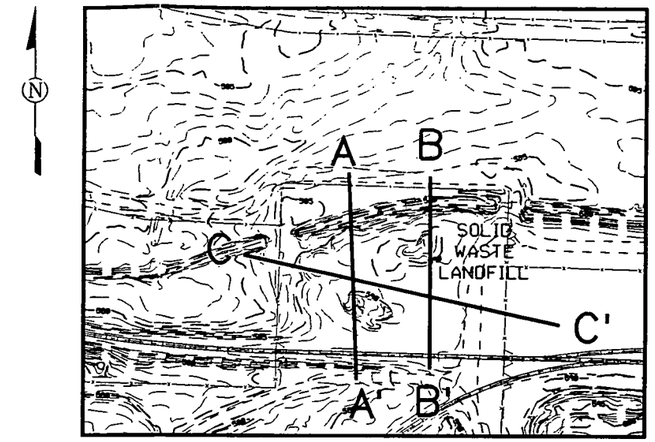
To determine the volume of material to be remediated for the FEMP with private ownership, the dermal/ingestion/fugitive dust emission PRL will be applied throughout the complete depth of the Solid Waste Landfill as opposed to only the surface of the landfill. This assumption was used because this land use scenario evaluates free release of the site, and the Federal government would have no control over the resident to prevent excavation and use of subsurface soils in a manner that would result in unacceptable health risks. The PRL for uranium-238, associated with the on-property resident farmer receptor, is 1.684 pCi/g. The amount of contaminated material above acceptable concentrations of uranium-238 is approximately 60,600 cu m (79,300 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, 45,700 cu m (59,800 cu yd) of the remaining till, and 18 cu m (23 cu yd) of sediment. This volume will be considered contaminated material because it is impacted by uranium-238 above acceptable health-based criteria.

After volumes of material based on uranium-238 are determined, other COCs are evaluated for the remaining material. The COCs are evaluated to determine if concentrations exceed their respective









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

000368

FIGURE 3-1
GEOLOGIC CROSS SECTIONS
SOLID WASTE LANDFILL

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PRL. For the future land use with private ownership scenario, no additional material would require remediation.

The PRLs associated with the federal ownership land use scenario assume the government retains ownership of the FEMP and that active controls are utilized. This land use therefore evaluates the expanded trespasser and off-property resident farmer for dermal/ingestion/fugitive dust emissions. In addition, federal ownership land use can consider the use of source controls to reduce risk from exposure to contaminants. The associated risk with the contaminants varies depending on the use of source controls at the subunit. If source controls are employed, the risk associated with the contaminants would be reduced.

There are no remediation volumes associated with uranium-238 if source controls are used. However, thorium-230 is present at levels which exceed PRLs based on ARAR requirements; the volume of material containing thorium-230 is 23 cu m (30 cu yd), and would require consideration during implementation of source controls.

The PRL for uranium-238, with no source controls for the federal ownership scenario, is 59 pCi/g. This concentration relates to a total remediation volume of 12,400 cu m (16,200 cu yd) of material. This volume consists of approximately 11,600 cu m (15,200 cu yd) of fill, 800 cu m (1,000 cu yd) of impacted till, and 18 cu m (23 cu yd) of sediment. The sediment is impacted by uranium-238 above the PRL. Other COCs were also evaluated to determine if additional volumes will require remediation. Based on this evaluation, it was determined that the volume of contaminated material containing uranium-238 encompassed all other material which contains additional COCs at concentrations above their respective PRLs. Table 3-1 provides a summary of the material which must be remediated for each of the waste types considered under the appropriate land use scenario and use of source controls.

3.2.2 Lime Sludge Ponds

The North and South Lime Sludge Ponds are each approximately 38 by 68 m (125 by 225 ft) in size. The North Pond, which is still in use, has a typical sludge depth of approximately 2.3 m (7.5 ft), while the South Pond has a typical sludge depth of approximately 3.2 m (10.5 ft). 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). The volume of

TABLE 3-1

SOLID WASTE LANDFILL

VOLUMES[a] OF MATERIAL TO BE REMEDIATED
FUTURE LAND USE SCENARIO

PRIVATE OWNERSHIP

REMEDIATION SCENARIO	Fill		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated Above ARAR Limits		TOTAL	
	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
No Source Controls	11600	15200	3300	4300	45700	59800	0	0	18	23	0	0	60618	79323
Source Controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

FEDERAL OWNERSHIP

REMEDIATION SCENARIO	Fill		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated Above ARAR Limits		TOTAL	
	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
No Source Controls	11600	15200	800	1000	0	0	0	0	18	23	0	0	12418	16223
Source Controls	0	0	0	0	0	0	0	0	18	23	23	30	41	53

[a] - All volumes listed are "in-place" volumes.
NA - Not Applicable

berm material that surrounds the two ponds is based on a comparison of pre-FEMP topography with current topography.

The volumes of material to be remediated at the Lime Sludge Ponds are determined by comparing the PRLs to the volumes determined through block modeling. Figure 3-2 provides a cross section of the Lime Sludge Ponds with regard to concentrations of uranium-238 at various depths based on kriging. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238 for four material types at the Lime Sludge Ponds. These material types include berm material, lime sludge, till, and unsaturated Great Miami Aquifer material. The berm material is 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 Ponds subunit. In addition to these four material types used for block modeling, sediments from the drainage ditch near the Lime Sludge Ponds was evaluated for contaminant impacts. Any material not previously included in the remediation volume for radionuclide contamination was evaluated to determine if PRLs, based on ARAR specified levels, were exceeded.

The remediation volumes developed for the Lime Sludge Ponds will be based on a future land use of the FEMP with private ownership or with federal ownership. For both scenarios only PRLs associated with dermal/ingestion/fugitive dust emissions will be considered to determine remediation volumes. No PRLs for protection of groundwater were developed based on the RI determination that the existing contamination in the Lime Sludge Ponds will not impact the Great Miami Aquifer at concentrations which result in an unacceptable threat to human health and the environment.

To determine the volume of material to be remediated for the future land use with private ownership, the dermal/ingestion/fugitive dust emission PRL will be applied throughout the complete depth of the Lime Sludge Ponds as opposed to only the surface of the ponds. This assumption was used because the land use scenario evaluates free release of the site and the federal government would have no control over the resident to prevent excavation and use of subsurface soils in a manner that would result in unacceptable health risks. The material requiring remediation will be considered contaminated material because it is impacted by uranium-238 above acceptable health-based criteria or exceeds acceptable ARAR specific criteria.

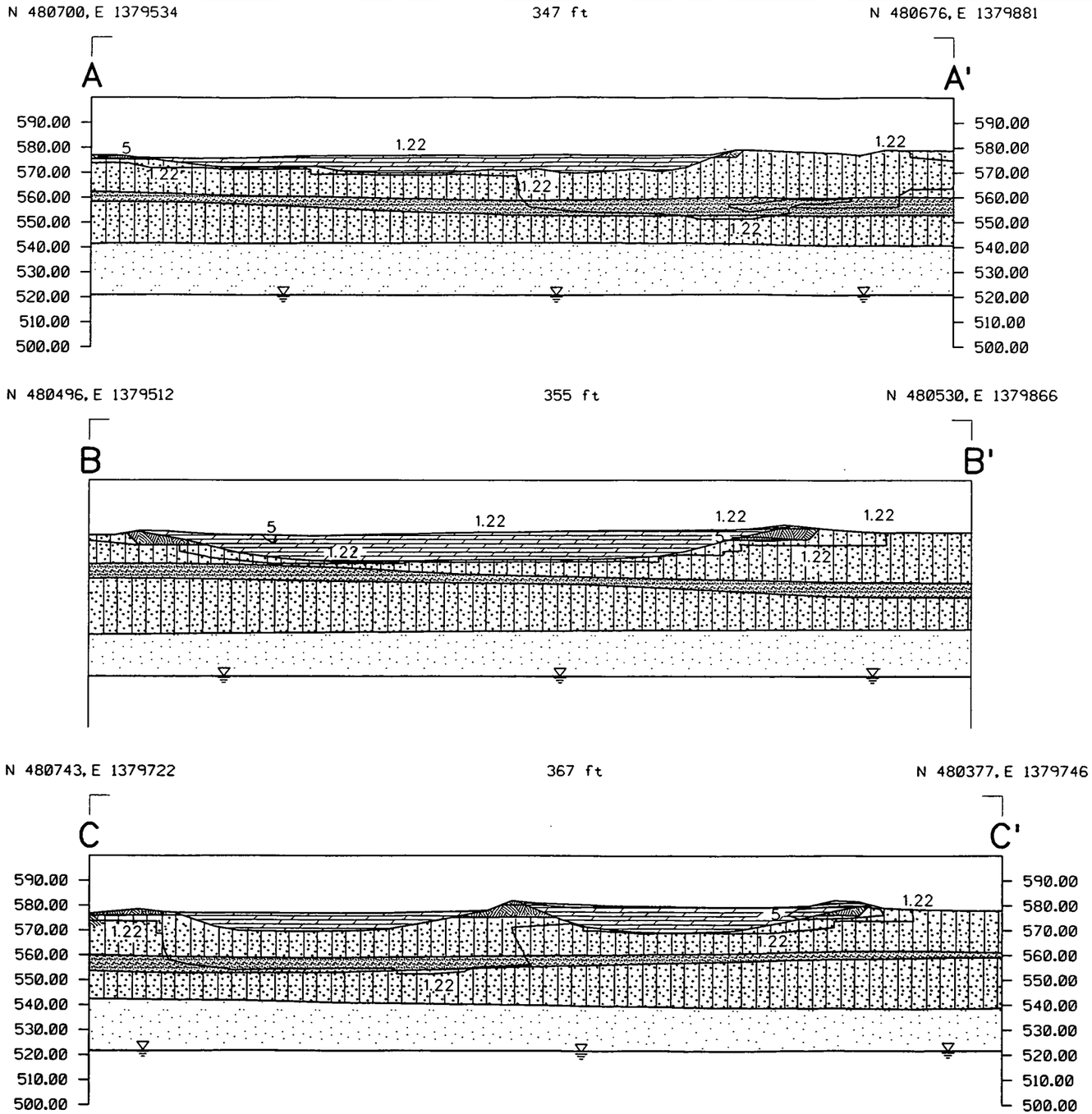
The PRL for uranium-238, associated with the resident farmer receptor, is 1.69 pCi/g. The amount of contaminated material above acceptable concentrations of the COCs is approximately 27,200 cu m (35,500 cu yd). This volume includes material exceeding the PRL for uranium-238 and the material which exceeds the PRLs based on ARAR requirements. The volume of material requiring remediation for uranium-238 consists of approximately 4,300 cu m (5,600 cu yd) of berm material, 12,600 cu m (16,500 cu yd) of lime sludge, and 10,300 cu m (13,400 cu yd) of till. For the on-property resident farmer scenario, no Great Miami Aquifer material or sediment would require remediation.

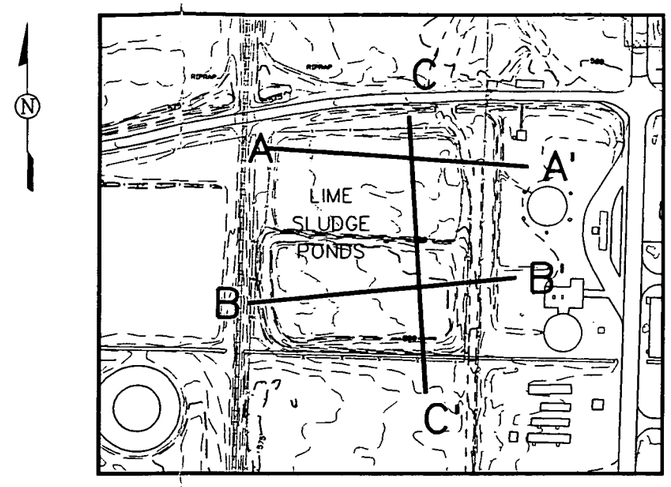
After volumes of material based on uranium-238 were determined, other COCs were evaluated for the remaining material to determine if concentrations were present above their respective PRL. Based on the PRL (ARAR specified level) for thorium-230, an additional 11 cu m (15 cu yd) material requires remediation.

The PRLs associated with the federal ownership land use scenario assume the government retains ownership of the FEMP and that active controls are utilized. This land use therefore evaluates the expanded trespasser and off-property resident farmer receptors for dermal/ingestion/fugitive dust emissions. In addition, federal ownership land use can consider the use of source controls to reduce risk from exposure to contaminants. The associated risk to the contaminants varies depending on the use of source controls at the subunit. If source controls are employed, the risk to the contaminants would be reduced.

There are no remediation volumes associated with uranium-238 if source controls are used. However, thorium-230 is present at concentrations above the PRL based on ARAR requirements and would require consideration during implementation of source controls. The volume of material containing thorium-230 is 37 cu m (48 cu yd). In addition, to allow implementation of the source controls, the K-65 slurry line would require relocation. Relocation of this line would result in generation of approximately 77 cu m (100 cu yd) of debris.

The PRL for uranium-238 with no source controls for the federal ownership scenario is 59 pCi/g. Based on this PRL, no material is impacted by uranium-238 at unacceptable levels. However, based on PRLs for other contaminants including the PRL based on ARARs for thorium-230, the total remediation volume would be 12,600 cu m (16,500 cu yd). This volume includes 11 cu m (15 cu yd)





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

000373

FIGURE 3-2
GEOLOGIC CROSS SECTIONS
LIME SLUDGE PONDS

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of material impacted by thorium-230. The remaining remediation volume consists of lime sludge that requires remediation based on other contaminants exceeding their respective PRLs. No till, Great Miami Aquifer material, or sediments contained COCs at unacceptable levels. Table 3-2 provides a summary of the material which must be remediated for each of the material types considered under the appropriate land use scenario and use of source controls.

3.2.3 Inactive Flyash Pile

The total area of the Inactive Flyash Pile is approximately 1.2 ha (three ac). Based on three-dimensional block modeling, the Inactive Flyash Pile contains approximately 73,300 cu m (95,900 cu yd) of fill and debris. Of that total, approximately 920 cu m (1,200 cu yd) are cover material, 33,300 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. Of the construction debris and fill, the volume of debris was estimated to be 3,100 cu m (4,000 cu yd). Fill depths greater than nine m (30 ft) have been observed in the middle and southern portions of the pile.

The volumes of material to be remediated at the Inactive Flyash Pile are determined by comparing the PRLs to the volumes determined through block modeling. Figures 3-3 through 3-5 provide cross sections through the Inactive Flyash Pile showing concentrations of uranium-238 at various depths based on kriging. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238 for six material types at the Inactive Flyash Pile. These material types include cover material, flyash, fill/debris, impacted till, 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 (two ft) of the natural till that contains excessive concentrations of uranium as compared to the remaining till; and the remaining till and unsaturated Great Miami Aquifer material are natural soils existing below the Inactive Flyash Pile subunit. In addition to these six material types used for block modeling, sediment from the drainage ditch to the north west of the flyash pile was evaluated for contaminant impacts. Any material not previously included in the remediation volume for radionuclide contamination was evaluated to determine if PRLs, based on ARAR specified levels, were exceeded.

The remediation volumes developed for the Inactive Flyash Pile will be based on a future land use of the FEMP with private ownership or with federal ownership. For both scenarios PRLs associated

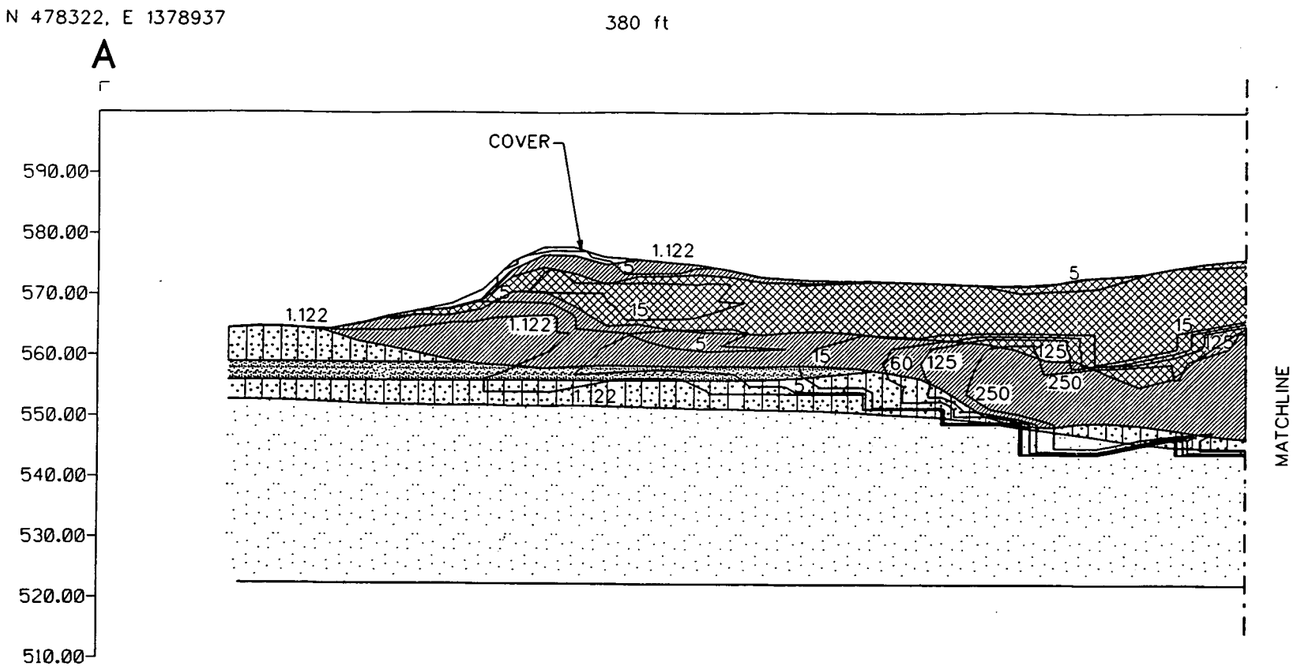
with dermal/ingestion/fugitive dust emissions and groundwater protection will be considered to determine remediation volumes. PRLs for protection of groundwater were developed based on determining the concentration of contaminants which can remain in the Inactive Flyash Pile and not impact the Great Miami Aquifer at concentrations which result in an unacceptable health based risks. Initially, the volume of material to be remediated is determined by the more stringent PRL for uranium-238 between dermal/ingestion/fugitive dust emission and groundwater protection.

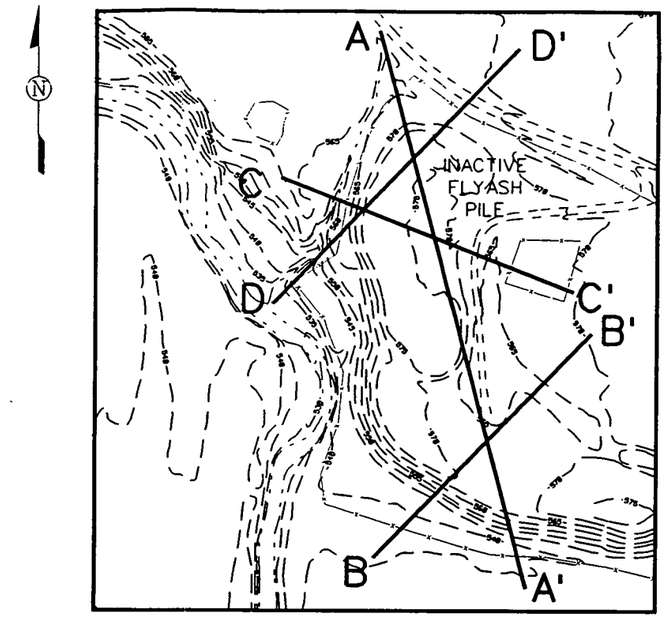
After volumes for uranium-238 are determined, additional COCs are evaluated only for the dermal/ingestion/fugitive dust emission PRL. For the private land use scenario, this evaluation was made throughout the complete depth of the Inactive Flyash Pile as opposed to only the surface. This assumption was used because the private land use scenario evaluates free release of the site and the federal government would not have control over the resident to prevent excavation and use of subsurface soils in a manner that would result in unacceptable health risks. For the federal ownership land use scenario, the PRLs were evaluated only against the surface and near surface of the soils remaining after the uranium contaminated material is removed.

The PRL for uranium-238, associated with the future land use scenario with private ownership, is 1.60 pCi/g for dermal/ingestion/fugitive dust emissions. The PRL established for groundwater protection is 1.12 pCi/g for all material types. Therefore, the groundwater protection PRL is controlling and will be used to determine remediation volumes for uranium-238.

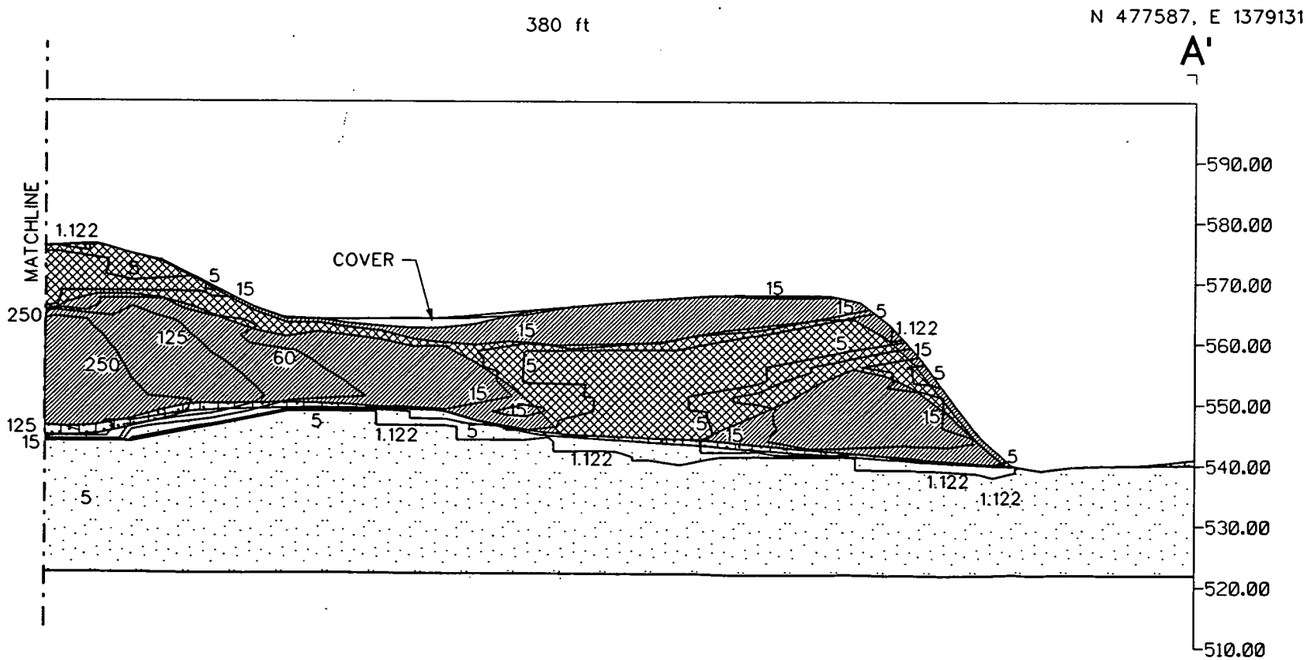
A threshold value of 10.0 pCi/g of uranium-238 will be used to determine the quantity of flyash which has been cross-contaminated by uranium-238. Cross-contaminated flyash is considered to be flyash which has been impacted by direct contact or leachate migration from post disposal practices of dumping contaminated soils or debris in or around the flyash. The 10.0 pCi/g value was selected based on a study which evaluated uranium concentrations in flyash from Kentucky coal (ORNL, David Klein, 1975:VPL, Furr, Parkinson, et al.). The study indicated that total uranium ranges from 9.0 to 30.1 ppm which equates to 3.0 to 10.0 pCi/g of uranium-238, respectively (see Appendix E for the conversion calculations). Therefore, 10.0 pCi/g of uranium-238 will be considered the upper bound for concentrations associated with typical flyash.

The amount of material contaminated with uranium-238 above the PRL is approximately 48,800 cu m (63,800 cu yd). This volume consists of approximately 765 cu m (1,000 cu yd) of cover material,





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

000376

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 3-3
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 1 OF 3

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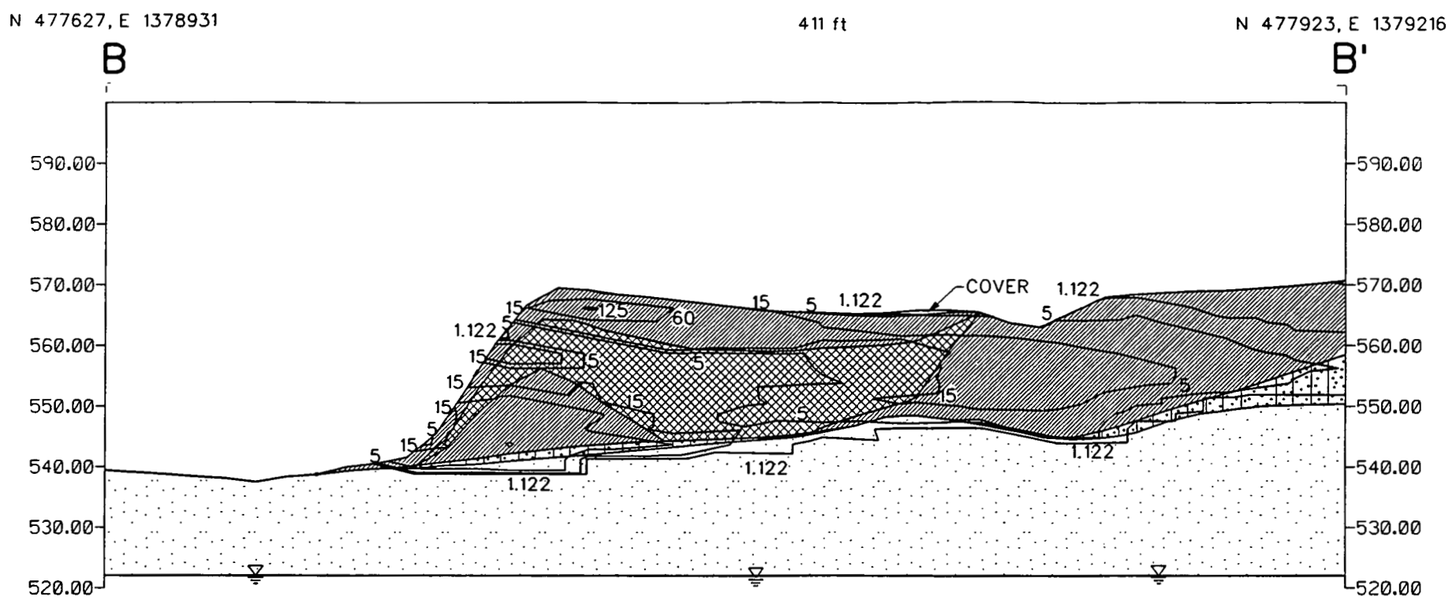
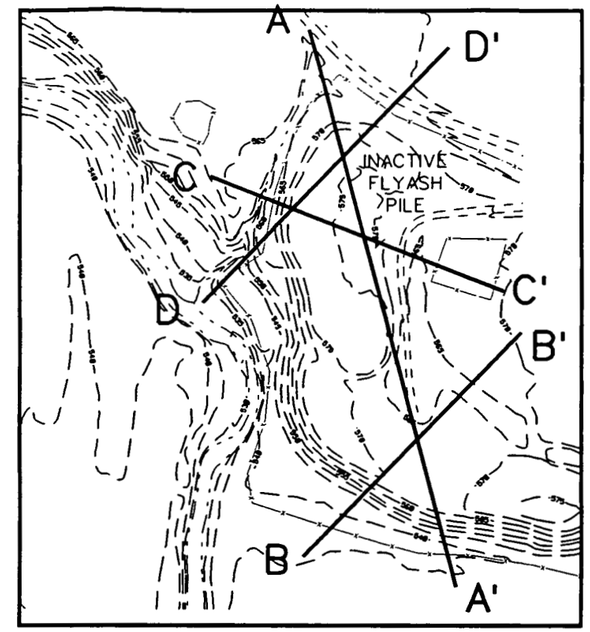
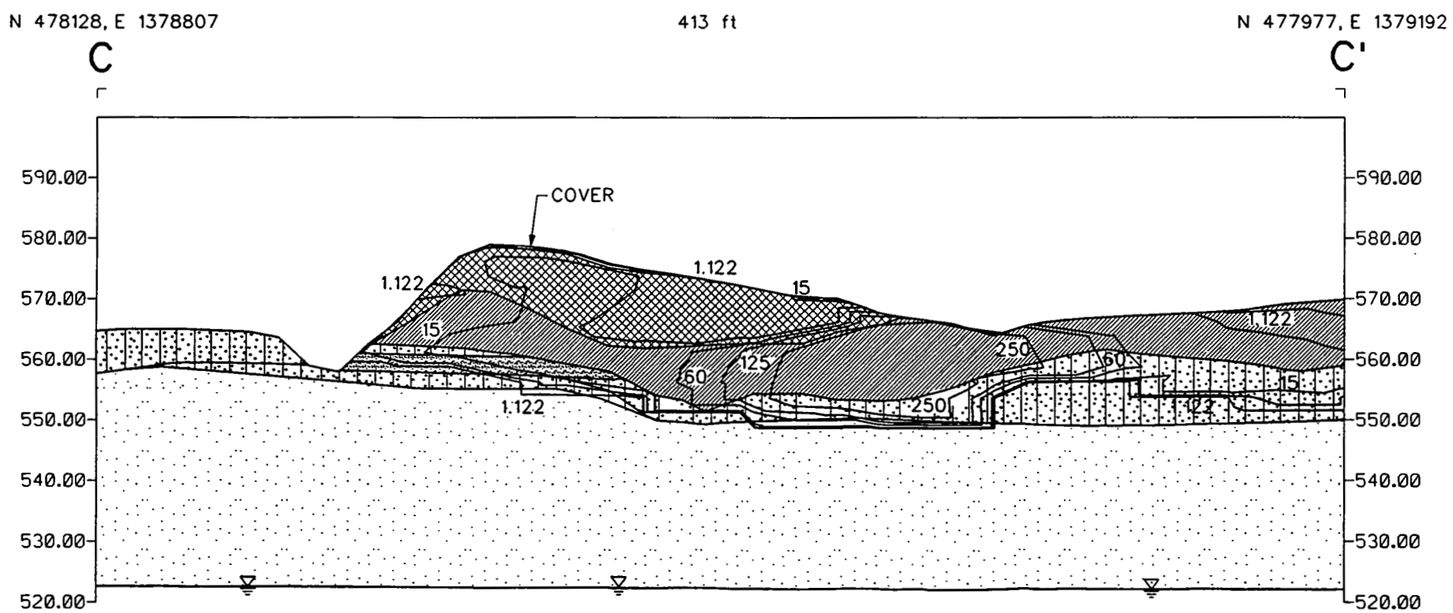




LOCATION KEY (1" = 200')



LEGEND	
575	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

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FIGURE 3-4
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 2 OF 3

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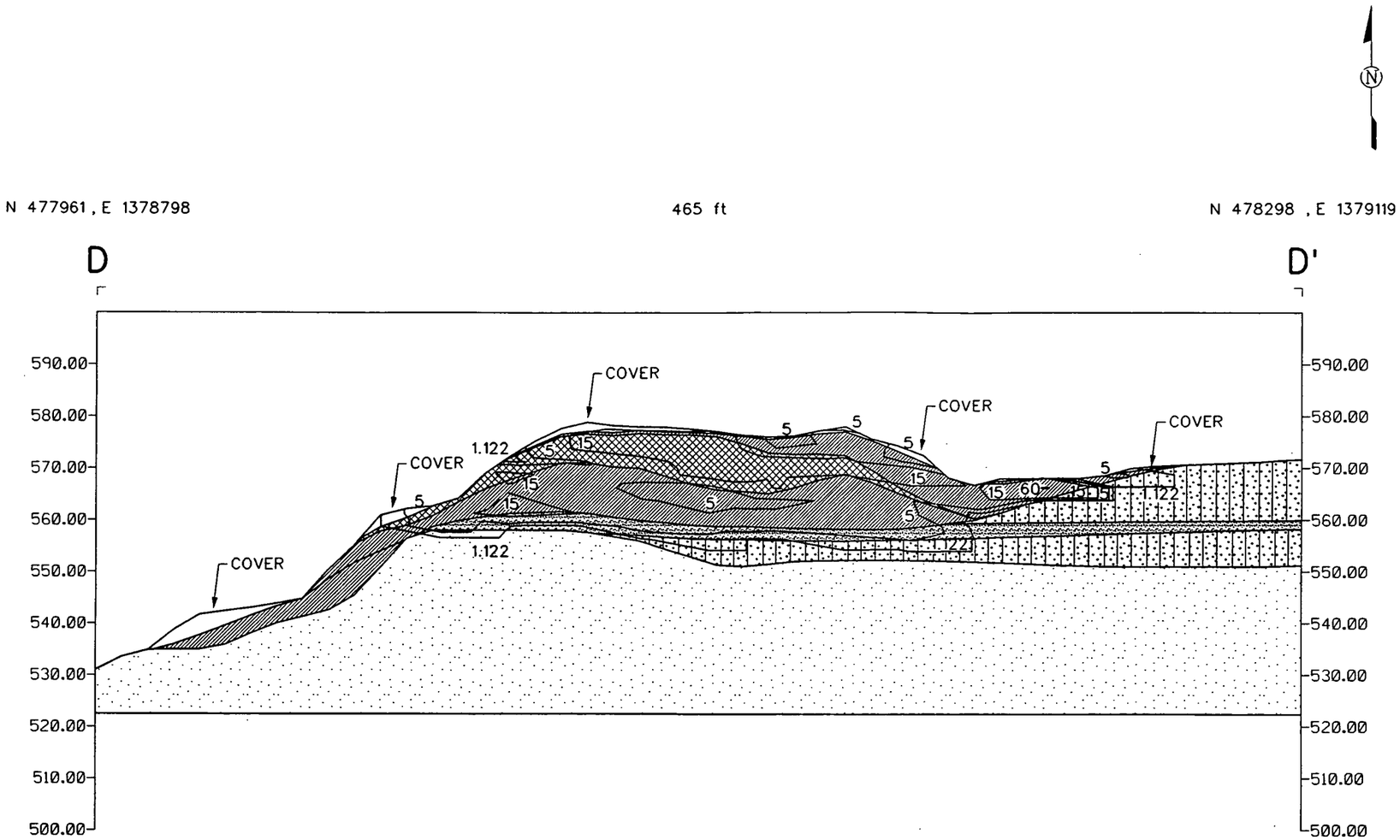

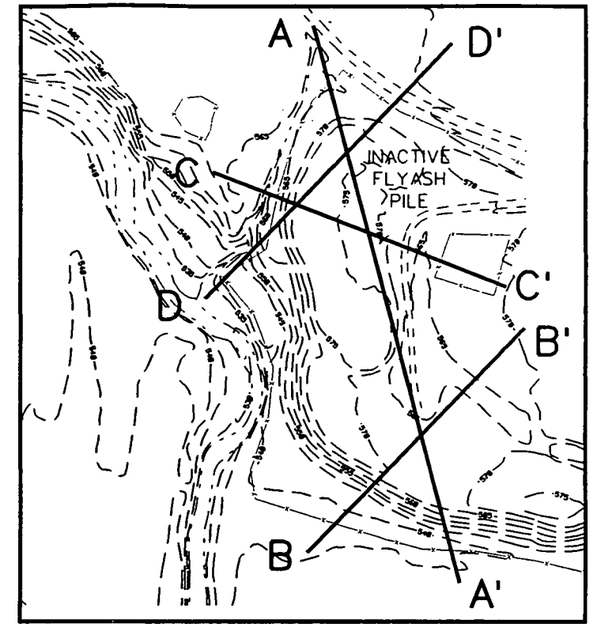

LOCATION KEY (1" = 200')

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.

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 000278
GEOLOGIC CROSS SECTIONS
INACTIVE FLYASH PILE
SHEET 3 OF 3

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TABLE 3-2

LIME SLUDGE PONDS

VOLUMES[a] OF MATERIAL TO BE REMEDIATED FUTURE LAND USE SCENARIO														
	PRIVATE OWNERSHIP													
REMEDIATION SCENARIO	Berm		Lime Sludge		Till		GMA Material		Sediment		Material Contaminated Above ARAR Limits		TOTAL	
	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
No Source Controls	4300	5600	12600	16500	10300	13400	0	0	0	0	11	15	27211	35515
Source Controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

	FEDERAL OWNERSHIP															
REMEDIATION SCENARIO	Berm		Lime Sludge		Till		GMA Material		Sediment		Material Contaminated Above ARAR Limits		K-65 Line Debris		TOTAL	
	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
No Source Controls	4300	5600	12600	16500	0	0	0	0	0	0	11	15	0	0	16911	22115
Source Controls	0	0	0	0	0	0	0	0	0	0	36	47	46	60	82	107

[a] - All volumes listed are "in-place" volumes.

NA - Not Applicable

000379

1501

9,300 cu m (12,100 cu yd) of flyash, 35,500 cu m (46,400 cu yd) of fill/debris material, 2,500 cu m (3,300 cu yd) of impacted till, and 750 cu m (980 cu yd) of Great Miami Aquifer material. This material will be considered contaminated material because it is impacted by uranium-238 above acceptable health-based criteria.

The remaining material which is not impacted by uranium-238 is evaluated for other COCs to determine if their concentrations exceed PRLs. Appendix E provides the evaluation of COCs and their respective PRLs. A total of 5,800 cu m (7,600 cu yd) of material requires removal for these other COCs. This volume consists of 92 cu m (120 cu yd) of cover material, 3,600 cu m (4,700 cu yd) of fill/debris, 920 cu m (1,200 cu yd) of impacted till, and 1,200 cu m (1,600 cu yd) of remaining till. No additional Great Miami Aquifer material required remediation. Overall, the remediation volumes included material contaminated above PRLs based on ARAR specified limits; therefore, no additional volume would require remediation. Approximately 24,200 cu m (31,600 cu yd) of flyash was found not to be cross contaminated by past disposal practices; however, typical concentrations of contaminants present in flyash are above their respective PRLs and will require remediation. The flyash volume which is not cross-contaminated by radionuclides will not require special consideration and can be handled as typical flyash.

The PRLs associated with the federal ownership land use scenario assume that the government retains ownership of the FEMP and that active controls are utilized. This land use evaluates the expanded trespasser for the dermal/ingestion/fugitive dust emissions and the off-property farmer for both groundwater protection and the dermal/ingestion/fugitive dust emissions. In addition, federal ownership can consider the use of source controls to reduce risk from exposure to contaminants. If source controls are employed, the risk from the contaminants would be reduced.

The remediation volume associated with uranium-238 or other COCs if source controls are employed is less than the volume if no source controls are used. Initially, volumes requiring remediation due to unacceptable levels of uranium-238 are determined. The PRL for uranium-238 is 59 pCi/g for dermal/ingestion/fugitive dust emissions and the PRLs for groundwater protection are 6.1 pCi/g for source material located directly upon the sand and gravel of the Great Miami Aquifer and 1210 pCi/g for source material located over till 5.5 m (18 ft) thick. Therefore, for uranium-238, the PRL for source material directly upon the sand and gravel of the Great Miami Aquifer is 6.1 pCi/g and the PRL for material above the till is 59 pCi/g.

Remediation volumes for uranium-238 for the material located over less than 5.5 m (18 ft) thick are determined based on groundwater protection to be 35,300 cu m (46,100 cu yd). No material above the thick till requires remediation. This 35,300 cu m (46,100 cu yd) includes 770 cu m (1,000 cu yd) of cover material, 32,100 cu m (41,900 cu yd) of fill/debris, 2,400 cu m (3,100 cu yd) of impacted till, and 20 cu m (26 cu yd) of sediment. This material will be considered contaminated because it is impacted with uranium-238 above acceptable levels. No remaining till or Great Miami Aquifer material will require remediation for uranium-238. All flyash will be remediated due to contaminants exceeding dermal PRLs. These contaminants are within typical ranges for flyash, but exceed human health based PRLs. A total of 33,400 cu m (43,600 cu yd) of flyash will require remediation. This volume of flyash contains approximately 9,300 cu m (12,100 cu yd) that is impacted with uranium-238 above 10.0 pCi/g and would be considered cross-contaminated.

Following the determination of remediation volumes for flyash and material contaminated with uranium-238, the remaining material is evaluated to determine if other COCs are present at concentrations above PRLs. Appendix E provides the evaluation of COCs and their respective PRLs. A total of 8,200 cu m (10,700 cu yd) of material require remediation based on other COCs being present at unacceptable levels. This total volume is comprised of 92 cu m (120 cu yd) of cover material, 7,000 cu m (9,200 cu yd) of fill/debris, and 1,100 cu m (1,400 cu yd) of impacted till. No additional remaining till, Great Miami Aquifer material, and sediment require remediation based on the other COCs. Any material impacted by COCs that exceed PRLs based on ARAR specified levels are encompassed by the above volumes; therefore, no additional volume requires remediation.

If source controls are not used, remediation volumes will be based on the controlling PRLs for either dermal/ingestion/fugitive dust emissions or for groundwater protection. Initially, volumes requiring remediation due to uranium-238 are evaluated. The PRL for uranium-238 is 59 pCi/g for dermal/ingestion/fugitive dust emissions and is 1.12 pCi/g for groundwater protection for all material types. Based on these PRLs, remediation volumes would be equivalent to those calculated for the future land use scenario with private ownership. Table 3-3 provides a summary of the material which requires remediation for each of the material types considered under the appropriate land use scenario and use of 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. Of this volume of fill and debris, the debris was estimated to be 5,000 cu m (6,500 cu yd). The maximum fill depth observed was approximately 8.5 m (28 ft) in the southern portion of the South Field.

The volumes of material to be remediated in the South Field are determined by comparing the PRLs to the volumes determined through block modeling. Figures 3-6 through 3-10 provide cross sections through the South Field showing to concentrations of uranium-238 at various depths. 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. These material types include fill/debris, impacted till, 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 (four ft) of natural till that contains excessive concentrations of uranium as compared to the remaining till; and 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 PRLs based on ARAR specified levels were exceeded.

The remediation volumes developed for the South Field will be based on a future land use of the FEMP with private ownership or with federal ownership. For both scenarios, PRLs associated with dermal/ingestion/fugitive dust emissions and groundwater protection will be considered to determine remediation volumes. PRLs for protection of groundwater were developed based on determining the concentration of contaminants which can remain in the South Field and not impact the Great Miami Aquifer at concentrations which result in unacceptable threat to human health and the environment. Initially, the volume of material to be remediated is determined by the controlling PRL for uranium-238 between dermal/ingestion/fugitive dust emission and groundwater protection.

After volumes for uranium-238 are determined, additional COCs are only evaluated for the dermal/ingestion/fugitive dust emission PRL. For the private land use scenario, this evaluation was made throughout the complete depth of the South Field as opposed to only the surface. This

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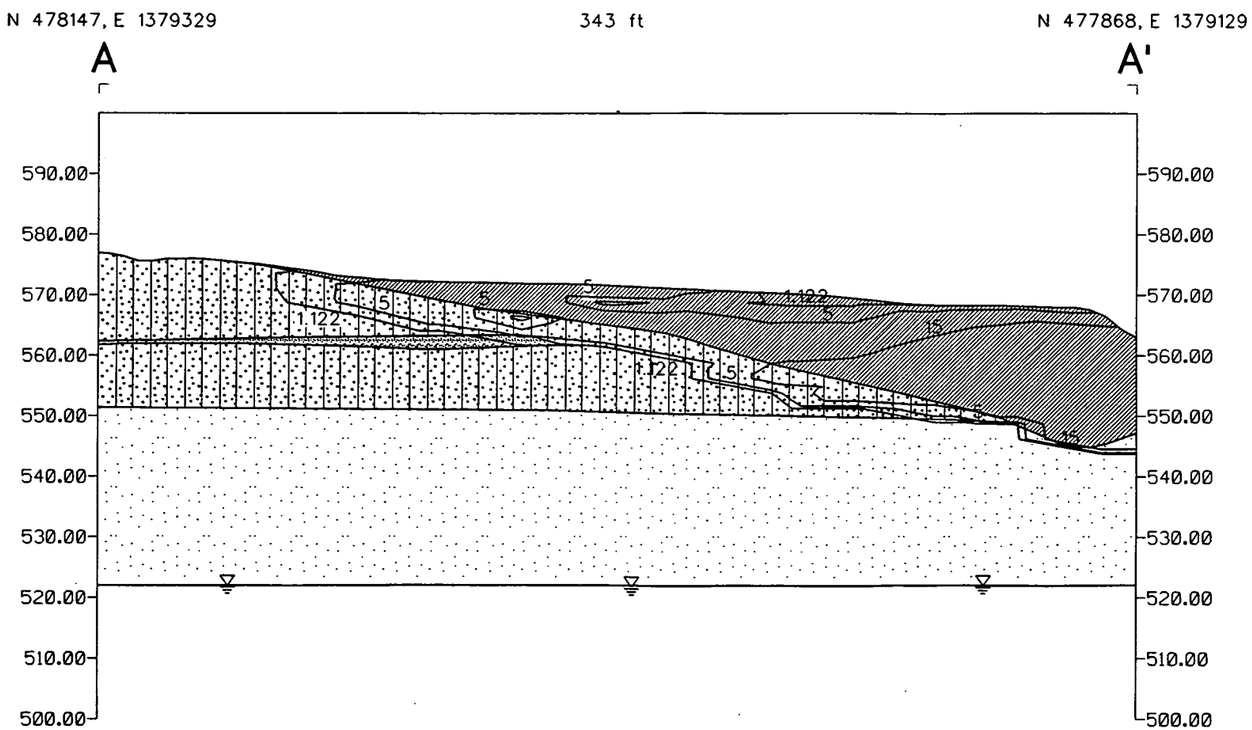

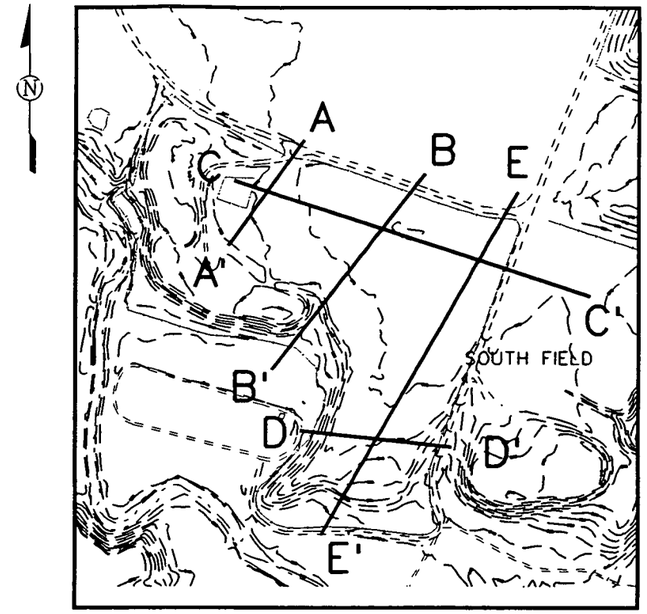

LOCATION KEY (1" = 400')

LEGEND

- 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.

000383

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 3-6
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 1 OF 5

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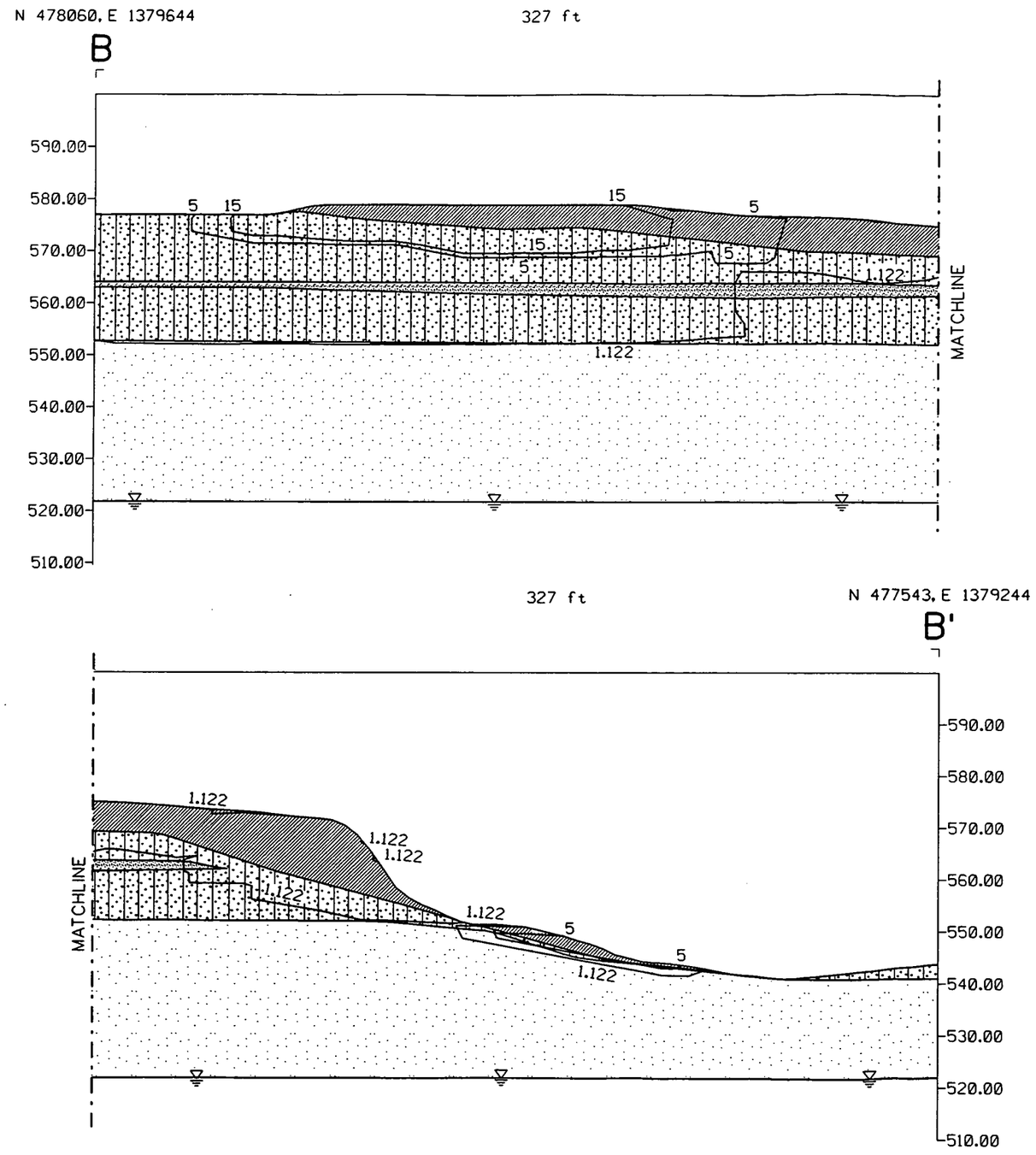

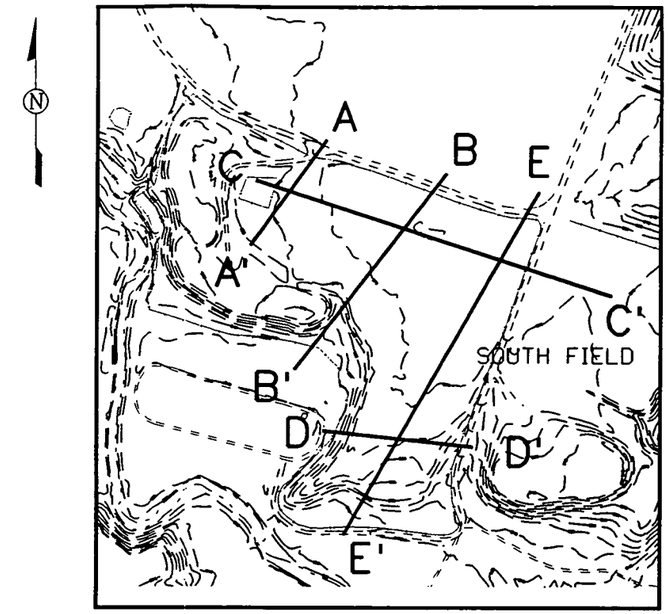

LOCATION KEY (1" = 400')

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

LEGEND

- 575 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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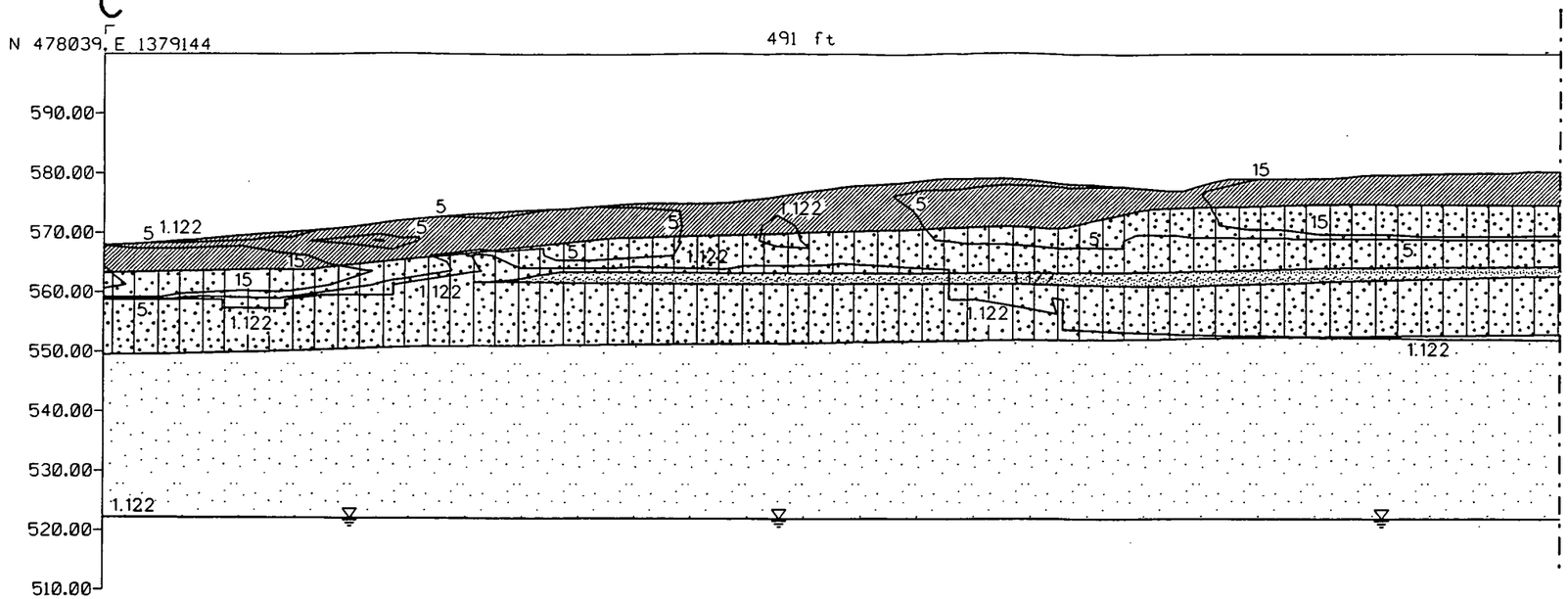
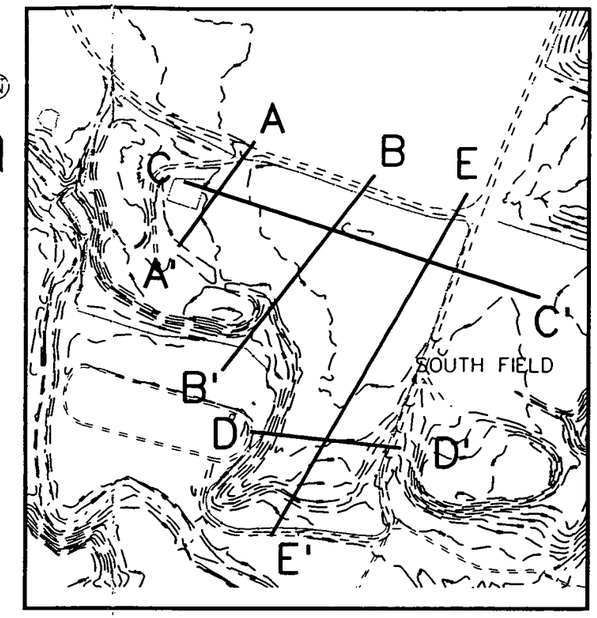
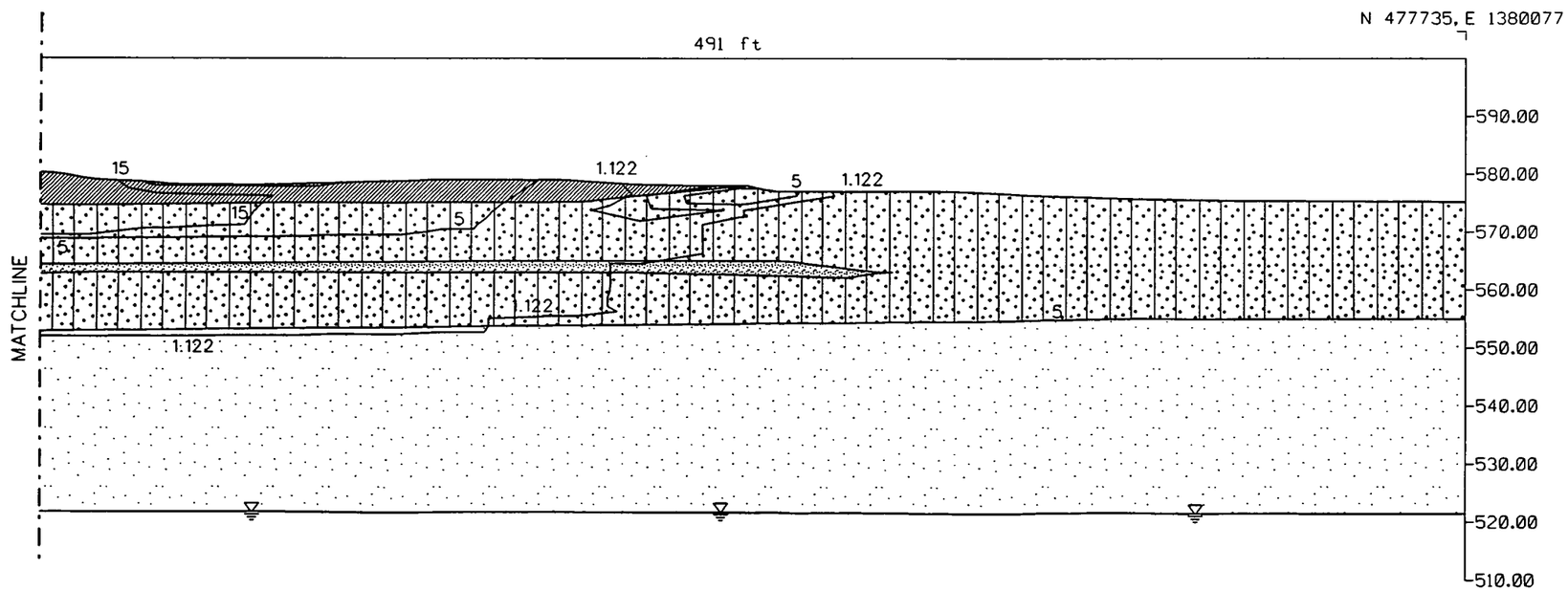




LOCATION KEY (1" = 400')



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.

000385

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 3-8
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 3 OF 5

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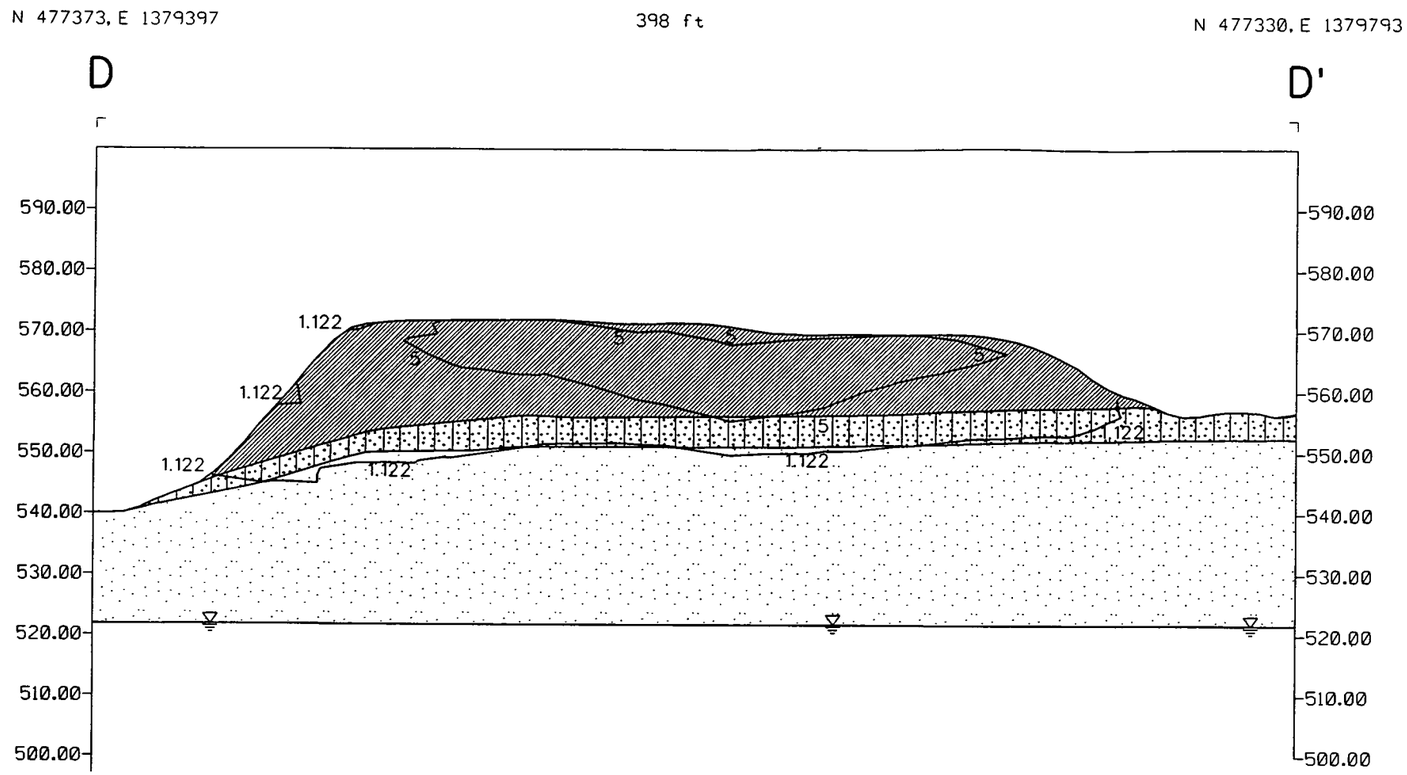

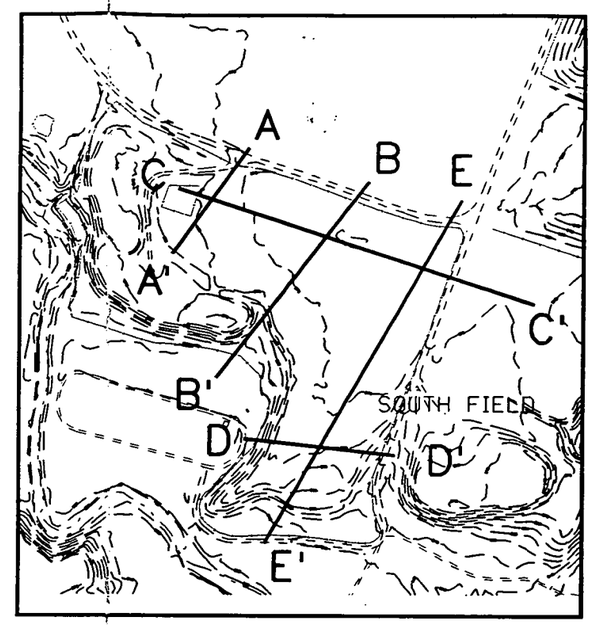

LOCATION KEY (1" = 400')

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.

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 3-9
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 4 OF 5

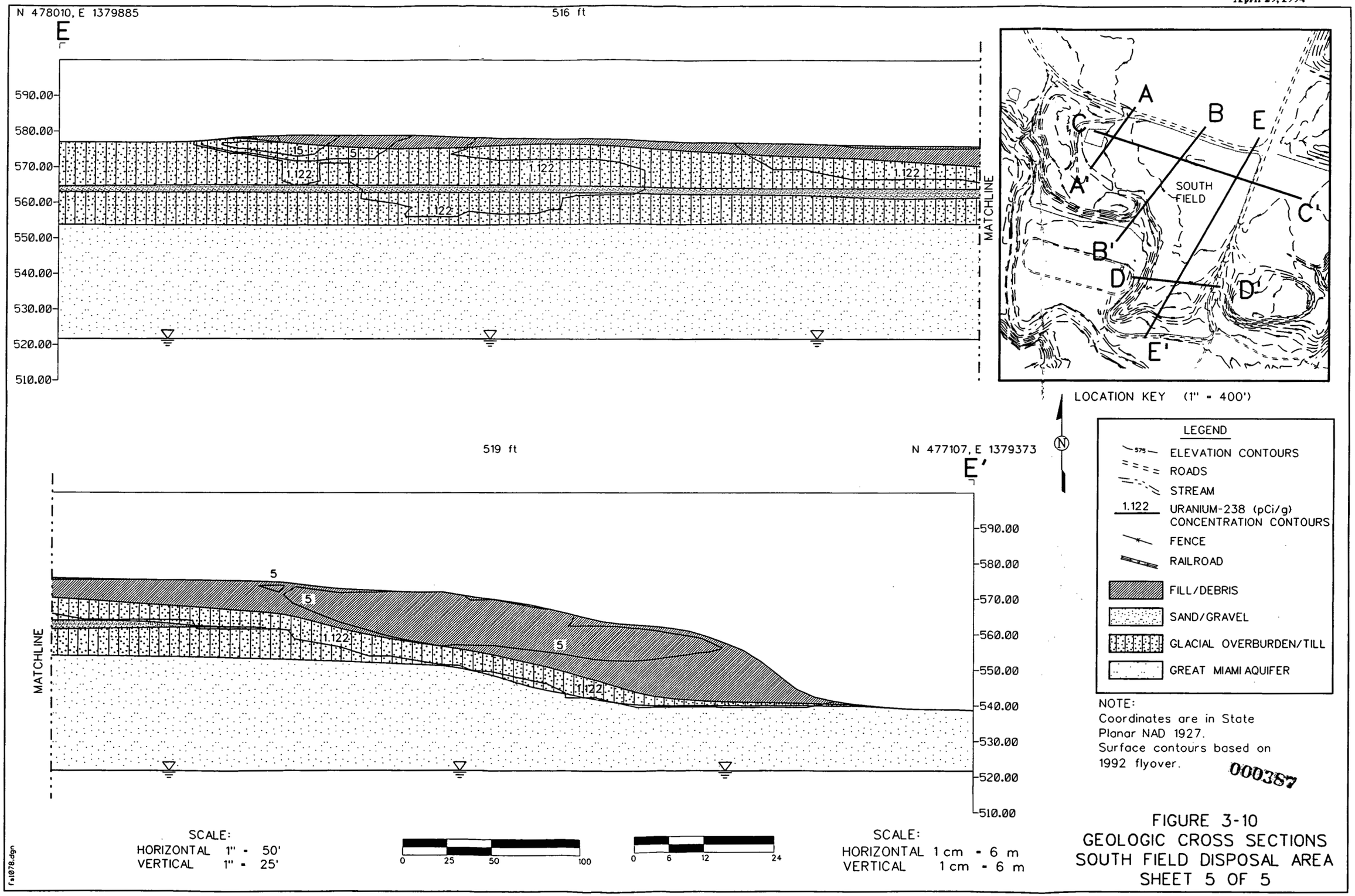

FIGURE 3-10
GEOLOGIC CROSS SECTIONS
SOUTH FIELD DISPOSAL AREA
SHEET 5 OF 5

TABLE 3-3

INACTIVE FLYASH PILE

VOLUMES[a] OF MATERIAL TO BE REMEDIATED
FUTURE LAND USE SCENARIO

PRIVATE OWNERSHIP

REMEDIATION SCENARIO	Cover Material		Flyash		Fill/Debris		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated above ARAR limits		TOTAL	
	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
No Source Controls	860	1120	33400	43600	39100	51000	3400	4500	1200	1600	750	980	20	26	0	0	78,730	102,826
Source Controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

FEDERAL OWNERSHIP

REMEDIATION SCENARIO	Cover Material		Flyash		Fill/Debris		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated above ARAR limits		TOTAL	
	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
No Source Controls	860	1120	33400	43600	39100	51000	3400	4500	1200	1600	750	980	20	26	0	0	78,730	102,826
Source Controls	860	1120	33400	43600	39100	51000	3400	4500	0	0	0	0	20	26	0	0	76,780	100,246

[a] - All volumes listed are "in-place" volumes.

NA - Not Applicable

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assumption was used because the private land use scenario evaluates free release of the site and the federal government would not have control over the resident to prevent excavation and use of the subsurface soils in a manner that would result in unacceptable health risks. For the federal ownership scenario, the PRLs were only evaluated against the surface and near surface of the soils remaining in place after the uranium-contaminated material is removed.

The PRL for uranium-238, associated with the on-property resident farmer receptor, is 1.60 pCi/g for dermal/ingestion/fugitive dust emissions. The PRL established for groundwater protection is 1.12 pCi/g for all material types. Therefore, the groundwater protection PRL is controlling and will be used to determine remediation volumes for uranium-238. The amount of material contaminated with uranium-238 above the PRL is approximately 165,900 cu m (216,800 cu yd). This volume consists of approximately 84,100 cu m (109,900 cu yd) of fill/debris material, 37,800 cu m (49,400 cu yd) of impacted till, 43,500 cu m (56,800 cu yd) of remaining till, 490 cu m (640 cu yd) of Great Miami Aquifer material, and 18 cu m (23 cu yd) of sediment. This material will be considered contaminated material because it is impacted by uranium-238 above acceptable health-based criteria.

After remediation volumes were determined for material impacted by uranium-238, the remaining material was evaluated for other COCs to determine if they exceed their respective PRL. Based on this evaluation, it was determined that for the on-property farmer receptor no additional material would require remediation.

The PRLs associated with the federal ownership land use scenario assume that the government retains ownership of the FEMP and that active controls are utilized. This land use evaluates the expanded trespasser for the dermal/ingestion/fugitive dust emissions and the off-property farmer for both groundwater protection and the dermal/ingestion/fugitive dust emissions. In addition, federal ownership can consider the use of source controls at the subunit. If source controls are employed, the risk to the contaminants would be reduced.

If source controls are used, remediation volumes will be based on the controlling PRLs for either dermal/ingestion/fugitive dust emissions, for groundwater protection, or ARAR requirements. Initially, volumes requiring remediation due to unacceptable levels of uranium-238 are evaluated. This evaluation requires selection of the lowest PRL. The PRL for dermal/ingestion/fugitive dust is 57 pCi/g, whereas the PRL for groundwater protection is 6.1 pCi/g for source material located over

less than 5.5 m (18 ft) of remaining till and 57 pCi/g for source material located over 5.5 m (18 ft) thick till. Therefore, the PRL for uranium-238, based on groundwater protection is used for the source material located over less than 5.5 m (18 ft) of remaining till and the PRL of 57 pCi/g for uranium-238, based on dermal/ingestion/fugitive dust emissions, is used for material located above the 5.5 m (18 ft) thick till.

Remediation volumes for uranium-238 are determined to be 30,200 cu m (39,500 cu yd). Approximately 28,800 cu m (37,700 cu yd) of this material is located below the 5.5 m (18 ft) of remaining till. Additionally, 1,400 cu m (1,800 cu yd) of material above this till line requires remediation. The 28,800 cu m (37,700 cu yd) includes 24,600 cu m (32,200 cu yd) of fill/debris, 4,300 cu m (5,600 cu yd) of impacted till, and 18 cu m (23 cu yd) of sediment. The 1,400 cu m (1,800 cu yd) volume consists of 700 cu m (900 cu yd) of fill/debris and 700 cu m (900 cu yd) of impacted till. No remaining till or Great Miami Aquifer material will require remediation for uranium-238. This material will be considered contaminated because it is impacted with uranium-238 above acceptable levels.

Following remediation of material for uranium-238, the remaining material is evaluated for all other COCs to determine if their concentrations exceed PRLs. Appendix E provides the evaluation of COCs and their respective PRLs. A total of 7,500 cu m (9,800 cu yd) of fill material requires remediation based on other COCs being present above PRLs. No additional impacted till, remaining till, Great Miami Aquifer material, or sediment require remediation based on PRLs for other COCs.

If source controls are not used, the PRLs for groundwater protection are equivalent to those for the on-property resident farmer which are 1.12 pCi/g for all material types. The PRL for dermal/ ingestion/fugitive dust emissions is 57 pCi/g for uranium-238. Based on these PRLs, the remediation volume will be the same as that calculated for the on-property resident farmer.

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 RCRA characteristic waste is present in the South Field. This material is located in the firing range and considered a hazardous waste because of its toxicity due to lead. Table 3-4 provides a summary of the material which requires remediation for each of the material types considered under the appropriate land use scenario and use of source controls.

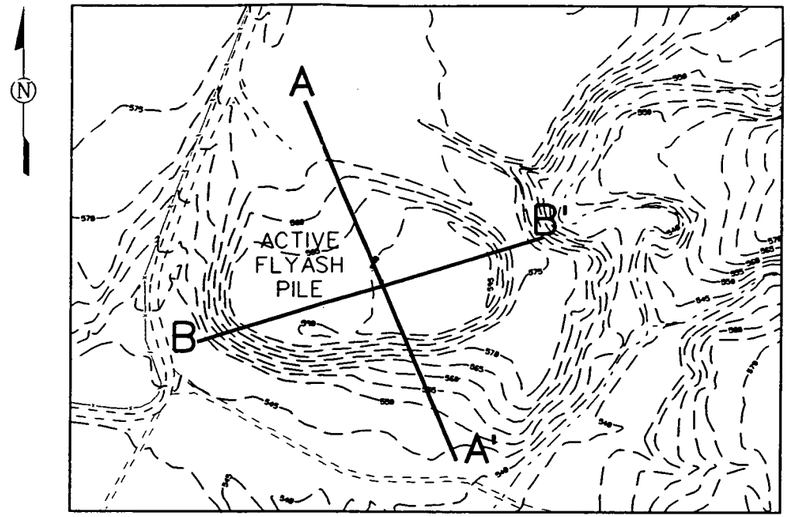
3.2.5 Active Flyash Pile

The total area of the Active Flyash Pile is approximately one ha (three ac). Based on three-dimensional block modeling, the Active Flyash Pile contains approximate 50,000 cu m (65,000 cu yd) of ash. The maximum fill depth observed was approximately 11.3 to 11.6 m (37 to 38 ft) in the southwest portion of the pile.

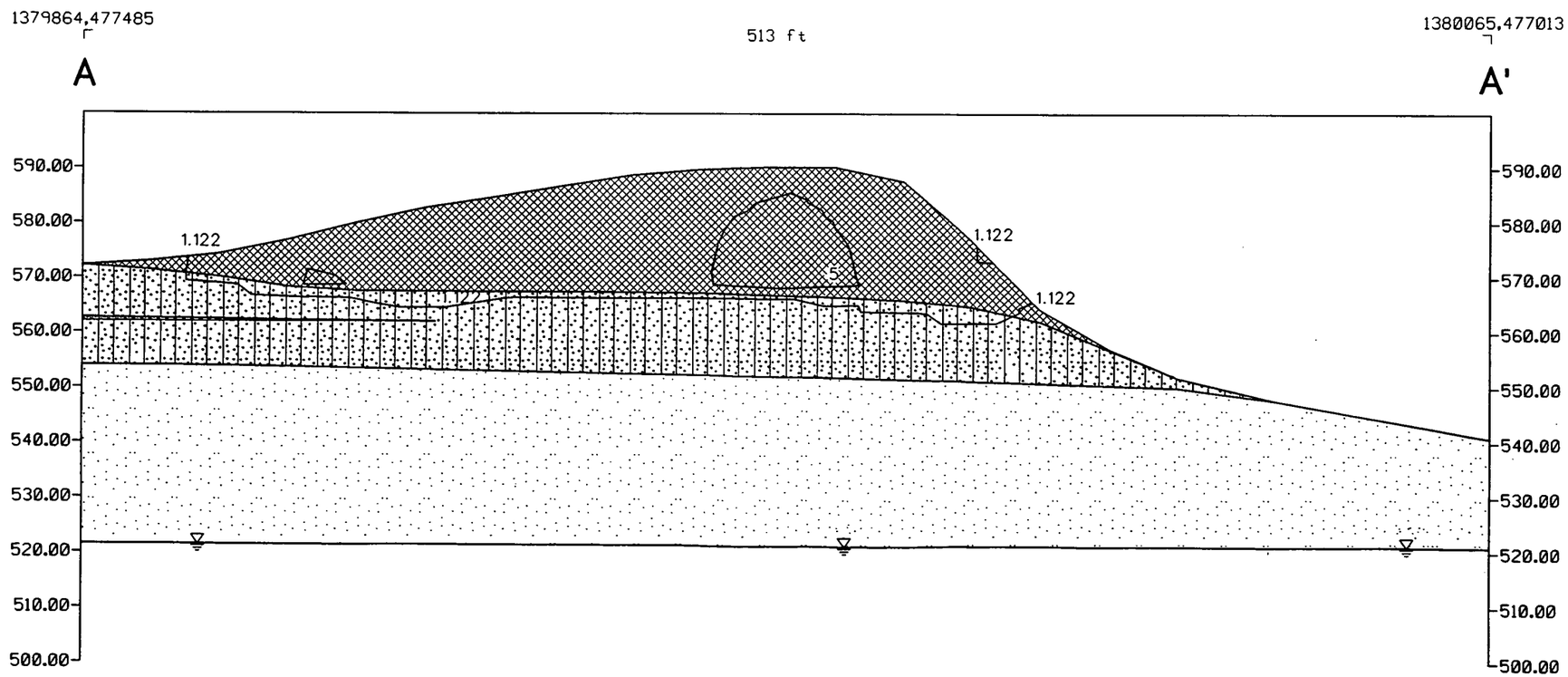
The volumes of material to be remediated at the Active Flyash Pile are determined by comparing the PRLs to the volumes determined through block modeling. Figures 3-11 and 3-12 provide cross sections through the Active Flyash Pile showing concentrations of uranium-238 at various depths. The block modeling uses the kriging results to calculate volumes associated with varying concentrations of uranium-238 for four material types at the Active Flyash Pile. These material types include flyash, impacted till, 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 till that contains excessive concentrations of uranium as compared to the remaining till; and 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 PRLs, based on ARAR specified levels, were exceeded.

The remediation volumes developed for the Active Flyash Pile will be based on a future land use of the FEMP with private ownership or with federal ownership. For both scenarios PRLs associated with dermal/ingestion/fugitive dust emissions and groundwater protection will be considered to determine remediation volumes. PRLs for protection of groundwater were developed based on determining the concentration of contaminants which can remain in the Active Flyash Pile and not impact the Great Miami Aquifer at concentrations which result in unacceptable threat to human health and the environment. Initially, the volume of material to be remediated is determined by the lowest PRL for uranium-238 between dermal/ingestion/fugitive dust emission and groundwater protection.

After volumes for uranium-238 are determined, additional COCs are only evaluated for the dermal/ingestion/fugitive dust emission PRL. For the private land use scenario, this evaluation was made throughout the complete depth of the Active Flyash Pile as opposed to only the surface. This assumption was used because the private land use scenario evaluated free release of the site and the



LOCATION KEY (1" = 200')



LEGEND

- 575 — 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 3-11
GEOLOGIC CROSS SECTION
ACTIVE FLYASH PILE
SHEET 1 OF 2

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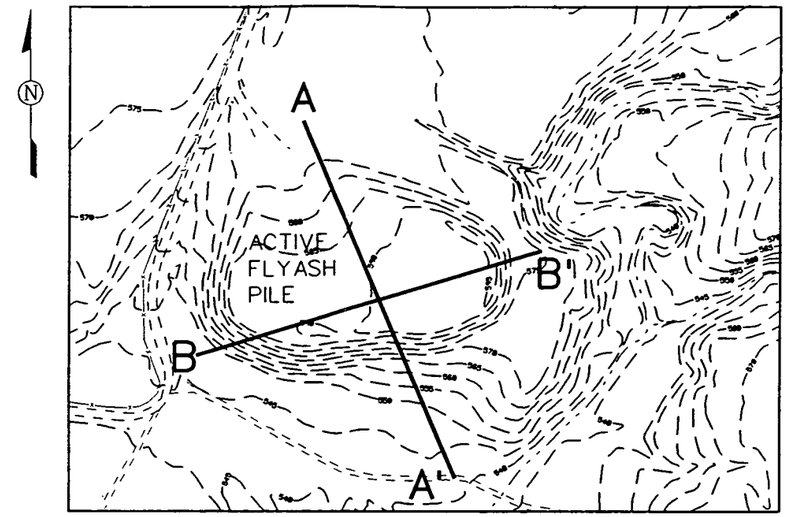
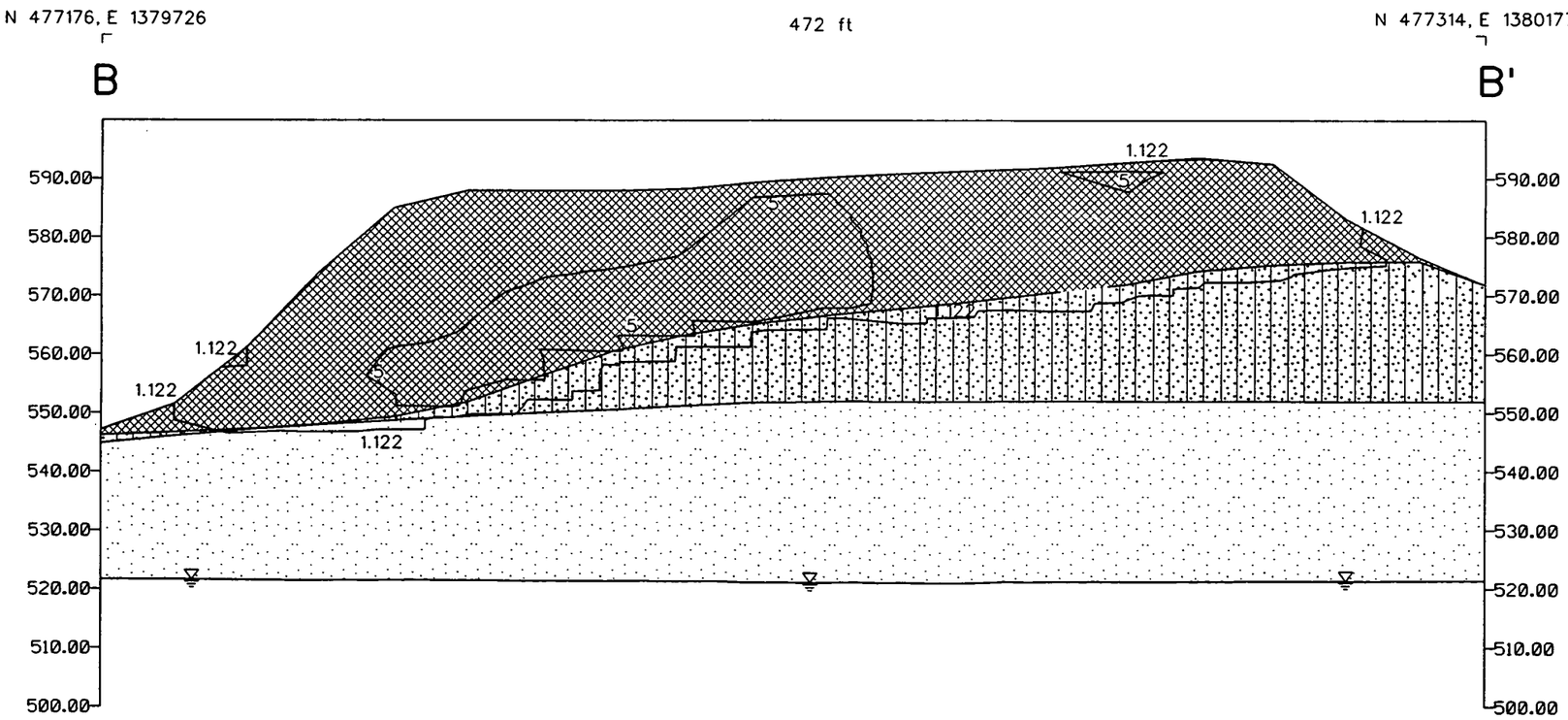


LOCATION KEY (1" = 200')



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 3-12
GEOLOGIC CROSS SECTION
ACTIVE FLYASH PILE
SHEET 2 OF 2

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TABLE 3-4

SOUTH FIELD

VOLUMES[a] OF MATERIAL TO BE REMEDIATED
FUTURE LAND USE SCENARIO

PRIVATE OWNERSHIP

REMEDIATION SCENARIO	Fill Debris		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated above ARAR limits		RCRA[b] Waste Volume		TOTAL	
	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
No Source Controls	84,100	109,900	37,800	49,400	43,500	56,800	490	640	18	23	0	0	230	300	166,138	217,063
Source Controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

FEDERAL OWNERSHIP

REMEDIATION SCENARIO	Fill Debris		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated above ARAR limits		RCRA[b] Waste Volume		TOTAL	
	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
No Source Controls	84100	109900	37800	49400	43500	56800	490	640	18	23	0	0	230	300	166,138	217,063
Source Controls	33000	43200	5340	7000	0	0	0	0	18	23	0	0	230	300	38,588	50,523

NA - Not Applicable
[a]All volumes listed are "in-place" volumes.
[b]This material orginates from the firing range and is contaminated with levels of lead that has failed the criteria for a RCRA characteristic waste in 40 CFR 261.

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federal government would not have control over the resident to prevent excavation and use of subsurface soils in a manner that would result in unacceptable health risks. For the federal ownership land use scenario, the dermal/ingestion/fugitive dust emission PRLs were only evaluated against the surface and near surface of the soils remaining after the uranium contaminated material is removed.

The PRL for uranium-238, associated with the on-property resident farmer receptor, is 1.60 pCi/g for dermal/ingestion/fugitive dust emissions. The PRLs established for groundwater protection vary based on where the material is located. Material located over less than 1.5 m (five ft) of till has a PRL for uranium-238 of 1.21 pCi/g. Material located over more than 1.5 m (five ft) of till has a PRL of 2.57 pCi/g. Therefore, the controlling PRLs for uranium-238 to be used for the on-property farmer receptor are as follows: 1.14 pCi/g will be used for material located over less than 1.5 m (five ft) of till; and 1.60 pCi/g will be used for all of the material located over more than 1.5 m (five ft) of till. Material exceeding these PRLs will require remediation.

Flyash has a typical background concentration of 10.0 pCi/g of uranium-238 which will be used as a threshold value to determine the quantity of flyash which has been cross-contaminated by uranium-238. The 10.0 pCi/g value was selected based on a study which evaluated uranium concentrations in flyash from Kentucky coal (ORNL, David Klein, 1975; VPL, Furr, Parkinson, et al.). The study indicated that total uranium ranges from 9.0 to 30.1 ppm which equates to 3.0 to 10.0 pCi/g of uranium 238, respectively (see Appendix E for the conversion calculations). Therefore, 10.0 pCi/g of uranium-238 will be considered the upper bound for concentrations associated with typical flyash. Typical concentrations of chemical contaminants within flyash exceed health-based criteria which will require the flyash to be remediated.

Based on the above PRLs, the amount of material contaminated with uranium-238 is approximately 4,900 cu m (6,400 cu yd). This volume consists solely of impacted till material. This material will be considered contaminated because it is impacted by uranium-238 above acceptable health-based criteria. In addition, 49,700 cu m (65,000 cu yd) of flyash will require remediation, but will not be considered cross-contaminated with uranium-238. No Great Miami Aquifer material would require remediation for uranium-238.

The material remaining after remediation for uranium-238 is then evaluated for other COCs to determine if their concentrations exceed PRLs. Appendix E presents this evaluation for each of the

COCs and their respective PRLs. A total of 2,800 cu m (3,700 cu yd) of the remaining till material would require remediation for the other COCs. In addition to these volumes, 140 cu m (180 cu yd) of sediment would require remediation. Based on this evaluation, no additional Great Miami Aquifer material would require remediation and no material has contaminate concentrations above PRLs based on ARAR limits. Thus, the total volume of materials requiring remediation under the private ownership land use scenario would be 57,600 cu m (75,300 cu yd).

The PRLs associated with the federal ownership land use scenario assume that the government retains ownership of the FEMP and that active controls are utilized. This land use evaluates the expanded trespasser for the dermal/ingestion/fugitive dust emissions and the off-property farmer for groundwater protection and the dermal/ingestion/fugitive dust emissions. In addition, federal ownership can consider either source controls or no source controls at the subunit. If source controls are used, the risk due to the contaminants would be reduced.

There are no remediation volumes associated with uranium-238 or other COCs if source controls are used. However, to allow implementation of those controls approximately 54,900 cu m (71,700 cu yd) of material would require relocation. This quantity was determined as shown in Appendix E and consists 4,900 cu m (6,400 cu yd) of impacted till, 49,700 cu m (65,000 cu yd) of flyash, and 140 cu m (180 cu yd) of sediment. The 4,900 cu m (6,400 cu yd) of impacted till would be relocated because it exceeds the uranium-238 groundwater protection PRL of 1.67 pCi/g for the off-property resident farmer.

If source controls are not used, remediation volumes will be based on the lowest of the PRLs for either dermal/ingestion/fugitive dust emissions, the PRLs for groundwater protection, or ARAR requirements. Initially, volumes requiring remediation due to unacceptable levels of uranium-238 are evaluated. This evaluation requires selection of the lowest PRL. The PRL for dermal/ingestion/fugitive dust emissions is 57.1 pCi/g. The PRL for groundwater protection is based on material type and location. The PRL is 1.14 pCi/g for material located over less than 0.60 m (2 ft) of till and is 1.15 pCi/g for material located above 0.6 m (2 ft) or more of till. Therefore, the PRL for uranium-238 is based on groundwater protection. The flyash will only be considered cross-contaminated if it contains uranium-238 in excess of 10.0 pCi/g.

Remediation volumes for uranium-238 are determined to be 54,900 cu m (71,700 cu yd). This volume consists of 4,900 cu m (6,400 cu yd) of impacted till. The volume also consists of 49,700 cu m (65,000 cu yd) of flyash that exceeds the PRLs but, based on the typical background concentration of uranium-238, is not cross-contaminated. No remaining till or Great Miami Aquifer material will require remediation for uranium-238.

Following remediation of material for uranium-238, the remaining material is evaluated for all other COCs to determine if their concentrations exceed PRLs. Appendix E provides the evaluation of COCs and their respective PRLs. No material was found to contain COCs at unacceptable health-based levels. However, 140 cu m (180 cu yd) of sediment was found to be contaminated with uranium-238 as well as other COCs and requires remediation. Based on this evaluation, additional material requires remediation. Table 3-5 provides a summary of the material which requires remediation for each of the material types considered under the appropriate land use scenario and use of source controls.

3.3 GENERAL RESPONSE ACTIONS

GRAs describe those actions that will satisfy the RAOs which are described in Section 2.0 of this FS report. The GRAs are listed by media of interest. For the Operable Unit 2 subunits, the media of interest are soil/sediment/waste and perched groundwater/construction water. The soil, sediment, and waste are similar in nature with regards to concentrations and types of contamination; therefore, they can be combined under one grouping of GRAs. Remediation of impacted perched groundwater or construction water will be considered in this FS for all of the Operable Unit 2 subunits.

The GRAs developed for the soil, sediment, and waste will be common for all of the Operable Unit 2 subunits. Similarly, the groundwater and construction water GRAs will also be common for all of the Operable Unit 2 subunits. A description of the GRAs developed for soil/sediment/waste and groundwater/construction water are provided 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 contaminants for any of the waste units and is considered in the FS to provide a baseline to which other remedial alternatives can be compared. The no-action alternative is retained throughout the FS process as required by the NCP (40 CFR § 300.430(e)(6)).

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TABLE 3-5

ACTIVE FLYASH

VOLUMES[a] OF MATERIAL TO BE REMEDIATED
FUTURE LAND USE SCENARIO

PRIVATE OWNERSHIP

REMEDIATION SCENARIO	Flyash		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated above ARAR limits		TOTAL	
	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
No Source Controls	49,700	65,000	4,900	6,400	2,800	3,700	0	0	140	180	0	0	57,540	75,280
Source Controls	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

FEDERAL OWNERSHIP

REMEDIATION SCENARIO	Flyash		Impacted Till		Remaining Till		GMA Material		Sediment		Material Contaminated above ARAR limits		TOTAL	
	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
No Source Controls	49,700	65,000	4,900	6,400	0	0	0	0	140	180	0	0	54,740	71,580
Source Controls	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] - All volumes listed are "in-place" volumes.

NA - Not Applicable

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- Institutional Actions: Institutional action applies various access restrictions and/or deed restrictions to reduce or eliminate exposure pathways related to direct human contact with contaminated material. Toxicity, mobility, or volume of the contaminants are not reduced through the singular application of institutional actions.

- Containment: Primarily includes physical measures to reduce contaminant migration. To reduce the migration of contaminants, the contaminated media must be isolated from the primary transport mechanisms such as wind, erosion, infiltration, and surface water through the use of surface barriers, revegetation, and regrading. The technology also reduces or eliminates exposure pathways related to direct human contact with the contaminated material. Only the contaminants' potential for migration is reduced through the use of containment.

- Removal: Includes the excavation and sorting of contaminated media. Removal must be implemented with treatment 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 is 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 the use of 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 is 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 the use of treatment.

- Disposal: Includes the removal of the waste material and placement in an on-site or off-site permanent engineered facility which will restrict contaminant migration and thus mitigate exposure routes. The toxicity, mobility, or volume of the contaminants is not reduced through the singular application of disposal. This technology will reduce or eliminate exposure pathways related to direct human contact with the contaminated material.

3.3.2 Groundwater/Construction Water GRAs

Currently, Operable Unit 5 is 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.

The GRAs listed below pertain to contaminated perched groundwater in the glacial overburden zone beneath the Operable Unit 2 subunits. The GRAs also pertain to construction water generated during the remedial action, including storm water and construction dewatering. Contaminated groundwater in the Great Miami Aquifer below the Operable Unit 2 subunits will be discussed in the Operable Unit 5 FS.

- No Action: Represents no remediation of the groundwater and is considered in the FS to provide a baseline to which other remedial alternatives can be compared. The no-action alternative is retained throughout the FS process as required by the NCP [40 CFR § 300.430(e)(6)].

- Institutional Actions: Represents minimal activity and includes groundwater monitoring and/or groundwater use restrictions and access controls to reduce or eliminate exposure pathways related to direct human contact with contaminated material. Toxicity, mobility, or volume of the contaminants is not reduced through the singular application of institutional actions.

- Containment/Control: Primarily includes in situ physical measures such as vertical barriers to restrict groundwater mobility and migration of contaminants. Toxicity, mobility, or volume of the contaminants is not reduced through the use of containment/control.

- Removal: Represents extraction wells, extraction trenches, or pumps placed in the areas of groundwater contamination or construction water accumulation to collect the contaminated water and pump it to the surface for treatment or discharge. Removal must be used in conjunction with other technologies.

- Treatment: Includes physical and chemical processes at the subunit or AWWT facility to reduce and/or remove contaminants from the groundwater/construction water, thereby reducing the toxicity, mobility, or volume of the contamination.

- Disposal: Represents the method for discharge/release of untreated or treated groundwater and construction water. Toxicity, mobility, or volume of the contaminants is not affected through the singular application of disposal.

3.4 INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

This section identifies the remedial technologies and process options associated with each of the GRAs developed in Section 3.3. The criteria for identifying potentially applicable technologies are provided in EPA RI/FS guidance (EPA 1988a) and in the NCP (EPA 1990b). There is strong statutory preference for remedies that will result in a permanent solution; that significantly decrease waste toxicity, mobility, or volume through treatment; and that provide long-term protection as identified in Section 121 of CERCLA, as amended. The final remedy must protect human health and the environment and comply with ARARs.

The remedial technologies and process options were initially selected for inclusion based on experience and results of previous applications for similar sites. The applicable process options are screened with respect to technical implementability considering the unique features and the COCs at each subunit.

The identification and initial screening of technologies and process options applicable to soil/sediment/waste are shown 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. Similarly, the identification and initial screening of technologies and process options applicable to the perched groundwater/construction water at the Solid Waste Landfill and the Lime Sludge Ponds are presented in Tables 3-11 and 3-12. The technologies for the groundwater/construction water at the Inactive Flyash Pile, South Field, and Active Flyash Pile will be grouped together because of their proximity and will be screened in Table 3-13.

Technical implementability on a subunit-specific basis was used as the initial screening criteria to eliminate technologies which were easily identifiable as not being applicable to site conditions and/or not being capable of remediating the primary COCs. Options identified as not applicable are indicated as shaded items on Tables 3-6 through 3-13. Those technologies which are considered not applicable for the remediation of the Operable Unit 2 subunits are not discussed further in this FS. The technologies and process options remaining which are applicable to the soil/sediment/waste are described in Section 3.5 and evaluated with respect to effectiveness, implementability, and cost in Section 3.7. Similarly, the technologies and process options remaining which are applicable to the groundwater/construction water are described in Section 3.6, and evaluated in Section 3.8.

3.5 DESCRIPTIONS OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL/SEDIMENT/WASTE

This section provides descriptions of the remedial technologies and process options which were retained from the initial screening performed in Section 3.4. All the technologies and process options that were not eliminated during the initial screening will be described, even though they may not be applicable to all of the subunits. The evaluations for effectiveness, implementability, and cost will be provided in Section 3.6 and will be subunit-specific.

3.5.1 No Action

Under no action, no removal or treatment of the contaminants would occur. The no action scenario is considered in the FS, as required by the NCP, to provide a baseline to which other remedial technologies and alternatives can be compared. No action is retained for all subunits.

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 Options	Descriptions	Screening Comments
No Action	None	Not Applicable	No remedial actions taken.	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
		Security Guards	Supplement physical barriers by monitoring for breaches and trespassers.	Potentially applicable
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable
Containment	Cap	Clay Cap	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and a 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. Clay cap would not meet the ARAR requirements based on the primary COCs.
		Composite Cap	Cover contaminated material with a cap designed with 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 concrete that can effectively control erosion and may decrease infiltration.	Not applicable. Cap is very susceptible to weathering and cracking, therefore, will not last for the long term. The composite cap provides more protectiveness.
		Asphalt-Based Cap	A single-layered cap composed of asphalt that can effectively control erosion and decrease infiltration.	Not applicable. Cap is very susceptible to weathering, therefore, will not last for the long term. In addition, a lower permeability and increased protectiveness are provided by the composite cap.

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Containment (Continued)	Surface Controls	Surface Water Controls	Topography modification around perimeter of Solid Waste Landfill to control erosion and manage surface water.	Potentially applicable
Removal	Excavation	Mechanical Excavation	Backhoes, dozers, and loaders used to excavate localized areas with elevated contaminant concentrations or entire areas. Material moved to treatment or disposal 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
	Surface Controls	Revegetation	Backfill excavated areas with clean fill and cover with vegetative supporting soil. Establish vegetation to minimize erosion.	Potentially applicable
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment.	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.	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	Mixing waste with cement or other fixation agents to stabilize the waste within a monolithic solid.	Not applicable based on waste characteristics (i.e., primarily heterogeneous waste with large objects). Solid waste and debris would prevent adequate mixing of cement and waste.
		Soil Flushing	In situ flushing of contaminants using injection/extraction well system around contaminated area.	Not applicable based upon the waste characteristics (i.e., primarily heterogeneous waste with large objects). Difficult to achieve uniform solvent/waste contact because of solid waste and debris.

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
In Situ Treatment (cont.)	In Situ Treatment (cont.)	Vapor 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.	Not applicable based upon the waste characteristics (i.e., primarily heterogeneous waste with large objects). Difficult to achieve uniform air flow through the debris. Vapor extraction is not applicable to semi-VOCs or metals treatment. Primary COCs are not volatile.
		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 (i.e., primarily heterogeneous waste with large objects). Primary COCs are not volatile.
	Thermal	Radio Frequency Heating	Soils are heated 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 (i.e., primarily heterogeneous waste with large objects). 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.	Not applicable based upon the waste characteristics (i.e., primarily heterogeneous waste with large objects). Debris in landfill would result in preferential pathways for electrical current.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions.	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.	Not applicable based on primary waste characteristics. Primary COCs are not readily biodegradable.
	Physical/ Chemical	Soil Washing	Desorption of contaminants through washing with an extraction solution. Contaminants must be readily removed by extraction solution.	Not applicable. Waste media in Solid Waste Landfill contains large amounts of non-enert debris that will be difficult to sort/segregate. Extraction solutions may react with non-enert wastes. Wastes may be less dense than water, reducing the effectiveness of clarifiers.

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Physical/ Chemical (cont.)	Stabilization/ Solidification	Mixing contaminated materials with cement or other fixation agents to stabilize the waste within a monolithic solid.	Not applicable. Waste media in Solid Waste Landfill contains large amounts of debris that will be difficult to sort/segregate.
		Thermoplastic Encapsulation	Mixing contaminated materials with asphalt, bitumen, paraffin, or polyethylene to seal the waste within a solid.	Not applicable. Waste media in Solid Waste Landfill contains large amounts of debris that will be difficult to sort/segregate.
		Dechlorination	Use of alkaline reagents such as potassium polyethylene glycolate (KPEG) to chemically strip chlorine from soils.	Not applicable. Primary COCs do not contain chlorine.
		Crushing/Shredding	Material handling of debris by mechanically crushing concrete debris or shredding waste material for compaction or 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. Waste is very heterogeneous. Insufficient volumes of specific wastes (e.g., concrete, steel, asbestos, etc.) to warrant development of a particular treatment process.
		Sandblasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris. This process generates excessive waste streams.	Not applicable. Waste is very heterogeneous. Insufficient volumes of specific wastes (e.g., concrete, steel, asbestos, etc.) to warrant development of a particular treatment process.
		High Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris. The process generates excessive waste streams.	Not applicable. Waste is very heterogeneous. Insufficient volumes of specific wastes (e.g., concrete, steel, asbestos, etc.) to warrant development of a particular treatment process.
		Crush and Wash Debris	This process includes crushing debris and washing the crushed material with solvents.	Not applicable. Waste is very heterogeneous. Insufficient volumes of specific wastes (e.g., concrete, steel, asbestos, etc.) to warrant development of a particular treatment process.

TABLE 3-6
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Thermal	Vitrification	Immobilization of inorganic contaminants and radionuclides 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. Waste media in solid waste landfill includes large amounts or debris that will be difficult to sort/segregate.
		Low Temperature Thermal Stripping	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.
		Vitrification of Debris	This process includes immobilization of contaminants in crushed debris by melting material to form a glass/crystalline product.	Not applicable. Waste is very heterogeneous. Insufficient volumes of specific wastes (e.g., concrete, steel, asbestos, etc.) to warrant development of a particular treatment process.
	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 degrees to 2,100 degrees 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 degrees 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 3-6
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	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 degrees 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.	Potentially applicable
	Waste Transportation	Truck Transport	Use trucks for transporting waste from the subunit to other areas of the FEMP, including on-site disposal, or for off-site disposal.	Potentially applicable.
		Rail Transport	Use rail transportation to transport waste off-site for disposal.	Potentially applicable.

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 Options	Descriptions	Screening Comments
No Action	None	Not Applicable	No remedial actions taken.	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.
		Security Guards	Supplement physical barriers by monitoring for breaches and trespassers.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable.
Containment	Cap	Clay Cap	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and a 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. A clay cap would not meet the ARAR requirements based on the primary COCs.
		Composite Cap	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 concrete that can effectively control erosion and may decrease infiltration.	Not applicable. Cap is very susceptible to weathering and cracking, therefore, will not last for the long term. The composite cap provides more protectiveness.
		Asphalt-Based Cap	A single-layered cap composed of asphalt that can effectively control erosion and decrease infiltration.	Not applicable. Cap is very susceptible to weathering, therefore, will not last for the long term. In addition, a lower permeability and increased protectiveness are provided by the composite cap.

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TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Containment (cont.)	Surface Controls	Surface Water Controls	Topography modification around perimeter of Lime Sludge Ponds to control erosion and manage surface water.	Potentially applicable.
Removal	Excavation	Mechanical Excavation	Backhoes, dozers, and loaders used to excavate localized areas with elevated contaminant concentrations or entire areas. Material moved to treatment or disposal areas.	Potentially applicable.
	Excavation	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.
	Surface Controls	Revegetation	Backfill excavated areas with clean fill and cover with vegetative supporting soil. Establish vegetation to minimize erosion.	Potentially applicable.
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment.	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.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
	Physical/ Chemical	Stabilization/ Solidification	Mixing lime sludge with cement or other fixation agents to stabilize the waste within a monolithic solid.	Not applicable. Not technically feasible to mix material type (lime sludge) in situ. In addition, ARARs do not warrant the use of in situ treatment for primary COCs.
		Soil Flushing	In situ flushing of contaminants using injection/extraction well system around contaminated area.	Not applicable because of low permeability of the clays surrounding lime sludge ponds. Difficult to install extraction system.
		Vapor 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 upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not volatile.

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
In Situ Treatment (cont.)	Physical/ Chemical (cont.)	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 (i.e., primarily inorganics). Primary COCs are not volatile.
	Thermal	Radio Frequency Heating	Soils are heated 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 (i.e., primarily inorganics). Primary COCs are not volatile.
		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 because of insufficient concentration of silica or other glass producing elements.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions.	Not applicable based on the waste characteristics (i.e. primarily inorganics).
		Anaerobic	Degradation of organics in a reactor using microorganisms under anaerobic conditions.	Not applicable based on the waste characteristics (i.e., primarily inorganics).
	Physical/ Chemical	Soil Washing	Desorption of contaminants through washing with an extraction solution. Contaminants must be readily removed by extraction solution.	Not applicable to primary COCs, ARARs do not warrant treatment. Level of uranium contamination is below levels which soil washing can practically achieve
		Stabilization/ Solidification	Mixing lime sludge with flyash and/or other fixation agents to stabilize the waste within a monolithic solid or to form low permeability material for placement into an engineered disposal facility.	Potentially applicable to lime sludge.
		Thermoplastic Encapsulation	Mixing waste with asphalt, bitumen, paraffin, or polyethylene to seal the waste within a solid.	Potentially applicable for primary COCs.
		Dechlorination	Use of alkaline reagents such as potassium polyethylene glycolate (KPEG) to chemically strip chlorine from soils.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs do not contain chlorine.
		Crushing/Shredding	Material handling of debris by mechanically crushing concrete debris or shredding waste material for compaction or preparation for treatment.	Potentially applicable when used in conjunction with other technologies.

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Physical/ Chemical (cont.)	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. Volumes of material do not warrant development of a treatment process.
		Sand Blasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris. This process generates excessive waste streams.	Not applicable. Volumes of material do not warrant development of a treatment process.
		High Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris. The process generates excessive waste streams.	Not applicable. Volumes of material do not warrant development of a treatment process.
		Crush and Wash Debris	This process includes crushing debris and washing the crushed material with solvents.	Not applicable. Volumes of material do not warrant development of a treatment process.
		Soil Conditioner	Lime sludge would be added to imporve soil quality for agricultural use.	Not implementable. Baseline risk analysis results indicate that lime sludge can not 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.
	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. Concentrations of primary COCs do not warrant use of this process. Characteristics of lime sludge would make process difficult to implement.

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Incineration (cont.)	Low Temperature Thermal Stripping	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). Primary COCs are not volatile.
		Vitrification of Debris	This process includes immobilization of contaminants in crushed debris by melting material to form a glass/crystalline product.	Not applicable. Volumes of material do not warrant development of a treatment process.
		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 degrees to 2,100 degrees 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 degrees 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 degrees 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.

TABLE 3-7
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
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.	Potentially applicable
	Waste Transportation	Truck Transport	Use trucks for transporting waste from the subunit to other areas of the FEMP, including on-site disposal, or for off-site disposal.	Potentially applicable.
		Rail Transport	Use rail transportation to transport waste off-site for disposal.	Potentially applicable.

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 Options	Descriptions	Screening Comments
No Action	None	Not Applicable	No remedial actions taken.	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
		Security Guards	Supplement physical barriers by monitoring for breaches and trespassers.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable
Containment	Cap	Clay Cap	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and a 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. Cap would not meet the ARAR requirements based on the primary COCs.
		Composite Cap	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 vegative cover soil layer.	Potentially applicable.
		Concrete-Based Cap	A single-layered cap composed of concrete that can effectively control erosion and may decrease infiltration.	Not applicable. Cap is very susceptible to weathering and cracking, therefore, will not last for the long term. The composite cap provides more protectiveness.
		Asphalt-Based Cap	A single-layered cap composed of asphalt that can effectively control erosion and decrease infiltration.	Not applicable. Cap is very susceptible to weathering, therefore, will not last for the long term. In addition, a lower permeability and increased protectiveness are provided by the composite cap.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Containment (cont.)	Surface Controls	Surface Water Controls	Topography modification around perimeter of Inactive Flyash Pile to control erosion and manage surface water.	Potentially applicable.
Removal	Excavation	Mechanical Excavation	Backhoes, dozers, and loaders used to excavate localized areas with elevated contaminant concentrations or entire areas. Material moved to treatment or disposal 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
	Surface Controls	Revegetation	Backfill excavated areas with clean fill and cover with vegetative supporting soil. Establish vegetation to minimize erosion.	Potentially applicable
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment.	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.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
	Physical/ Chemical	Stabilization/ Solidification	Mixing waste with cement or other fixation agents to stabilize the waste within a monolithic solid.	Not applicable. The existing waste unit borders the Paddys Run 100-year floodplain. Significant portions of the treated waste would remain in the floodplain.
		Soil Flushing	In situ flushing of contaminants using injection/extraction well system around contaminated area.	Not applicable because flushing reagent might not be recovered and Great Miami Aquifer is a sole-source aquifer.
		Vapor 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 upon the waste characteristics (i.e., primarily inorganics, radionuclides, and PCBs). Primary COCs are not volatile.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
In Situ Treatment (cont.)	Physical Chemical (cont.)	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 (i.e., primarily inorganics and radionuclides). Primary COCs are not volatile.
	Thermal	Radio Frequency Heating	Soils are heated 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 (i.e., primarily inorganics, radionuclides, and PCBs). 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.	Not applicable. The existing waste unit borders the Paddys Run 100-year floodplain. Significant portions of the treated waste would remain in the floodplain.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics and radionuclides).
		Anaerobic	Degradation of organics in a reactor using microorganisms under anaerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics and radionuclides).
	Physical/ Chemical	Soil Washing	Desorption of contaminants through washing with an extraction solution. Contaminants must be readily removed by extraction solution.	Potentially applicable.
		Physical Separation	Separation of radionuclides based on particle size.	Not applicable because the particle size distribution does not indicate that one fraction is more contaminated than another.
		Stabilization/ Solidification	Mix low-level waste or flyash with lime sludge, cement, and/or other fixation agents to stabilize the waste within a monolithic solid or to form low permeability material for placement into an engineered disposal facility.	Potentially applicable.
		Thermoplastic Encapsulation	Mixing waste with asphalt, bitumen, paraffin, or polyethylene to seal the waste within a solid.	Potentially applicable.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Physical/ Chemical (cont.)	Dechlorination	Use of alkaline reagents such as potassium polyethylene glycolate (KPEG) to chemically strip chlorine from soils.	Not applicable based upon the waste characteristics, i.e., primarily inorganics. Primary COCs do not contain chlorine.
		Crushing/Shredding	Material handling of debris by mechanically crushing concrete debris or shredding waste material for compaction or 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. Waste is heterogenous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
		Sand Blasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris. This process generates excessive waste streams.	Not applicable. Waste is heterogenous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
		High Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris. The process generates excessive waste streams.	Not applicable. Waste is heterogenous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
		Crush and Wash Debris	This process includes crushing debris and washing the crushed material with solvents.	Not applicable. Waste is heterogenous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
	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.	Potentially applicable.

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TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Thermal (cont.)	Low Temperature Thermal Stripping	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.
		Vitrification of Debris	This process includes immobilization of contaminants in crushed debris by melting material to form a glass/crystalline product.	Not applicable. Waste is heterogenous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
	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 degrees to 2,100 degrees 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 degrees 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 degrees 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.

TABLE 3-8
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
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.	Potentially applicable.
		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.
	Waste Transportation	Truck Transport	Use trucks for transporting waste from the subunit to other areas of the FEMP, including on-site disposal or for off-site disposal.	Potentially applicable.
		Rail Transport	Use rail transportation to transport waste off site for disposal.	Potentially applicable.

TABLE 3-9

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR THE SOUTH FIELD SOIL/SEDIMENT/WASTE MEDIA

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
No Action	None	Not Applicable	No remedial actions taken.	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
		Security Guards	Supplement physical barriers by monitoring for breaches and trespassers.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable
Containment	Cap	Clay Cap	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and a 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. Cap would not meet the ARAR requirements based on primary COCs.
		Composite Cap	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 concrete that can effectively control erosion and may decrease infiltration.	Not applicable. Cap is very susceptible to weathering and cracking, therefore, will not last for the long term. The composite cap provides more protectiveness.
		Asphalt-Based Cap	A single-layered cap composed of asphalt that can effectively control erosion and decrease infiltration.	Not applicable. Cap is very susceptible to weathering, therefore, will not last for the long term. In addition, a lower permeability and increased protectiveness are provided by the composite cap.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Containment (cont.)	Surface Controls	Surface Water Controls	Topography modification around perimeter of South Field to control erosion and manage surface water.	Potentially Applicable
Removal	Excavation	Mechanical Excavation	Backhoes, dozers, and loaders used to excavate localized areas with elevated contaminated concentrations or entire areas. Material moved to treatment or disposal areas. Also, minimize waste areas into smaller areas to construct smaller cap.	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
	Surface Controls	Revegetation	Backfill excavated areas with clean fill and cover with vegetative supporting soil. Establish vegetation to minimize erosion.	Potentially applicable
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment.	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.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
	Physical/ Chemical	Stabilization/ Solidification	Mixing waste with cement or other fixation agents to stabilize the waste within a monolithic solid.	Not applicable because presence of construction debris in South Field which would prevent adequate mixing.
		Soil Flushing	In situ flushing of contaminants using injection/extraction well system around contaminated area.	Not applicable because flushing reagent might not be recovered and Great Miami Aquifer is a sole-source aquifer.
		Vapor 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 upon the waste characteristics (i.e., primarily inorganics, radionuclides, and PCBs). Primary COCs are not volatile

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
In Situ Treatment (cont.)	Physical/ Chemical (cont.)	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 (i.e., primarily inorganics and radionuclides). Primary COCs are not volatile.
	Thermal	Radio Frequency Heating	Soils are heated 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 (i.e., primarily inorganics, radionuclides, and PCBs). 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.	Not applicable based upon waste characteristics (i.e., contains construction debris and other large objects). Debris would result in preferential pathways for electrical current.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics and radionuclides).
		Anaerobic	Degradation of organics in a reactor using microorganisms under anaerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics and radionuclides).
	Physical/ Chemical	Soil Washing	Desorption of contaminants through washing with an extraction solution. Contaminants must be readily removed by extraction solution.	Potentially applicable.
		Physical Separation	Separation of radionuclides based on particle size.	Not applicable because the partaicle size distribution does not indicate that one fraction is contaminated more than another.
		Stabilization/ Solidification	Mixing waste with cement or other fixation agents to stabilize the waste within a monolithic solid.	Potentially applicable.
		Thermoplastic Encapsulation	Mixing waste with asphalt, bitumen, paraffin, or polyethylene to seal the waste within a solid.	Potentially applicable.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Physical/ Chemical (cont.)	Dechlorination	Use of alkaline reagents such as potassium polyethylene glycolate (KPEG) to chemically strip chlorine from soils.	Not applicable based upon waste characteristics, i.e., primarily inorganics. Primary COCs do not contain chlorine.
		Crushing/Shredding	Material handling of debris by mechanically crushing concrete debris or shredding waste material for compaction or 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. Waste is heterogeneous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
		Sand Blasting of Debris	This process includes removal of contaminants by abrasive thrust at high pressures against the surface of metal and concrete debris. This process generates excessive waste streams.	Not applicable. Waste is heterogeneous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
		High Pressure Water Washing of Debris	This process exerts water at high pressures against the surface of metal and concrete debris. The process generates excessive waste streams.	Not applicable. Waste is heterogeneous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
		Crush and Wash Debris	This process includes crushing and debris and washing the crushed material with solvents.	Not applicable. Waste is heterogeneous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
	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.	Potentially applicable.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	Thermal (Cont.)	Low Temperature Thermal Stripping	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.
		Vitrification of Debris	This process includes immobilization of contaminants in crushed debris by melting material to form a glass/crystalline product.	Not applicable. Waste is heterogeneous and quantities of special materials are unknown. Limited quantities of data regarding contaminants makes implementation of technology difficult.
	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 degrees to 2,100 degrees 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 degrees 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 degrees 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.

TABLE 3-9
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
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 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.	Potentially applicable
		Hazardous Waste Disposal Facility	Waste transported to an off-site RCRA permitted disposal facility	Potentially applicable
	Waste Transportation	Truck Transport	Use trucks for transporting waste from the subunit to other areas of the FEMP, including on-site disposal or for off-site disposal.	Potentially applicable.
		Rail Transport	Use rail transportation to transport waste off site for disposal.	Potentially applicable.

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 Options	Descriptions	Screening Comments
No Action	None	Not Applicable	No remedial actions taken.	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
		Security Guards	Supplement physical barriers by monitoring for breaches and trespassers.	Potentially applicable.
		Deed Restrictions	Restrictions on deeds for property within contaminated areas to restrict future use of property.	Potentially applicable
In Situ Containment	Cap	Clay Cap	24-inch thick compacted clay layer covered with 12-inch thick granular drainage layer and a 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.	Potentially applicable
		Composite Cap	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.	Not applicable. There is no material above ARAR requirements (40 CFR 192 and DOE Order 5400.5); therefore, the ARAR driven composite cap is not warranted. A clay cap provides the necessary level of protectiveness.
		Concrete-Based Cap	A single-layered cap composed of concrete that can effectively control erosion and may decrease infiltration.	Not applicable. Cap is very susceptible to weathering and cracking, therefore, will not last for the long term. The clay cap provides more protectiveness.
		Asphalt-Based Cap	A single-layered cap composed of asphalt that can effectively control erosion and decrease infiltration.	Not applicable. Cap is very susceptible to weathering, therefore, will not last for the long term. In addition, a lower permeability and increased protectiveness are provided by the clay cap.

TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Containment (cont.)	Surface Controls	Surface Water Controls	Topography modification around perimeter of Active Flyash Pile to control erosion and manage surface water.	Potentially applicable
Removal	Excavation	Mechanical Excavation	Backhoes, dozers, and loaders used to excavate localized areas with elevated contaminant concentrations or entire areas. Material moved to treatment or disposal 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
	Surface Controls	Revegetation	Backfill excavated areas with clean fill and cover with vegetative supporting soil. Establish vegetation to minimize erosion.	Potentially applicable
In Situ Treatment	Biological	Aerobic	In situ degradation of organics using microorganisms in an aerobic environment.	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.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
	Physical/ Chemical	Stabilization/ Solidification	Mixing flyash with cement or other fixation agents to stabilize the waste within a monolithic solid.	Not applicable. The existing waste unit borders the Paddys Run 100-year floodplain. Significant portions of the treated would remain in the floodplain.
		Soil Flushing	In situ flushing of contaminants using injection/extraction well system around contaminated area.	Not applicable because flushing reagent might not be recovered and Great Miami Aquifer is a sole-source aquifer.
		Vapor 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 upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not volatile.

TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
In Situ Treatment (cont.)	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 upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not volatile.
		Radio Frequency Heating	Soils are heated 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 (i.e., primarily inorganics). Primary COCs are not volatile.
		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.
Ex Situ Treatment	Biological	Aerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics).
		Anaerobic	Degradation of organics in a reactor using microorganisms under aerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics).
	Physical/ Chemical	Soil Washing	Desorption of contaminants through washing with an extraction solution. Contaminants must be easily soluble in flushing agent.	Not applicable for flyash. Radionuclides are at concentrations which are typical of flyash. Other media is not contaminated at concentrations which treatment will be effective.
		Physical Separation	Separation of radionuclides based on particle size.	Not applicable because the particle size distribution does not indicate one fraction is more contaminated than another.
		Stabilization/ Solidification	Mix flyash with lime sludge, cement or other fixation agents to form low permeability material for placement into an engineered disposal facility.	Potentially applicable for flyash. Other media is not contaminated at concentrations which require treatment.
		Thermoplastic Encapsulation	Mixing waste with asphalt, bitumen, paraffin, or polyethylene to seal the waste within a solid.	Not applicable because radionuclides are at concentrations which are typical of flyash. Other media is not contaminated at concentrations which require treatment.

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TABLE 3-10
(Continued)

General Response Action	Remedial Technology	Process Options	Descriptions	Screening Comments
Ex-Situ Treatment (cont.)	Physical/ Chemical (cont.)	Dechlorination	Use of alkaline reagents such as potassium polyethylene glycolate (KPEG) to chemically strip chlorine from soils.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs do not contain chlorine.
		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 typical of flyash. Vitrification is not a treatment technology which is typically considered for flyash. Vitrification is typically considered for low-level radioactive waste or highly toxic material.
		Low Temperature Thermal Stripping	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). 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 degrees to 2,100 degrees 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 degrees 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 Options	Descriptions	Screening Comments
Ex Situ Treatment (cont.)	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 degrees 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 an off-site facility meeting OAC 3745-27 and OEPA Policy 4.07 requirements.	Potentially applicable.
		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.
	Waste Transportation	Truck Transport	Use trucks for transporting waste from the subunit to other areas of the FEMP, including on-site disposal or for off-site disposal.	Potentially applicable.
		Rail Transport	Use rail transportation to transport waste off site for disposal.	Potentially applicable.

C00430

TABLE 3-11

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER/CONSTRUCTION WATER SOLID WASTE LANDFILL

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions taken to remediate groundwater. Required by the NCP as a baseline.	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.	Potentially applicable
	Monitoring	Groundwater Monitoring Wells	Installation of monitoring wells and periodic sampling and analysis of groundwater to detect contaminant migration.	Potentially applicable
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.
		French Drain/ Interception Trenches	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.

TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Removal (cont.)	Extraction (cont.)	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 at the subunit 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.
		Carbon Adsorption	Water flows over activated carbon for adsorption of organic contaminants onto the activated carbon media.	Not applicable. Organics were not found in perched groundwater.
		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.

TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont.)	Chemical Treatment (cont.)	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 upon 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.

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TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont.)	Chemical Treatment (cont.)	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 upon 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 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	Anaerobic Contact	Biodegradation of organics in an engineered reactor under anaerobic conditions.	Not applicable due to waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.

TABLE 3-11
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont.)	Biological (cont.)	Aerobic Treatment	Biodegradation of organics in an engineered reactor under aerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Aerobic)	Biodegradation of contaminants in an environment containing oxygen.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Anaerobic)	Biodegradation of contaminants in an oxygen deficient environment.	Not applicable based upon 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 upon 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.	Potentially applicable
		Injection	Injection of treated or untreated groundwater into the aquifer.	Not applicable because Great Miami Aquifer is a sole-source aquifer.

TABLE 3-12

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER/CONSTRUCTION WATER LIME SLUDGE PONDS

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions taken to remediate groundwater. Required by the NCP as a baseline.	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.	Potentially applicable
	Monitoring	Groundwater Monitoring Wells	Installation of monitoring wells and periodic sampling and analysis of groundwater to detect contaminant migration.	Potentially applicable
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.
		French Drain/ Interception Trenches	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 Options	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 at the subunit 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.
		Carbon Adsorption	Water flows over activated carbon for adsorption of organic contaminants onto the activated carbon media.	Not applicable. Organics were not found in the perched groundwater.
		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 Options	Description	Screening Comments
Treatment (Cont.)	Chemical Treatment (cont.)	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 upon 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 Options	Description	Screening Comments
Treatment (Cont.)	Chemical Treatment (cont.)	Biosorption	A sorption process for removing toxic metal ions from water is based upon 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	Anaerobic Contact	Biodegradation of organics in an engineered reactor under anaerobic conditions.	Not applicable due to waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
		Aerobic Treatment	Biodegradation of organics in an engineered reactor under aerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Aerobic)	Biodegradation of contaminants in an environment containing oxygen.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Anaerobic)	Biodegradation of contaminants in an oxygen deficient environment.	Not applicable based upon 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 upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.

TABLE 3-12
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (Cont.)	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
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.	Potentially applicable
		Injection	Injection of treated or untreated groundwater into the aquifer.	Not applicable because Great Miami Aquifer is a sole-source aquifer.

TABLE 3-13

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER/CONSTRUCTION WATER INACTIVE FLYASH PILE, SOUTH FIELD, AND ACTIVE FLYASH PILE

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	Not Applicable	No remedial actions taken to remediate groundwater. Required by the NCP as a baseline.	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.	Potentially applicable
	Monitoring	Groundwater Monitoring Wells	Installation of monitoring wells and periodic sampling and analysis of groundwater to detect contaminant migration.	Potentially applicable
Containment/ Control	Subsurface Barriers/ Controls	Slurry Wall	Use of soil/bentonite low permeability material to restrict horizontal migration of groundwater.	Potentially applicable
		Grout Curtain	Use of cements to restrict horizontal migration of groundwater.	Potentially applicable
		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 and would be difficult to impose a continuous artificial hydraulic gradient because the radius of influence would be minimal.
Removal	Extraction	Extraction Wells	Use of wells to extract groundwater.	Not applicable. Perched groundwater zone is a relatively thin layer and would be difficult to impose a continuous artificial hydraulic gradient because the radius of influence would be minimal.
		French Drain/ Interception Trenches	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 and 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 Options	Description	Screening Comments
Removal (cont.)	Extraction (cont.)	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.
		Carbon Adsorption	Water flows over activated carbon for adsorption of organic contaminants onto the activated carbon media.	Not applicable. The concentration of organic contaminants do not warrant pretreatment.
		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.

TABLE 3-13
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont.)	Chemical Treatment (cont.)	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 upon 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.

TABLE 3-13
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont.)	Chemical Treatment (cont.)	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 upon 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 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	Anaerobic Contact	Biodegradation of organics in an engineered reactor under anaerobic conditions.	Not applicable due to waste characteristics (i.e., primarily inorganics). Primary COCs are not biodegradable.
		Aerobic Treatment	Biodegradation of organics in an engineered reactor under aerobic conditions.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.

TABLE 3-13
(Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Treatment (cont.)	Biological (cont.)	Biological (Aerobic)	Biodegradation of contaminants in an environment containing oxygen.	Not applicable based upon the waste characteristics (i.e., primarily inorganics). Primary COCs are not readily biodegradable.
		Biological (Anaerobic)	Biodegradation of contaminants in an oxygen deficient environment.	Not applicable based upon 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 upon 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.	Potentially applicable
		Injection	Injection of treated or untreated groundwater into the aquifer.	Not applicable because Miami Aquifer is a sole-source aquifer.

3.5.2 Institutional Actions

Institutional actions are used to regulate intentional or unintentional access to a site or contaminated media. There are active and passive actions. Active actions include physical barriers and security guards preventing 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 reduce human contact with the contaminants by preventing individuals from entering the site. Physical barriers would include a site perimeter fence with gates. Additional fences could be placed around the individual waste sites. These barriers would discourage trespassing and require individuals to enter through security gates and controlled entrances. Physical barriers are retained for all subunits.

Security Guards

Security guards would supplement physical barriers by monitoring for breaches in the barriers and for trespassers that may have entered the controlled areas. Security guards are retained for all subunits.

Deed Restrictions

Deed restrictions are a form of legal administrative control that would prohibit specified land usage activities. Limited land usage might include prohibiting well drilling, earth excavation operations, and erection of buildings. Deed restrictions are retained for all subunits.

3.5.3 Containment

Containment consists of technologies that confine contaminated media to their current locations. Containment is used to minimize infiltration, to reduce transport of exposed waste materials, and to minimize the potential for direct contact with contaminants. Containment typically involves the installation of a low permeability compacted soil and geomembrane liner over the wastes or contaminated soils and includes an overlying layer of topsoil and vegetation to protect the low permeability barrier. Often, regrading of surface soils and relocation of the contaminated materials within the area to be capped is required. The regrading and relocation of material is done to maintain the flat side slopes on the cap in order to provide internal stability of the cap components and surface water control. The containment technologies reduce contaminant migration, but they do not reduce contaminant toxicity or volume. Containment is effective at reducing risks of exposure to the contaminated material (EPA 1989).

Composite Cap

A composite cap involves the installation of a low permeability multi-layered cover over an area that contains contaminated material. The composite cap is used for contaminated material containing radionuclides as COCs. The composite cap will be defined by a series of requirements which are specified in 40 CFR 192 and DOE Order 5400.5. As a minimum, the design requirements are as follows:

1. Provide, to the extent reasonably achievable, an effective life of 1,000 years with a design life of at least 200 years.

2. Limit radon-222 emanation to the atmosphere from the wastes to less than an average release rate of 20 $pCi/m^2/s$, and prevent increases in the annual average radon-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L.

3. Before any potentially biodegradable contaminated wastes are placed in a long-term management facility, condition such wastes so that the generation and escape of biogenic gases will not cause the requirement in paragraph 2 to be exceeded and that biodegradation within the facility will not result in premature structural failure.

4. Protect groundwater in accordance with legally applicable federal and state standards.

5. Use appropriate administrative and physical measures to control access to property and prevent contact with on-site material contaminated by residual radioactive material. These controls should be designed to be effective to the extent reasonable for at least 200 years.

While the requirements listed above do not specify particular layers in a composite cap, such a cap in the eastern United States would probably require the following layers from top to bottom:

- Vegetative soil cover layer consisting of top soil and common soil graded to a minimum slope of four percent.

- Filter layer consisting of sand and enveloped in a geotextile.

- Biotic barrier consisting of cobbles and underlain by a geotextile.

- Drainage layer consisting of pea gravel.

- Infiltration and radon barrier consisting of both a bentonite geocomposite and a low permeability compacted clay soil barrier.

Typical composite cap details are included in Appendix E. A composite cap is being retained for the Solid Waste Landfill, Lime Sludge Ponds, Inactive Flyash Pile, and South Field subunits.

Clay Cap

A clay cap involves the installation of a low permeability compacted clay layer over the waste to reduce potential contact with the waste and reduce vertical infiltration of water into the waste, thereby reducing the vertical migration of contaminants. A clay cap typically consists of the following components, from top to bottom (EPA/530-SW-89-047, OAC 3745-27-11):

1. A 61 cm (24 in.) thick vegetative soil cover as a top layer with a minimum slope of five percent. This layer must provide sufficient thickness such that the top of the compacted clay layer lies below the local frost penetration depth of 38 cm (15 in.) (USDA, Water Atlas).

2. A 30 cm (12 in.) thick middle drainage layer with a hydraulic conductivity not less than 1×10^{-2} cm/sec. Synthetic fabric filter is placed between the vegetative soil cover and the drainage layer to prevent clogging of the drainage material.

3. A low permeability layer consisting of a minimum of 61 cm (24 in.) of compacted clay with a hydraulic conductivity of not more than 1×10^{-7} cm/sec.

A clay cap would also comply with OEPA Policy 4.07 and would have a minimum life of 30 years with proper maintenance. Typical details of the clay cap are provided in Appendix E. A clay cap is being retained for the Active Flyash Pile subunit.

Surface Water Controls

Regrading the land surface to divert surface runoff around the waste areas can minimize surface water infiltration, runoff, and erosion. Surface water controls will reduce migration of the contaminants. Perimeter ditches may need to be relocated to prevent scouring or erosion of a cap. Sediment basins are effective in collecting surface water runoff and controlling the suspended solids entrained in surface flows. Surface water controls are retained for all subunits.

3.5.4 Removal

Contaminated material is removed before ex situ treatment and/or disposal, and it is also used in conjunction with capping and regrading. The appropriate waste removal technology will depend 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

The waste removal technology will be one of various mechanical excavation process options that could include backhoes, bulldozers, scrapers, loaders, and trucks. Dust control would be accomplished by application of water or dust suppressants. This process option will focus on the most efficient means of handling and moving the soil/sediment/waste media. Mechanical excavation is being retained for all subunits.

Backhoes would be utilized to excavate radiological hot spots that are located in small areas. The locations of the hot spots have been specified in the Operable Unit 2 RI report. Safe slopes on excavation side walls will have to be maintained for safety of the construction personnel. Water that collects in the bottom of the excavations (construction water) will be pumped to the AWWT facility. Backhoes may also be used to separate out construction debris. Backhoes can load material directly into trucks or place the material into stockpiles for later handling by loaders.

Bulldozers would be utilized for moving materials relatively short distances. Bulldozers would be used to sort out construction debris, facilitate material stockpiling, and grade wastes prior to capping. Scrapers would be utilized for moving materials distances over 500 ft. Scrapers could be used to minimize the area that would need to be capped by moving the waste media into a smaller area, enabling a smaller cap to be constructed. Loaders and trucks would be used for moving large quantities of materials, especially if public streets would be used. Loaders and trucks could be used in conjunction with either on-site or off-site disposal facilities. Using trucks for off-site disposal would require compliance with United States Department of Transportation (DOT) regulations.

Sorting/Separation

Sorting/separation will be used to separate excavated materials into one of the three following groups: radiologically contaminated material, contaminated material, or clean soil.

Excavated materials will be sorted visually using mechanical excavating equipment to separate large debris or pockets of radiologically contaminated materials. Materials may also be sorted in the field using gamma detectors or photoionization detectors to detect low-level radioactive waste or volatile organics, respectively. Mechanical screening techniques might also be employed to separate soils from waste media.

Sorting/separation will minimize the total amount of material to be contained, treated, or disposed and will be retained for all subunits.

Revegetation

Revegetation is a cost-effective method to stabilize the surface, especially after excavation and backfilling. Revegetation decreases erosion by wind and water and contributes to the development of a naturally fertile and stable surface environment. Revegetation is used with removal options that do not contain the waste under a cap. Revegetation is being retained for all subunits.

3.5.5 Ex Situ Treatment

Prior to ex situ treatment, the waste will be mechanically excavated using backhoes, bulldozers, and/or loaders. Visually sorting out large debris, sorting radiologically, and using mechanical screening techniques in order to minimize the total amount of material to be treated or disposed may also be performed.

Soil Washing

The soil washing process utilizes physical separation and chemical extraction for the removal of contaminants from soil. This process can be used on excavated soils that are fed into a washing unit. A review of soil washing technology and their applicability to Superfund sites (EPA 1989e) reported that soil washing with extractant reagents is applicable for cleaning nonvolatile hydrophilic and hydrophobic organics, and heavy metals from soils. The report concluded that although extraction of organics and toxic metal contaminants from excavated sandy/silty soil low in clay and humus content has been successfully demonstrated at several facilities, extraction from clay and humus soil fractions is more complicated. A study conducted by Lockheed Environmental Systems and Technologies Company (1993) for a uranium contaminated site found that for sandy soils reductions in uranium concentrations from 1079 pCi/g to 27.2 pCi/g could be obtained by soil washing. Efficiency of extraction is also dependent on the host soil's chemical and physical properties as well as its mineralogical and physical properties and the contaminants involved.

Soil washing has been successfully used on soils contaminated with radionuclides. Richardson et al. (1989) conducted soil washing studies on the removal of radium-226 and thorium-230 from two soils. The results of their wet-sieving and water washing studies indicated that the combination of the two processes can significantly reduce the radionuclide levels in soil.

Removal of uranium is the primary goal of the soil washing system proposed at FEMP. It is currently under development using both bench- and pilot-scale testing. Approximately 25 different extractants were tested in the preliminary stages. Out of the 25, four extraction solutions showed the greatest promise of success. These four (sodium carbonate, sulfuric acid, citric acid, and citrate-bicarbonate-dithionite) were more extensively evaluated. Findings show sulfuric acid to be the most effective extractant for removing uranium, but the process has serious secondary problems (voluminous sludge generation). The sodium carbonate is not as effective in the removal of uranium, but the process does not pose secondary problems. Because secondary environmental problems are not created, sodium carbonate is the extractant of choice, provided the degree of uranium removal meets the site remediation objectives.

A preliminary conceptual design of a full-scale sodium carbonate system has been prepared based upon the bench- and pilot-scale test results. The soil washing is performed by passing excavated soil through units which separate the material by particle size. First, the soil is conveyed to a dry grizzly where the material is separated for into plus and minus 152 cm (6 in.) particle size. Particles which are greater than 152 cm (6 in.) are delivered via conveyor belt to a coarse solids washer. In this unit, groundwater from the site is used to provide a high pressure wash which will remove fine soil particles from the larger material. The washed coarse material is returned to the site as clean material. The fine particles washed from the larger coarse solids material plus the solids less than 4.8 millimeter (mm) (3/16 in.), which have been sent to the coarse solids washer from other sections of the washing process, are combined in the wash. These particles are sent to a clarifier where the solids are settled out and added back to the washing process via the screen separator. The supernatant is recirculated back to the coarse solids washer.

The undersized soil [less than 152 mm (6 in.) in diameter] from the grizzly is conveyed in slurry form to a drum washer where high pressure sodium carbonate extractant is used to further separate the particles. Soil particles with a diameter greater than 12.7 mm (1/2 in.) are sent to the coarse solids washing system while the undersized solids are combined with the fines from the coarse washer. The combined solids (slurry) are sent to the separation screen where they are passed over a screen which makes a 4.8 mm (3/16 in.) diameter separation. The oversized material is sent to the coarse washer system; the slurry (about 10 percent solids) containing undersized solids is treated with a polymer and pumped to clarifiers where the solids are allowed to settle out.

The supernatant from the clarifiers is pumped to a holding tank where it is recycled back into the system. The underflow from the clarifiers is a 30 percent solid slurry. This slurry is pumped to an attrition scrubber which operates in series with a reactor. The purpose of the attrition scrubber and the reactor is to enhance the contact between the soil solids and the sodium carbonate extractant to maintain a predetermined concentration. A temperature of 40°C will be maintained in the attrition scrubber/reactor units. Detention time in the attrition scrubber reactor is one hour.

Discharge from the attrition scrubber is pumped to the dewater/washing units. Here the extractant containing uranium is removed from the soil and the soil is washed with water. A filter press is likely to be used for the dewater/washing unit. Extracted groundwater will be used for the makeup of new sodium carbonate extractant solution. A portion of the extractant dewatered from the soil will be recycled back to the soil washing system while a second portion will be treated for uranium removal. The treatment may be at the AWWT facility or a new deionization unit installed as part of the soil washing system. Effluent from an ion exchange unit would probably be recycled to the soil washing process. An alternative to recycling the effluent would be to discharge to the AWWT facility. Residual solids from the soil washing process would contain elevated levels of uranium-238 and would be dewatered and disposed off-site at a low-level radioactive waste disposal facility. Depending on the effectiveness of the process and the PRLs, the decontaminated soil would be returned to the site or would undergo further processing.

Review of the PRLs would also determine if other contaminants, besides uranium, may need to be removed from some of the site soils. Soil with other contaminants of concern might also undergo additional treatment before being returned to the site. These requirements are currently under review. Soil washing is being retained for the Inactive Flyash Pile and South Field subunits.

Another application of soil washing is as one step in the Minimum Additive Waste Stabilization (MAWS) program. In the MAWS process, silica rich soils are washed using the soil washing process. This separates the coarse grained sand (silica) particles from the fine grained particles and contaminants. The silica is then used as feed material in the vitrification/glass encapsulation process.

Stabilization/Solidification

Stabilization/solidification technologies are applicable to contaminated material whose primary contaminants are metals and radionuclides. This technology reduces mobility through the binding of

hazardous constituents into a solid mass with low permeability that resists leaching or by chemically binding them to the stabilization reagents thereby resisting leaching. 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 and organophilic clays can be added to adsorb organic contaminants. Stabilization/Solidification is being retained for the Lime Sludge Ponds, Inactive Flyash Pile, South Field, and Active Flyash Pile subunits.

Stabilization/solidification technologies have been most successful when applied to inorganic waste streams, sludges, contaminated soil containing nonvolatile organics such as PCBs and creosote, and incinerator ash containing heavy metals (EPA, September 1988). Stabilization/solidification is often used to pretreat radiologically contaminated wastes prior to disposal.

EPA has used stabilization/solidification on many hazardous waste sites to determine treatment standards and the best demonstrated available technology (BDAT). It has been demonstrated that small amounts of organic contaminants can retard the cementing reaction in cement-based and lime/flyash-based processes. Such contaminants decrease the compressive strength and increase the leachability of the contaminants (Sheffield, et al., 1987; Eaton, et al., 1987). Although several vendors have successfully used organophilic proprietary compounds as additives to bind organics (at low concentration levels) to the solid matrix to inhibit their retarding effect, high concentrations of volatile organic compounds (VOCs) will still cause retarding effects. Pre-treating the waste before solidification to remove the organics by soil washing, thermal treatment, or chemical oxidation can prevent retarding effects.

Site demonstration tests were conducted using the Hazcon cement/pozzolan-based solidification process on six different sludges and soils containing a wide variety of organic and metal contaminants. The tests indicated that, in general, a significant reduction in mobility was achieved for the heavy metals, but not for the organic contaminants (both volatile and semi-volatile) (Sawyer, 1988).

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, 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 is dependent 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.

Stabilization/solidification can also be an effective means of treatment for lime sludge and flyash containing metals and radionuclides. Treatability studies have proven that mixtures of lime and flyash can result in a material exhibiting cementitious properties. A treatability study will be performed on the lime sludge and flyash located in Operable Unit 2. This study will investigate the potential of creating a modified soil that achieves a low permeability (1×10^{-6} cm/sec), thus reducing the potential for contaminant mobility and leachability.

The specific ratio of lime sludge to flyash will be based on utilization of all available lime sludge (from both the North and South Lime Sludge Ponds) and flyash (from both the Inactive Flyash Pile and Active Flyash Pile). This ratio will be tested alone and with additives (hydrated lime and/or clay.) These additives will be used to aid in reduction of leachability and permeability. Acceptance criteria for the modified soil include: passing all regulatory requirements for RCRA toxicity criteria, ensuring groundwater protection, and developing operating ranges for field implementation. In addition, bulking and free liquids will be minimized to achieve on-site disposal requirements. The treatability study will address both non-radioactive contaminated material and radiologically contaminated material.

Thermoplastic Encapsulation

Thermoplastic encapsulation involves sealing a waste in a matrix by the addition of a binder. The binder material may be asphalt bitumen, paraffin, sulfur cement, polystyrene, or polyethylene. The waste is dried, heated, and mixed with a heated binder material. The heated (130° to 260°C) waste-binder mixture is placed in a container or mold where it solidifies as it cools. Thermoplastic encapsulation is being retained for the Inactive Flyash Pile and South Field subunits.

Thermoplastic encapsulation reduces the hazard potential of a waste by physically surrounding the waste and containing it in a less soluble, mobile, and/or concentrated form. Since there is no chemical reaction associated with this remedial technology, there is a decreased possibility that the waste would be incompatible with the binder. This technology will result in a volume increase due to the addition of the binder material.

Thermoplastic techniques include both micro- and macro-encapsulation processes. Micro-encapsulation isolates and surrounds individual particles and macro-encapsulation produces a solid mass of particles surrounded by a thermoplastic container. Macro-encapsulation, also called jacketing, isolates the waste by completely surrounding it with a durable, impermeable coating. Methods include sealing the waste in polyethylene or in a polyethylene-lined drum or mixing the waste with an organic polymer and then compressing the mixture into a polyethylene-coated block using a pressure/heating technique.

Bench-scale thermoplastic encapsulation of DOE Rocky Flats wastes was performed by Brookhaven National Laboratory (BNL). The low-level radioactive wastes included in the thermoplastic encapsulation bench scale testing were reactor-generated evaporator concentrate salts (sodium sulfate and boric acid), incinerator ash, and ion exchange resins. Full scale thermoplastic encapsulation of a simulated nitrate salt waste was also successfully performed by BNL. BNL reports that thermoplastic encapsulation can not be used for waste that contain highly volatile organics unless the waste is pretreated for the removal of the highly volatile organics.

Crushing/Shredding

Contaminated concrete debris would be sorted using various removal technologies. Contaminated concrete chunks would then be crushed using a standard hydraulic concrete crusher or a ball mill to make gravel sized particles. These particles could then be used as feed for a treatment technology that would either reduce the contaminant's toxicity, mobility, or volume.

Waste debris would also be sorted using various removal technologies. Contaminated debris could be shredded to be used as feed for a treatment technology that would either reduce the contaminant's toxicity, mobility, or volume. Crushing/shredding is being retained for all of the subunits.

Drying

Drying would be used to remove excess moisture from a medium. This process would be used in conjunction with certain other technologies or processes that require dry material because of either technical or administrative requirements. Materials may need to be dried as a pretreatment step, as the primary method of treatment, or the residues of other treatments may need to be dried as a post treatment step. Drying is being retained for all of the subunits.

Drying may include physical or thermal processes. Some thermal processes may require physical drying as a pretreatment step to extract excess water from the raw material prior to thermal drying. Physical drying processes include filter presses or spreading out in drying beds. Filter presses might be suitable for treating residue from a water pretreatment process option.

Thermal processes are typically classified in two ways, direct heating and indirect heating. Direct heating methods accomplish drying by direct contact between the wet solids and hot gases. Indirect heating methods dry materials by transferring heat to the wet solids through a retaining wall. Indirect methods minimize dust creation, but are less energy efficient than direct methods. Either method will require air pollution controls such as High-Efficiency Particulate Air (HEPA) filters or scrubbers to contain dust or other emissions.

The most likely thermal processes that would be used on site are direct and indirect rotary dryers. Direct rotary dryers use a rotating cylinder, referred to as a kiln, where wet solids and hot flue gas move countercurrently through the cylinder. The kiln is natural gas fired with the flue gases in direct contact with the wet solids. Operating temperature inside the kiln can range from 300° to 600°F. The kiln will dry feed with moisture contents up to 70 percent. Moisture contents above this level would have to be initially treated in a filter press. The kiln will also volatilize VOCs and oxidize metals. Uranium will potentially oxidize to U_3O_8. A rotary kiln currently exists on the FEMP site. It is permitted for material drying and has a feed rate of 1,000 lbs/hr.

An indirect heat rotary dryer is similar to a direct heat rotary dryer except that there is an outer concentric cylinder around the inner rotating cylinder containing the wet solids. Hot gases or steam are circulated through the interstitial space between the outer and inner cylinders. Heat is transferred to the wet solids through the wall of the inner cylinder. Indirect heating can also be accomplished using a hollow auger. Hot gases are passed through the center of the auger which increases the heat

transfer surface area from the auger to the wet soils. Indirect rotary dryers operate at lower temperatures than direct rotary dryers and are used when high temperatures are not required.

Ex Situ Vitrification

Ex situ vitrification is a thermal treatment process similar to in situ vitrification, but uses different process methods to bind the waste into a glassy, solid matrix resistant to leaching. The vitrification of the waste material is achieved in a reaction chamber in which high temperature is used to reduce toxic organic compounds to elemental gas and carbon. The inorganic contaminants are either entrained in the glass and siliceous melts or are volatilized at the temperatures they are exposed to in the reaction chamber. The advantages of vitrification over other thermal processes are the lack of oxidation products and large air emissions, and the reduced leachability of inorganic materials such as heavy metals (EPA, 1992).

The reaction chamber melter is divided into a upper and 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-gas" 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 with the waste entering the reactor, mixed with frit (glass making material) and molten glass being withdrawn. The "off-gas" and vapors are treated in a gas scrubber system and released to the atmosphere. The water in the scrubber system is recycled. The concentrations of hazardous constituents and the reduction of leachability in the residuals are such that further treatment is not required (EPA, 1992).

Soils containing radioactive material such as uranium can be successfully treated by vitrification. The organics in the soil would be treated by the "off-gas" system during pyrolysis when they become vaporized. The uranium and metals in the soil would be chemically bonded with the melted soil in a glass product.

In designing the vitrification system, considerations should be given to the organic and silica content of the soil and the volume of soil to be treated. The "off-gas" collection system would be sized based on the amount of organics in the soil and would include HEPA filters, scrubbers, etc. to prevent any

airborne radionuclides from entering the atmosphere. The amount of silica would determine the waste loading of the melter and whether any additives (silica material) would be needed in the soil before melting. The amount of soil to process would also determine the size of melter needed. The "off-gas" systems and melters for vitrification would be commercially available through several vendors. The melter sizes that are available range form 150 pounds per hour units to 100 tons per hour units.

The weathering behavior of volcanic glass (a natural analog to the vitrified product) can provide some measure of the long-term stability and durability of the vitrified product. Only very thin weathering rinds develop on volcanic glass over a period of several million years. The slowness in the overall degradation of a glass grain suggests that the diffusion coefficient or leachability index would remain relatively unchanged over time. Data on the long-term stability of vitrified material are not available, and the life expectancy of the vitrified product is difficult to estimate for short-term leach rates. On the basis of the longevity of volcanic glass and diffusion calculations, the vitrified product would be expected to withstand environmental exposure for thousands of years.

One approach to vitrifying soils has been undertaken in the MAWS program. In the MAWS process, silica rich soils are washed using the soil washing process. This separates the coarse grained sand (silica) particles from the fine grained particles and contaminants. The silica is then used as feed material in the vitrification process. This process option is potentially applicable for the contaminated material at the Inactive Flyash Pile and South Field subunits.

3.5.6 Disposal

Disposal technologies are classified in two ways, on-site disposal and off-site disposal, either of which would require transportation using rail, truck, or a combination of both. On-site disposal consists of technologies that confine contaminated/treated materials at locations on site, but different from their origin. On-site disposal is used to minimize infiltration, to reduce transport of contamination, and to minimize the potential of direct contact with contaminated/treated material. On-site disposal involves the construction of a common disposal cell in accordance with applicable regulations and usually includes regrading surface soils to divert and collect surface waters to prevent damage to the cell caused by erosion. On-site disposal will restrict contaminant migration but does not reduce contaminant toxicity, mobility, or volume.

Off-site disposal consists of technologies that confine contaminated/treated material in engineered disposal facilities located off-site. The off-site facilities may be located near the FEMP or in another state. Off-site disposal minimizes the potential of direct contact with contaminated material. Off-site disposal will restrict contaminant migration, but it does reduce contaminant toxicity, mobility, or volume.

Waste transportation consists of technologies that transport waste on site and off site. Truck transport is utilized for transport of all waste within the FEMP as well as off-site disposal of waste at local facilities and small quantities of waste at NTS. Rail transport would be used in combination with truck transport for off-site disposal of large quantities of material at NTS. Waste transportation is only to be used in conjunction with disposal options.

Specific federal requirements for the off-site transport of chemically hazardous and/or radioactive material have been identified to address factors such as packaging and labeling. Many states, including Ohio, also have transportation requirements and many require advance notice for shipments of radioactive material.

On-Site Disposal Facility

The general requirements for an on-site disposal facility are regulated under OEPA Policy 4.07, OAC 3745-27, 40 CFR 192, and DOE Order 5400.5. The on-site disposal facility would store waste by confinement in an aboveground earthen structure. It would use operational methods to reduce the volume of waste, ease the handling of waste, and reduce human radiation exposure and contamination. Waste received at the facility would have to meet acceptance criteria which may include: moisture content, limits on concentration and quantities of radioactivity, and toxic and hazardous chemicals restrictions. 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.

The facility would accept contaminated material from all of the Operable Unit 2 subunits. The final design and construction of the disposal facility will depend upon the site hydrology, geology, and the waste characteristics. An on-site disposal facility is retained for all subunits. In addition, a FEMP-wide disposal facility sized to contain the contaminated material from all of the operable units will be evaluated during the remedial design.

The on-site disposal cell incorporates a liner systems of soils and geosynthetics, a perimeter encapsulation system of compacted fill, and a multicomponent cover of soil and geosynthetics. The waste is placed in the cell in a bulk or undifferentiated form. For example, if the waste is a vitrified frit, the frit would be placed in mass and be surrounded only by the liners, perimeter berms, and the cover.

The disposal cell would consist of the following components from bottom to top to meet the requirements of 40 CFR 192 and DOE Order 5400.5.

1. A 1.5 m (five ft) thick compacted clay layer with a hydraulic conductivity of not more that 1 x 10^{-7} cm/sec.

2. A geomembrane liner physically and chemically resistant to chemical attack by the proposed contaminated material to be disposed. The liner shall be protected from the gravel drainage layer by a geotextile cushion layer.

3. A leachate collection layer consisting of a 30 cm (12 in.) thick layer of gravel having a minimum conductivity of 1 x 10^{-2} cm/sec. This includes leachate collection pipes, sumps, and lift stations. The leachate collection layer must be covered with a geotextile to protect and prevent clogging of the gravel layer.

4. A 30 cm (12 in.) thick cushion layer of contaminated material without any sharp objects.

5. The remainder of the contaminated material would be placed in lifts and compacted.

6. A contouring layer of clean compacted fill material to provide a foundation for the cap, graded to 4 percent slopes.

7. A 61 cm (24 in.) thick compacted clay infiltration barrier with a maximum hydraulic conductivity of 1 x 10^{-7} cm/sec covered by a bentonite geocomposite.

8. A 30 cm (12 in.) thick drainage layer of gravel having a minimum hydraulic conductivity of 1 x 10^{-2} cm/sec. Geotextile layers would be placed above the drainage layer to prevent migration of fines into the drainage layer.

9. A 91 cm (36 in.) thick biotic barrier of cobblestone to serve as an inadvertent intrusion barrier to burrowing animals.

10. A 15 cm (six in.) thick filter layer of sand with geotextile fabric placed above and below.

11. A 53 cm (21 in. thick) vegetative soil layer for a root support zone.

12. A 15 cm (six in.) thick topsoil layer and grass cover.

Typical details of the on-site disposal cell are provided in Appendix E.

The top soil will be planted with grass for sheet flow erosion protection. The sand will act as a drainage layer to remove the infiltration water before it reaches the infiltration barrier. The infiltration barrier will consist of a bentonite geosynthetic clay and a geomembrane. The clay material located below the infiltration barrier will act as a radon and infiltration barrier. The clay and bentonite will have permeability values from 10^{-7} to 10^{-9} cm/sec.

Off-Site Disposal Facility

An off-site disposal facility would be used for the disposal of non-toxic flyash and bottom ash from the Active and Inactive Flyash Piles as well as soils or other solid materials with non-radiological contaminant levels above the PRLs. The landfill would be approved to accept wastes meeting Ohio Administrative Code (OAC) 3745-27 and OEPA Policy 4.07 requirements. The construction, operating, monitoring, and closure requirements would be in compliance with OAC and OEPA. The life expectancy of an off-site disposal facility would be a minimum of 30 years post closure.

Off-Site Low-Level Radioactive Waste Disposal Facility

The construction, operation, monitoring, and closure requirements of an off-site LLWDF are similar to the requirements for the on-site disposal cell. 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. Small quantities would be shipped by truck in accordance with DOT procedures. Currently, the FEMP is sending contaminated material from other operable units to the NTS. However, material from the Operable Unit 2 subunits would be subjected to NTS waste acceptance criteria prior to disposal.

The waste form criteria are based on current DOE LLW management policies and practices per DOE Order 5820.2A guidelines. Any waste streams not meeting these basic requirements listed below must be evaluated on a case-by-case basis and must not compromise the performance objectives for the disposal site or violate any permit requirements (NTS, June 1992).

1. Transuranics: LLW must have a transuranic nuclide concentration less than 100 pCi/g. The mass of the waste container, including shielding, shall not be used in calculating the specific activity of the waste.

2. Hazardous Waste Components: LLW offered for disposal at NTS waste management sites shall not exhibit any characteristics of, or be listed as, hazardous waste as identified in

Title 40 CFR 261, "Identification and Listing of Hazardous Waste" or state-of-generation hazardous waste regulations.

3. Free Liquids: Free liquids mean liquids which readily separate from the solid portion of a waste under ambient temperature and pressure conditions.

   LLW disposed at the NTS waste management sites shall contain as little free liquids as is reasonably achievable, but in no case shall the liquid equal or exceed 0.5 percent by volume of the external waste container and shall meet the following criteria:

   - Bottles, cans, or other similar well-drained containers may contain residual liquids.
   - Where practicable, residual liquids in well-drained containers shall be mixed with absorbent or solidified so that free liquids are no longer observed.
   - If absorbent materials are added to a waste for control of free liquids, the generator must calculate the volume of liquid in the waste and use a quantity of sorbent material sufficient to absorb a minimum of twice the calculated volume of the liquid. When significant differences of temperature exist between the generating site and the disposing site, provisions for additional absorbent materials must be made for affected waste forms.
   - To demonstrate compliance with the free liquids requirement, the generator may be required to use Method 9095 (Paint Filter Test) as described in "Test Methods For Evaluating Solid Wastes, Physical/Chemical Methods" (EPA Publication No. SW-846). The Paint Filter Test may not be applicable to certain waste forms; e.g., concrete. If the generator determines that the waste form is not conducive to the Paint Filter Test, documentation must be provided to substantiate the claim.

4. Particulates: Fine particulate wastes shall be immobilized so that the waste package contains no more than 1 weight percent of less-than-10-micrometer-diameter particles, or 15 weight percent of less-than-200-micrometer-diameter particles. Waste that is known to be in a particulate form or in a form that could mechanically or chemically be transformed to a particulate during handling and interim storage shall be immobilized.

   When immobilization is impractical, other acceptable waste packaging shall be used, such as the following:

   - Overpacking (i.e., 55-gallon drum inside 83- or 85-gallon drum);
   - steel box with no liner;
   - wooden box with a minimum of 6-mil sealed plastic liner;
   - steel drum with a minimum of 6-mil sealed plastic liner.

5. Gases: LLW gases shall be stabilized or absorbed so that pressure in the waste package does not exceed 1.5 atmospheres at 20° C.

Compressed gases as defined by Title 49, CFR 173.300, including unpunctured aerosol cans, will not be accepted for storage or disposal. Aerosol cans will have puncture disfigurements recognizable by real-time radiography (RTR). Expended gas cylinders must have the valve mechanism removed.

6. Stabilization: Where practical, waste shall be treated to reduce volume, promote waste minimization, and provide a more structurally and chemically stable waste form.

   Structural stability can be accomplished by crushing, shredding, and placing a smaller piece inside an opening of a larger piece, such as nesting pipes.

   Chemical stability must be documented to show that significant quantities of harmful gases, vapors, or liquids are not generated. Wastes shall not react with the packaging during storage, shipping, and handling time.

   Where stabilization is required for the waste to meet this waste acceptance criteria, it must be shown that the stabilization process is adequately controlled. Control is shown through the use of procedures, sampling, test plans, etc., and the results of such controls shall be made available for examination and approval.

7. Etiologic Agents: LLW containing pathogens, infectious wastes, or other etiologic agents as defined in Title 49, CFR 173.386 will not be accepted for disposal at NTS.

8. Chelating Agents: LLW containing chelating or complexing agents at concentrations greater than 1 percent by weight of the waste from will not be accepted.

9. Polychlorinated Biphenyls (PCBs): PCB-contaminated LLW will not be accepted for disposal at NTS unless the PCB concentration meets municipal solid waste disposal levels of 50 ppm or less. See Title 40 CFR 761.60 for PCB disposal requirements.

10. Explosives and Pyrophorics: LLW containing explosive and/or pyrophoric material in a form that may spontaneously explode or combust, if the container is breached, will not be accepted.

In addition to these waste acceptance criteria, certification and transfer requirements are identified in NVO-325 (Rev. 1) (NTS, June 1992).

Based on discussions with NTS, the life expectancy of the facility is unknown. NTS is upgrading an existing EA to an EIS. Results of the EIS will identify the life expectancy but will not be available in the near future. Contaminated material would be packaged in polyethylene-lined international bulk containers (IBCs). The IBCs would in turn be placed in an International Storage Organization (ISO) container for transportation to a disposal facility.

The Envirocare Facility in Utah is a private facility that may also be available to accept this waste. A regional facility yet to be constructed may also be able to accept this waste. An off-site low-level radioactive waste disposal facility is being retained for all Operable Unit 2 subunits.

Off-Site Hazardous Waste Disposal Facility

The construction, operation, and maintenance of an off-site hazardous waste disposal facility would be performed in accordance with RCRA requirements (40 CFR 264). A hazardous waste disposal facility would be required for the disposal of soils from the firing range located in the South Field subunit. These soils would contain lead that leaches to unacceptable levels. The life expectancy of a hazardous waste disposal facility would be a minimum of 30 years post closure.

Truck Transportation

Truck transport can easily offer portal-to-portal service with the road system available at the FEMP site. The primary disadvantages with this process option are the relatively undeveloped and heavily traveled roads near the FEMP site and the higher cost to the public as compared to rail transport. Truck transportation is applicable to all Operable Unit 2 subunits.

Rail Transport

The FEMP site can readily support rail transportation by using existing on-site rail spurs. Some off-site disposal options have facilities with the capability of receiving the waste by rail. Transportation to NTS may require a combination of truck and rail transport. Contaminated material shipped by rail to NTS would go through the Las Vegas, Nevada terminal. In cases where exclusive use shipments are required, the contaminated material would be placed within an ISO container and placed on a flat bed rail car. At the Las Vegas terminal, the ISO container would be removed from the train without losing exclusive use status and placed on flatbed trucks where they would be transported to NTS. The Las Vegas Terminal is a new facility which has been constructed to handle the transfer of hazardous materials, including radioactive material for the NTS. Although rail transport has a lower percentage of accidents per trip, the volume of material hauled per trip is many times higher. Rail transportation is applicable to all Operable Unit 2 subunits.

3.6 REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER/CONSTRUCTION WATER

3.6.1 No Action

Under no action, no removal or treatment of the contaminants would occur. The no action scenario is considered in the FS, as required by the NCP, to provide a baseline to which other remedial technologies and alternatives can be compared. No action is being retained for all Operable Unit 2 subunits.

3.6.2 Institutional Actions

Institutional actions are used to regulate intentional or unintentional use or contact with contaminated groundwater/construction water. There are active and passive actions. Active actions include groundwater monitoring to detect contaminant migration while passive actions include legal controls such as deed restrictions.

Deed Restrictions

Deed restrictions are a form of legal administrative control that would prohibit specified ground and usage activities. Limited groundwater usage might include prohibiting supply wells or water for farming. Deed restrictions are being retained for all Operable Unit 2 subunits.

Groundwater Monitoring Wells

Groundwater monitoring, sampling, and analysis of selected wells are used to assess the concentration levels, to detect movement of the contaminants of concern, and to verify that remedial action clean-up concentrations are achieved. Groundwater monitoring will be appropriate as either compliance monitoring or response action monitoring and will be retained for use at all Operable Unit 2 subunits.

3.6.3 Containment/Control

Slurry Wall

Slurry walls are applicable for the Inactive Flyash Pile, South Field, and Active Flyash Pile subunits. Slurry walls are vertical, low permeability barriers that restrict horizontal movement of groundwater. A slurry cutoff trench/wall is constructed by excavating a narrow vertical trench, typically two to four ft wide, and backfilling with a low-hydraulic conductivity material to contain a waste source and to prevent contamination from migrating off site. The trench, as excavation proceeds, is filled with a

bentonite-water slurry which stabilizes the walls of the trench, thereby preventing collapse. The slurry penetrates into the permeable soils, creating a filter cake on the trench walls that seals the soil formations, prevents slurry loss, and also contributes to the low permeability of the completed cutoff wall. The slurry in the trench is then displaced by the low permeability backfill mixture consisting of a thoroughly blended mix of clay, sand, bentonite, and water. Slurry walls are differentiated by the materials used to backfill the slurry trench. If a mixture of soil and bentonite is used, then the wall is known as a soil-bentonite slurry cutoff wall. In some cases, the trench is excavated under a slurry of portland cement, bentonite, and water, and this mixture is left in the trench to harden into a cement-bentonite slurry wall. Vibrated beam walls form a low permeability cutoff by vibrating a steel beam into the ground. As the beam is withdrawn, a bentonite grout is injected under pressure into the void.

Slurry walls can be installed in several configurations. Circumferential installations (totally surrounding the wastes) are the most common type of slurry wall (EPA 1985). Downgradient placement of a slurry wall can be used to prevent downgradient migration of contaminated groundwater. A slurry wall could also be installed upgradient of a contaminated area to divert clean groundwater around a site.

Vertical configurations of slurry cutoff walls may be "keyed-in" or "hanging." A keyed-in slurry cutoff wall is excavated into a continuous low-permeability, underlying horizontal confining layer, such as a clay deposit or competent bedrock. The confining layer forms the bottom of the contained site and penetration into the confining layer of 0.6 to 0.9 m (two to three ft) is essential for containment. The depth of the confining layer will also impact the type of excavation equipment used and the completed wall costs. Hanging slurry walls are not tied into a confining layer, but extend to a hydraulically calculated depth to act as a barrier to the movement of floating contaminants (such as oil or fuels) or migrating gases, or for creating an inward hydraulic gradient used in conjunction with a groundwater treatment system. The hydraulic conductivity of a soil-bentonite or vibrating beam wall, with good construction quality control, is approximately 1×10^{-8} cm/sec. The hydraulic conductivity of a good cement-bentonite wall is typically 1×10^{-6} cm/sec or less (EPA 1985).

A number of factors may limit the application of slurry cutoff walls. Site topography can limit the use of a soil-bentonite wall because the excavation slurry and the backfill will flow under stress. Thus, the trench line must be within a few degrees of level. Cement-bentonite walls that harden

quicker are better suited to irregular topography. If a keyed-in slurry wall is considered, the depth to and nature of the confining layer becomes a concern. The layer must have sufficiently low permeability to prevent leakage underneath the wall; it must have adequate thickness to allow an adequate key [0.6 to 0.9 m (two to three ft)]. If the bottom of the slurry wall is beyond the conventional depth [15 to 21 m (50 to 70 ft)], excavation of the trench will be less cost-effective.

A major limitation to the application of a slurry cutoff wall/trench as a physical barrier is the compatibility of the cutoff trench backfill mixture with site contaminants. Soil-bentonite and vibrating beam backfills are susceptible to attack by strong acids or bases, strong salt solutions, and some organic chemicals. Cement-bentonite backfills are susceptible to attack by sulfates, strong acids and bases, and highly ionic substances. In order to minimize this problem, compatibility testing should be performed using soil and groundwater samples with the highest concentrations of contaminants from the site. The concentration of bentonite in the mix can be adjusted, or chemically resistant bentonite or sulfate-resistant cement can be used to provide a satisfactory solution. Additionally, susceptibility to migration of radionuclides has not been established.

Grout Curtain

Grout curtains are applicable to the Inactive Flyash Pile, South Field, and Active Flyash Pile subunits. Grout curtains are vertical, low permeability barriers that restrict horizontal movement of groundwater. They are constructed by drilling holes into the rock or soil surrounding the waste and injecting cementitious grout under high pressure. By drilling the holes in an overlapping arrangement an impermeable wall or curtain is formed. This technology may be more permeable than slurry walls since the native material is left in place and not 100-percent replaced by the grout. The main application for grout curtains is for sealing fractured rock formations where other technologies may not be viable.

Grout curtains can be installed in several configurations. Circumferential installations to totally surround the wastes, downgradient to prevent migrations of contaminated groundwater, and upgradient to divert clean groundwater around a site are all possible. As with the slurry walls, the cement used in the grout is susceptible to attack by sulfates, strong acids and bases, and highly ionic substances.

3.6.4 Removal Technologies

French Drains/Interceptor Trenches

French drains/interceptor trenches are applicable to the Inactive Flyash Pile, South Field, and Active Flyash Pile subunits. French drains/interceptor trenches are effective in collecting contaminated groundwater from shallow aquifers (in the FEMP, the perched groundwater is typically less than 20 ft below grade) through trenches or horizontal perforated pipes which drain to a collection sump. The depths of french drains will be dependent on the thickness of the glacial till and the perched groundwater layers beneath each specific Operable Unit 2 subunit. The collected perched groundwater can be pumped to the surface for treatment or sent directly to the AWWT facility.

Drains or trenches are typically installed perpendicular to the direction of groundwater flow, although other orientations may be applicable in certain cases. 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 water from passing through it.

Bio-polymer trenches are collection trenches that use the same principle as the slurry wall except that the backfill has a very high hydraulic conductivity. The slurry degrades biologically leaving a gravel cutoff/collection trench. Bio-polymer walls can be installed to greater depths than conventional trenches and the need for shoring is eliminated.

Trenches and drains can be either active (pumped) or passive (gravity flow). Passive systems are usually left open with an installed skimming pump or settlement tank for removal of the pollutant.

There are a number of limitations to the use of subsurface drains as a remedial technique. Subsurface drains are not feasible at depths exceeding 12 m (40 ft), due to the difficulty of shoring during installation. Also, contamination at great depth or in bedrock aquifers may cause construction costs to be prohibitive, particularly if a substantial amount of rock must be excavated. The excavation

required for trench or drain installation is complicated in areas where the location of subsurface utilities is unknown, or where tanks, buildings, and roadways exist.

Excavation Dewatering

This process option includes pumping out 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. Construction water could also include water extracted from a wellpoint system if the primary objective of that dewatering is to provide stability to the excavation.

During excavation activities at any of the Operable Unit 2 subunits, attempts will be made to keep surface water runoff out of the excavations through the use of berms and diversion ditches. Some water will still accumulate, and this will be pumped out using a suction pump with enough hose to reach the base of the excavation. Using a suction pump should eliminate the need for personnel to enter the excavation.

Discharge from excavation dewatering may need to be pretreated prior to being sent to the AWWT facility.

3.6.5 Treatment

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 amount of liquid to be treated. In determining the tank volume, the liquid must be allowed to stay in the primary sedimentation tanks for a sufficient period of time, typically 1.5-2.5 hours, to allow the solids to settle. The tanks are designed to also provide storage capacity if the groundwater/construction water collection rate is greater than what can be sent to the AWWT facility. Chemicals can be added to the settling tanks which help promote the settling of the solids. The sedimentation process can be used as a preliminary treatment prior to the AWWT facility if sedimentation treatment of the groundwater/construction water is needed. Sedimentation is being retained for all of the Operable Unit 2 subunits.

There are many variables that affect sedimentation efficiency (i.e., particle size, retention time, density of suspended particles); however, without the use of additional technologies, such as a chemical flocculent, the removal of very fine particles becomes impractical. Sedimentation is a common process technique used for liquids containing suspended solids. When the liquid containing the solids is placed in a relatively quiescent (tranquil) state, the solids have the tendency to settle out. The objective of pre-treatment by sedimentation is to remove the readily settleable solids and thus reduce the suspended solids content prior to primary treatment at the AWWT facility. Sedimentation also 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.

Each phase uses the following major treatment steps:

- Flow equalization and pH adjustment to 11.5
- TRU/Clear addition and clarification (TRU/Clear) for bulk removal of radionuclides and heavy metals. TRU/Clear is targeted at removal of radionuclides other than uranium,

however, uranium will also be removed. The system will have the capability to use alternate coagulants if TRU/Clear is not required.

- Clarifier effluent is directed to multi-tube filtration (solids collected from the clarifiers and filtration unit backwash will be directed to Plant 8 for dewatering)
- Filtered wastewater will pass through carbon filters for removal of organic compounds
- pH adjustment to 8.0 using sulfuric acid (optimum for ion exchange)
- Ion exchange for uranium removal (Dowex 21-K)
- Final pH adjustment to within NPDES limits (6.5-9.0)
- Final filtration

Metals precipitation is one of several methods that uses chemicals or other additives to remove/extract contaminants from a waste stream. One metals precipitation process that was developed for the precipitation of radionuclides and metals is the TRU/Clear process. This process uses potassium ferrite as an inorganic coagulant to remove radionuclides and other priority pollutants from waste waters.

Ion exchange is the process where hazardous/radioactive ions are removed from a solution by being exchanged with harmless ions held by the ion exchange material. The ion exchange material is typically a resin with ionic functional groups attached. The use of the AWWT facility as a process option applies to all of the Operable Unit 2 subunits.

3.6.6 Disposal

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.

Discharge to Paddys Run

This process option consists of discharging treated site groundwater and construction water through a new pipeline to a discharge at Paddys Run. A new National Pollutant Discharge Elimination System (NPDES) permit would be necessary. Due to the intermittent nature of Paddys Run, there would be no credit for mixing zones. As a result, end-of-pipe, water quality-based NPDES discharge permit

limits would need to be achieved. This is applicable to all Operable Unit 2 subunits following treatment at the AWWT facility.

3.7 EVALUATION OF TECHNOLOGIES FOR SOIL/SEDIMENT/WASTE

This section will consist of the evaluation all remedial technologies and process options for soil, sediment, and waste that were retained after the initial screening. The evaluation of the remedial technologies and process options will be conducted according to requirements of individual waste units. This approach has been taken because different contaminants of concern, hydrogeological, and geological characteristics exist for the different waste units which may preclude the use of various remediation options.

The remediation technologies and process options will be evaluated further, based on the following criteria:

- Effectiveness

  Specific technologies remaining after the initial screening are evaluated further on their effectiveness relative to other processes within the same technology type. The evaluation focuses on:

  - The potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs.
  - The potential impacts to human health and the environment during the construction and implementation phase.
  - How proven and reliable the process is with respect to the contaminants, media, and conditions at the site.

- Implementability

  Implementability encompasses both the technical and administrative feasibility of implementing a technology process. Technical implementability was used as the initial screening criteria in Tables 3-6 through 3-13 to eliminate clearly ineffective technology types. This evaluation places greater emphasis on the institutional aspects of implementability. The evaluation focuses on:

  - Availability of necessary equipment, skilled workers, vendors, mobile units, etc.
  - Ability to obtain necessary permits for either off-site or on-site actions.
  - Availability of treatment, storage, and disposal services.

- Cost

  Cost plays a limited role in the evaluation process. The evaluation focuses on:

  - Relative capital and O&M costs
  - Costs presented as high, medium or low relative to other process options in same technology type.
  - O&M costs are initiated after the remedial action has been completed.

All of the items listed under each criterion may not apply directly to each technology, and therefore each item will only be addressed where appropriate.

Screening evaluations will focus on effectiveness and implementability with less effort directed at cost evaluations. At this stage, no technologies will be eliminated based upon cost.

3.7.1 Solid Waste Landfill

The technologies and process options for the Solid Waste Landfill remaining after the initial screening are evaluated based on effectiveness, implementability, and cost.

3.7.1.1 No Action

Effectiveness - No action does not meet the remediation goals identified in the RAOs. No action would not reduce the risk to human health associated with direct exposure to the soil/waste. No action would not provide any protection of the environment, as contaminants would continue to migrate from the soil/waste to the underlying soil and groundwater.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated with no action.

Conclusion - Retain no action for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.7.1.2 Institutional Actions

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 Solid Waste Landfill. 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 as contaminants could continue to migrate into the environment through groundwater, soil, surface water, and the atmosphere; however, 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 impact to both 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, physical barriers can be breached during acts of vandalism or vagrancy.

Implementability - Physical barriers are administratively feasible and require no special permitting to implement. Physical barriers are currently in place; however, security and maintenance activities would be required for long-term implementation.

Cost - When compared to the deed restriction process option, physical barriers would have a moderate capital cost and a moderate O&M cost. O&M costs include both security and maintenance activities.

Conclusion - Retain physical barriers for further consideration in conjunction with containment and on-site disposal technologies.

Security Guards

Effectiveness - Security guards are effective in supplementing physical barriers. Security forces would monitor the physical barriers for breaches. Random patrols would discourage vandalism or vagrancy. Security guards would physically remove trespassers that did breach the barriers. Security guards provide no reduction in toxicity, mobility, or volume of contaminants. Security guards are

effective in protecting human health by restricting public access to the waste site. Security guards are a reliable and proven method of restricting access of the general public to a waste site.

Implementability - Security guards are administratively feasible. Security forces are currently on site. Physical barriers would be required for long term implementation.

Cost - Security guards have a low capital cost and moderate O&M cost. These costs are included in the cost of physical barriers.

Conclusion - Retain security guards for further consideration. Use with physical barriers in conjunction with containment and on-site disposal technologies.

Deed Restrictions

Effectiveness - Deed restrictions would be effective in placing legal restraints on the future usage or development of areas required to contain or dispose of contaminated material contained at the Solid Waste Landfill. Deed restrictions can be effective in protecting human health by restraining agricultural, construction, or other usage or development activities that could increase personal or public exposure to the contaminated material. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

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. However, deed restrictions could prevent the drilling of wells that could allow or increase the migration of contaminants into and through the underlying soil and groundwater. Deed restrictions are a reliable method for placing legal restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to the waste site.

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 a low capital cost with no O&M costs, as compared to physical barriers.

Conclusion - Retain deed restrictions for further consideration. Use in conjunction with containment and on-site disposal technologies in which contaminants remain on site.

3.7.1.3 In Situ Containment

Composite Cap

Effectiveness - A composite cap would be able to effectively cover the area containing contaminated material in the Solid Waste Landfill. A composite cap would be an effective method for reducing the infiltration rate of surface water through 12,500 cu m (16,300 cu yd) of material containing arsenic, uranium-238, radium-228, thorium-228, and beryllium contaminated material. A composite cap would also be effective at limiting the release of radon and biogenic gases to the atmosphere. Construction of a composite cap would be effective in meeting the remediation goals since it would reduce the migration of the contaminants (EPA, 1988).

During construction, significant volumes of construction material may have to be hauled from off-site sources to the site. Dust and truck traffic on local highways and roads can be mitigated by using dust suppressants, limiting truck traffic during rush hours, and enforcing traffic laws. This would decrease the possibility of traffic accidents.

A composite cap would be designed to provide an effective life of 1,000 years with a minimum life of 200 years. The longevity of composite caps is not well proven because all of the caps currently existing have been recently constructed; therefore, the effective life 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 assure 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 - Retain composite cap for further consideration.

Surface Water Controls

Effectiveness - Surface water controls can be very effective in managing and directing surface water around areas required to handle, treat, or dispose of contaminated material contained in the Solid Waste Landfill. Surface water controls are effective in meeting remediation goals by reducing the migration of contaminants through surface water. Surface water controls are effective in protecting both human health and the environment by reducing the quantity of contaminants migrating along with surface water to areas outside the site. 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 unvegetated soils and by using dust suppressants. Surface water control technology is well proven and understood, and is a reliable method for controlling surface water.

Implementability - Surface water controls are administratively feasible, although some controls may require obtaining approval from the COE and other governmental agencies and departments having relevant jurisdiction due to the nearby wetlands. Resources required to construct the surface water controls are readily available. Surface water controls are appropriate for use with containment options.

Cost - Surface water controls have low capital and low O&M costs.

Conclusion - Retain surface water controls for further consideration with containment technologies.

3.7.1.4 Removal

Mechanical Excavation

Effectiveness - Mechanical excavation can be very effective in moving, excavating and handling large quantities of soil, rocks, or debris; and in excavating localized areas of elevated contaminant concentrations. However, excavation is not, by itself, a primary remediation technology. Therefore, the use of mechanical excavation alone is not effective in meeting remediation goals, or in protecting either human health and the environment. During implementation, risks to human health would be mitigated by observing excavation safety procedures and by using dust suppressants. Excavation is a reliable method for material handling or earth moving operations, when used in support of other remediation technologies.

Implementability - The use of mechanical excavation is administratively feasible at the site. Both resources and services required to provide excavation and earth moving operations are readily available.

Cost - When compared to other removal options, the use of mechanical excavation has moderate capital and O&M costs.

Conclusion - Retain mechanical excavation for further consideration as a support action to other primary technologies.

Sorting/Separation

Effectiveness - Sorting/separation would be an effective technology for handling the volume of contaminated material present at the Solid Waste Landfill. Sorting/separation would be effective for reducing the total amount of material that would have to be treated or disposed. The use of sorting/separation is not effective by itself in meeting remediation goals. However, it is effective when used in conjunction with other process options. During construction, risks to site workers using field screening equipment can be mitigated by using safe work procedures. Sorting/separation is reliable for visually identifying large debris and solid waste, and sorting using mechanical excavators. It is also reliable for separating solid waste from soils by particle size using mechanical screening techniques. The identification process for separating radiologically contaminated materials from non-radiologically contaminated materials is relatively slow.

Implementability - Sorting/separation is administratively feasible if conservative sorting decisions are made in the field. A method of quality assurance will need to be developed to calibrate the field readings with laboratory analysis to ensure that material sorted as non-contaminated is, in fact, clean. The resources for sorting using mechanical excavators and mechanical screening are readily available. The currently available resources for sorting radiological contamination are slow. Devices that can identify large quantities of radiologically contaminated material relatively quickly are currently being developed. A site demonstration is currently planned for 1994.

Cost - When compared to other removal options, sorting/separation has a moderate capital cost and high O&M cost.

Conclusion - Retain sorting/separation for further consideration as a support action to other technologies that require contaminated waste to be separated prior to treatment or off-site disposal.

Revegetation

Effectiveness - Revegetation can be effective in stabilizing surface soils when used in conjunction with removal technologies that excavate the entire contents of the Solid Waste Landfill. Revegetation is effective in helping to achieve the remediation goal of protecting the environment by reducing the migration of surface soils into streams. Revegetation is effective at controlling wind and surface water erosion. Revegetation is a reliable method for surface stabilization; however, revegetation is not a reliable method for surface stabilization in areas where strong erosion forces, steep grades, ponding conditions, infertile soil, or surface contaminants exist.

Implementability - Revegetation is administratively feasible and requires no special permitting to implement. Both resources and services required to place a vegetative cover are readily available.

Cost - When compared to other surface controls options, revegetation has a moderate capital cost and low O&M costs.

Conclusion - Retain revegetation for further consideration with removal technologies.

3.7.1.5 Ex Situ Treatment

Crushing/Shredding

Effectiveness - Crushing/shredding would be effective as a pretreatment step for reducing the size and improving the material handling characteristics of large pieces of contaminated debris, construction debris, containers, etc. found in the Solid Waste Landfill. Approximately 4,100 cu m (5,300 cu yd) of debris would require crushing/shredding. This process would help meet the remediation goals for the site by allowing contaminated debris to be treated by one of the other treatment steps.

During construction, potential impacts to workers can be mitigated through the use of sound construction safety practices when operating the crushing and shredding equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated. Crushing and shredding processes are well proven. Shredders are commonly used at resource recovery centers as a debris pretreatment step.

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 ex situ chemical/physical treatment options, crushing/shredding has low capital and O&M costs.

Conclusion - Retain crushing/shredding for alternative evaluation.

Drying

Effectiveness - Drying would be effective as a pretreatment step for material preparation for other treatment processes, as a primary treatment step to dry contaminated material for shipment off site without any other treatment, and as a post treatment step. Drying would be required for 5,400 cu m (7,000 cu yd) of material at the Solid Waste Landfill.

During construction, potential impacts to workers can be mitigated through the use of construction safety procedures when operating the drying equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated or disposed. "Off-gasses" and dust may be created by drying, but their impacts will be mitigated through the use of the appropriate controls (e.g., HEPA filters). Drying processes are well proven. Filter presses are commonly used for sludge dewatering at wastewater treatment plants. Pulse drying and kiln drying have been used successfully for drying soils, sediments, and debris.

Implementability - Drying is administratively feasible as either a pretreatment, primary treatment, or post treatment step. The equipment and labor to operate this equipment is readily available.

Cost - When compared to other ex situ chemical/physical treatment options, drying has moderate capital and O&M costs.

Conclusion - Retain drying for alternative evaluation.

3.7.1.6 Disposal

On-Site Disposal Facility

Effectiveness - An on-site disposal cell would be effective in containing the volumes of contaminated material from the Solid Waste Landfill, and would be effective in meeting the remediation goals by reducing migration of the contaminants. A disposal cell could be designed to receive 12,500 cu m (16,300 cu yd) of material containing any of the COCs from the Solid Waste Landfill. The toxicity, mobility, or volume of the contaminants would not be reduced. An on-site disposal cell would be effective in protecting human health by reducing public exposure to the contaminated material. An on-site disposal cell would be effective in protecting the environment by reducing wildlife exposure to the waste material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination and reducing releases of radon gas (EPA, 1988). A disposal cell would be reliable in minimizing the exposure of contaminated material to surface water, groundwater, wind, and other environmental forces; however, the 1,000 year effective life has not yet been proven on any disposal cell (EPA, 1988).

During construction and filling of a disposal cell, potential impacts to workers can be mitigated through the use of sound construction safety practices. The contaminated materials would have to be transported and compacted, which may increase airborne contamination; however, 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.

Implementability - Implementation of an on-site disposal cell 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 can be readily constructed by several experienced civil contractors and skilled workers. Resources required to construct the disposal cell are readily available. The placement of geomembrane liners requires a skilled labor force to assure 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 cell has a high capital cost and a high O&M cost.

Conclusion - Retain the option of using an on-site disposal cell.

Off-Site Low-level Radioactive Waste Disposal Facility

Effectiveness - An off-site LLWDF would be effective in containing the 60,700 cu m (79,300 cu yd) of contaminated material from the Solid Waste Landfill and would be effective in meeting the remediation goals by reducing migration of all of the contaminants at the subunit. However the toxicity, mobility, or volume of the contaminants would not be reduced. An off-site LLWDF would be effective in protecting human health at the FEMP by reducing public exposure to the waste material. An off-site LLWDF would be effective in protecting the environment at the site by reducing wildlife exposure to the waste material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas (EPA, 1988).

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. A LLWDF would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces (EPA, 1988).

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. Any free-standing water in the LLW will have to be dried prior to disposal. Waste material would have to meet all acceptance criteria for the off-site LLWDF identified in Section 3.5.6. It also may be difficult to obtain permits to transport the waste across state lines to get to the existing facilities. Resources required to excavate and transport the waste material are readily available. Options for disposing LLW at off-site facilities are limited:

- Nevada Test Site (currently accepting FEMP low-level waste)
- Envirocare (not yet authorized to accept FEMP low-level waste)

Using either of these options for the disposal of contaminated material would probably require the construction of a new waste cell at that facility. An off-site low-level waste cell could be developed in conjunction with other FEMP remedial efforts.

Approval must be gained from the DOE headquarters (Washington - EM1) and the off-site facility prior to off-site disposal of contaminated material. Also, the use of other DOE facilities to dispose of contaminated material may be difficult to implement.

Cost - When compared to other off-site disposal options, an off-site LLWDF has a high capital cost and a moderate O&M cost.

Conclusion - Retain the option of using an off-site LLWDF for further consideration.

Truck Transportation

Effectiveness - Truck transport is effective for short distances, but is not as effective as rail transport for the distances required for the off-site disposal option at NTS or other facilities depending on the availability of rail spurs. Truck transport is a highly reliable means of transporting contaminated material. Truck transport would be required for on-site disposal and off-site disposal to facilities without rail spurs.

Implementability - Truck transport would be easily implemented at the site. Notification to state and local agencies along the transport route would be required.

Cost - When compared to rail transportation, truck transportation has a moderate capital cost and a high O&M cost.

Conclusion - Retain the option of using truck transportation for further consideration.

Rail Transportation

Effectiveness - Rail transportation is effective for transportation of contaminated material to off-site disposal facilities with railroad spurs and NTS. Rail transportation allows large volumes of contaminated material to be transported at one time. Typically, fewer accidents occur on a per-trip basis by rail than by truck. However, should an accident occur, much larger quantities of contaminated material could be exposed to the public. Rail transport is highly reliable. Rail transport would be applicable to off-site disposal options at facilities with rail spurs and in combination with truck transport for disposal at NTS.

Implementability - Rail transport is readily implementable because the FEMP site has an existing on-site rail spur. However, rail transport is susceptible to route availability and coordination with state and local agencies along the route. In addition, special packaging of waste would be required for rail transport.

Cost - When compared to truck transportation, rail transportation has a high capital cost and low O&M costs.

Conclusion - Retain the option of using rail transportation for further consideration.

3.7.2 Lime Sludge Ponds

The technologies and process options for the Lime Sludge Ponds remaining after the initial screening are evaluated based on effectiveness, implementability, and cost.

3.7.2.1 No Action

Effectiveness - No action does not meet the remediation goals identified in the RAOs. No action would not reduce the risk to human health associated with direct exposure to the soil/lime sludge/waste. No action would not provide any protection of the environment, as contaminants would continue to migrate from the soil/lime sludge/waste to the underlying soil and groundwater.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated no action.

Conclusion - Retain no action for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.7.2.2 Institutional Actions

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 Lime Sludge Ponds. 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 as contaminants could continue to migrate into the environment through groundwater, soil, surface water, and the atmosphere; however, 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 impact to both 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, physical barriers can be breached during acts of vandalism or vagrancy.

Implementability - Physical barriers are administratively feasible and require no special permitting to implement. Physical barriers are currently in-place; however, security and maintenance activities would be required for long-term implementation.

Cost - When compared to the deed restriction process option, physical barriers would have a moderate capital cost and a moderate O&M cost. O&M costs include both security and maintenance activities.

Conclusion - Retain physical barriers for further consideration in conjunction with containment and on-site disposal technologies.

Security Guards

Effectiveness - Security guards are effective in supplementing physical barriers. Security forces would monitor the physical barriers for breaches. Random patrols would discourage vandalism or vagrancy. Security guards would physically remove trespassers that did breach the barriers. Security guards provide no reduction in toxicity, mobility, or volume of contaminants. Security guards are effective in protecting human health by restricting public access to the waste site. Security guards are a reliable and proven method of restricting access of the general public to a waste site.

Implementability - Security guards are administratively feasible. Security forces are currently on site. Physical barriers would be required for long term implementation.

Cost - Security guards have a low capital cost and moderate O&M cost. These costs are included in the cost of physical barriers.

Conclusion - Retain security guards for further consideration. Use with physical barriers in conjunction with containment and on-site disposal technologies.

Deed Restrictions

Effectiveness - Deed restrictions would be effective in placing legal restraints on the future usage or development of areas used to contain or dispose of contaminated material contained at the Lime Sludge Ponds. Deed restrictions can be effective in protecting human health by restraining agricultural, construction, or other usage or development activities that could increase personal or public exposure to the contaminated material. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

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. However, deed restrictions could prevent the drilling of wells that could allow or increase the migration of waste into and through the underlying soil and groundwater. Deed restrictions are a reliable method for placing legal restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to the waste site.

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 - When compared to physical barriers, deed restrictions have both low capital and O&M costs.

Conclusion - Retain deed restrictions for further consideration. Use in conjunction with containment and on-site disposal technologies in which contaminants remain on site.

3.7.2.3 In Situ Containment

Composite Cap

Effectiveness - A composite cap would be able to effectively cover the area containing contaminated material in the Lime Sludge Ponds. A composite cap would be an effective method for reducing the infiltration rate of surface water through 12,600 cu m (16,500 cu yd) of material containing uranium-238, radium-228, thorium-228, beryllium, and Aroclor-1254. A composite cap would also be effective at limiting the release of radon and biogenic gases to the atmosphere. Construction of a

composite cap would be effective in meeting the remediation goals since it would reduce the migration of the contaminants (EPA, 1988). The K-65 slurry line would have to be relocated prior to constructing a composite cap over the Lime Sludge Ponds. Also, any standing water would be removed from the ponds.

During construction, significant volumes of cobbles may have to be hauled from off-site sources to the site. Dust and truck traffic on local highways and roads can be mitigated by using dust suppressants, limiting truck traffic during rush hours, and enforcing traffic laws. This would decrease the possibility of traffic accidents.

A composite cap would be designed to provide an effective life of 1,000 years with a minimum life of 200 years. The longevity of composite caps is not well proven because all of the caps currently existing have been recently constructed; therefore, the effective life 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 assure 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 - Retain composite cap for further consideration.

Surface Water Controls

Effectiveness - Surface water controls can be very effective in managing and directing surface water around areas required to handle, treat, or dispose of contaminated material contained in the Lime Sludge Ponds. Surface water controls are effective in meeting remediation goals by reducing the migration of contaminants through surface water. Surface water controls are effective in protecting both human health and the environment by reducing the quantity of contaminants migrating along with surface water to areas outside the site. 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 unvegetated soils and by using dust suppressants. Surface water control technology is well proven and understood, and is a reliable method for controlling surface water.

Implementability - Surface water controls are administratively feasible. Resources required to construct the surface water controls are readily available. Surface water controls are appropriate for use with containment options.

Cost - Surface water controls have low capital and low O&M costs.

Conclusion - Retain surface water controls for further consideration with containment technologies.

3.7.2.4 Removal

Mechanical Excavation

Effectiveness - Mechanical excavation can be very effective in moving, excavating and handling large quantities of soil or lime sludge, and in excavating localized areas of elevated contaminant concentrations. However, excavation is not, by itself, a primary remediation technology. Therefore, the use of mechanical excavation alone is not effective in meeting remediation goals, or in protecting either human health or the environment. During implementation, risks to human health would be mitigated by observing excavation safety procedures and by using dust suppressants. Excavation is a reliable method for material handling or earth moving operations, when used in support of other remediation technologies.

Implementability - The use of mechanical excavation is administratively feasible at the site. Both resources and services required to provide excavation and earth moving operations are readily available.

Cost - When compared to other removal options, the use of mechanical excavation has moderate capital and O&M costs.

Conclusion - Retain mechanical excavation for further consideration as a support action to other primary technologies.

Sorting/Separation

Effectiveness - Sorting/separation would be an effective technology for handling the volume of contaminated material present at the Lime Sludge Ponds. Sorting/separation would be effective for reducing the total amount of contaminated waste that would have to be treated or disposed. The use of sorting/separation is not effective by itself in meeting remediation goals. However, it is effective when used in conjunction with other process options. During construction, risks to site workers using field screening equipment can be mitigated by using safe work practices. Sorting/separation is reliable for visually identifying lime sludge or soil and sorting using mechanical excavators. It is also reliable for separating dried lime sludge from soil materials by particle size using mechanical screening techniques. The identification process for separating radiologically contaminated materials from non-radiologically contaminated materials is relatively slow.

Implementability - Sorting/separation is administratively feasible if conservative sorting decisions are made in the field. A method of quality assurance will need to be developed to calibrate the field readings with laboratory analysis to ensure that material sorted as non-contaminated is, in fact, clean. The resources for sorting using mechanical excavators and mechanical screening are readily available. The currently available resources for sorting radiological contamination are slow. Devices that can identify large quantities of radiologically contaminated material relatively quickly are currently being developed. A site demonstration is currently planned for 1994.

Cost - When compared to other removal options, sorting/separation has a moderate capital cost and a high O&M cost.

Conclusion - Retain sorting/separation for further consideration as a support action to other technologies that require contaminated material to be separated prior to treatment or off-site disposal.

Revegetation

Effectiveness - Revegetation can be effective in stabilizing surface soils when used in conjunction with removal technologies that excavate the entire contents of the Lime Sludge Ponds. Revegetation is effective in meeting the remediation goal of protecting the environment by reducing the migration of surface soils into streams. Revegetation is effective at controlling wind and surface water erosion. Revegetation is a reliable method for surface stabilization; however, revegetation is not a reliable

method for surface stabilization in areas where strong erosion forces, steep grades, ponding conditions, infertile soil, or surface contaminants exist.

Implementability - Revegetation is administratively feasible and requires no special permitting to implement. Both resources and services required to place a vegetative cover are readily available.

Cost - When compared to other surface controls, revegetation has both low capital and O&M costs.

Conclusion - Retain revegetation for further consideration with removal technologies.

3.7.2.5 Ex Situ Treatment

Stabilization/Solidification

Effectiveness - Stabilization/solidification can be very effective in reducing the mobility of the inorganic contaminants and radionuclides present in the soil/lime sludge media at the Lime Sludge Ponds. These contaminants include radium-228, thorium-228, uranium-238, and beryllium. Approximately 12,600 cu m (16,500 cu yd) of material would require stabilization/solidification. This process would also be effective for creating a stabilized material by mixing the lime sludge with flyash. Stabilized soil meets the remediation goals by preventing human contact with the contaminants and minimizing the potential for leaching of contaminants to the environment (EPA, 1988). Stabilization/solidification would not reduce the toxicity of contaminants in the soil or lime sludge and there would be a net volume increase. Stabilization/solidification is effective in the long term because the mobility of the contaminants can be reduced. The reliability and effectiveness of these processes on soil containing heavy metals and radioactive material is well proven (EPA, 1988).

During construction and operation of the stabilization/solidification facility, impacts to human health and the environment can be mitigated by using sound construction safety practices when handling the contaminated waste materials.

Implementability - Stabilization/solidification is administratively feasible when used in conjunction with other technologies such as on-site disposal. Implementation of cement/pozzolan-based processes involves traditional cement mixing equipment that is widely available and supplied by many vendors. Some sorting/separation of the soils/lime sludge may be required to produce an acceptable feedstock to the stabilization/solidification process. A treatability study for the lime sludge/flyash will be

required to determine effectiveness and optimum mixing ratios. EPA accepts stabilization/solidification as a proven technology for treating many hazardous wastes. The final stabilized material could be disposed on-site and would be in a solid/stable form for ease in handling and transporting. The final product would meet requirements for disposal at an on-site facility.

Cost - When compared to other ex situ physical/chemical treatment options, stabilization/solidification has moderate capital and O&M costs.

Conclusion - Retain stabilization/solidification for alternative evaluation.

Thermoplastic Encapsulation

Effectiveness - Thermoplastic encapsulation can be effective in reducing the mobility of the radiological contaminants present in the soil/lime sludge at the Lime Sludge Ponds; however, the volume of material to be disposed would increase due to the addition of the thermoplastic material. Encapsulated contaminated material meets the remediation goals by preventing human contact with the contaminants and minimizing the potential for leaching to the environment. In the encapsulation process, the contaminated materials do not react chemically with the encapsulation material; therefore, this technology does not reduce the toxicity of the contaminated material.

During construction and operation of the thermoplastic encapsulation facility, impacts to human health and the environment can be mitigated through the use of sound construction safety practices when handling the contaminated materials or the molten encapsulation material.

Thermoplastic encapsulation is moderately effective in the long term because the radiological COC's mobility can be reduced. The reliability and effectiveness of this process on metals have only been proven on pilot scale studies. In general, there has been limited treatment of low-level radioactive waste materials and contaminated soils using thermoplastic encapsulation. Because of limited information, laboratory and bench scale studies would have to be performed on the waste to assure the technology can treat the waste. The performance of thermoplastic encapsulation is highly waste specific, requiring thorough physical and chemical characterization of the contaminated material to determine the most suitable encapsulation material and mixing ratios. Also, special material handling requirements and pretreatment methods may be needed in the process.

Implementability - Implementation of the thermoplastic encapsulation process is administratively feasible. This technology involves specialized polymer mixing equipment that is only supplied by a few vendors. Thermoplastic encapsulation is not a proven technology for immobilizing low level radioactive contaminants. Contractors and skilled workers that have performed the encapsulation process on waste material will be limited.

Cost - When compared to other ex situ physical/chemical treatment options, thermoplastic encapsulation has high capital and O&M costs.

Conclusion - Eliminate thermoplastic encapsulation for further consideration based on a lack of proven capabilities and the associated large volume increases. Stabilization/solidification will be retained because it provides a similar effectiveness, is easier to implement, and has a lower cost than thermoplastic encapsulation.

Crushing/Shredding

Effectiveness - Crushing/shredding would be effective as a pretreatment step for reducing the size and improving the material handling characteristics of large pieces of contaminated debris, construction debris and containers, etc., found in the K-65 slurry line at the Lime Sludge Ponds. Approximately 46 cu m (60 cu yd) of debris from the K-65 slurry line would require crushing/shredding. This process would help meet the remediation goals for the site by allowing contaminated debris to be treated by one of the other treatment steps.

During construction, potential impacts to workers can be mitigated through the use of sound construction safety practices when operating the crushing and shredding equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated. Crushing and shredding processes are well proven. Shredders are commonly used at resource recovery centers as pretreatment step.

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 ex situ physical/chemical treatment options, crushing/shredding has low capital and O&M costs.

Conclusion - Retain crushing/shredding for alternative evaluation.

Drying

Effectiveness - Drying would be effective as a pretreatment step for material preparation for other treatment processes and as a primary treatment step to dry the lime sludge or contaminated material for shipment off site without additional treatment. Drying would be required for 5,400 cu m (7,100 cu yd) of material at the Lime Sludge Ponds.

During construction, potential impacts to workers can be mitigated by using safe work practices when operating the drying equipment. After construction, this process would enable the contaminated materials to be readily treated. "Off-gases" and dust may be created by drying, but their impacts will be mitigated through the use of the appropriate controls (e.g., HEPA filters). Drying processes are well proven. Filter presses are commonly used for sludge dewatering at wastewater treatment plants. Pulse drying and kiln drying have been used successfully for drying soils and sludges.

Implementability - Drying is administratively feasible as either a pretreatment or primary treatment step. The equipment and labor to operate this equipment is readily available.

Cost - When compared to other ex situ physical/chemical treatment options, drying has moderate capital and O&M costs.

Conclusion - Retain drying for alternative evaluation.

3.7.2.6 Disposal

On-Site Disposal Facility

Effectiveness - An on-site disposal cell would be effective in containing the volumes of contaminated material from the Lime Sludge Ponds and would be effective in meeting the remediation goals by reducing migration of the contaminants. A disposal cell could be designed to receive 12,600 cu m (16,500 cu yd) of material from the Lime Sludge Ponds. The toxicity, mobility, or volume of the contaminants would not be reduced. An on-site disposal cell would be effective in protecting human health by reducing public exposure to the contaminated material. An on-site disposal cell would be effective in protecting the environment by reducing wildlife exposure to the contaminated material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination,

and reducing releases of radon gas (EPA, 1988). The disposal cell would be designed for minimum life of 200 years in accordance with 40 CFR 192 and DOE Order 5400.5. A disposal cell would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces; however, the 1,000 year effective life has not yet been proven on any disposal cell (EPA, 1988).

During construction and filling of a disposal cell, potential impacts to workers can be mitigated through the use of sound construction safety practices. The materials would have to be transported and compacted, which may increase airborne contamination. However, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented.

Implementability - Implementation of an on-site disposal cell 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 can be readily constructed by experienced civil contractors and skilled workers. Resources required to construct the disposal cell are readily available. The placement of a geomembrane liner requires a skilled labor force to assure 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 cell has a high capital cost and a high O&M cost.

Conclusion - Retain an on-site disposal cell for further consideration.

<u>Off-Site Low-level Radioactive Waste Disposal Facility</u>

Effectiveness - An off-site LLWDF would be effective in containing the 27,200 cu m (35,500 cu yd) of contaminated material from the Lime Sludge Ponds and would be effective in meeting the remediation goals by reducing the migration of contaminants at the subunit. However, the toxicity, mobility, or volume of the contaminants would not be reduced. An off-site LLWDF would be effective in protecting human health at the FEMP by reducing public exposure to the contaminated material. An off-site LLWDF would be effective in protecting the environment by reducing wildlife

exposure to the contaminated material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas (EPA, 1988).

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 minimized by using rail transportation. A LLWDF would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces.

Implementability - Using an off-site LLWDF is administratively feasible; however, it must be proven that the material has not been contaminated with hazardous constituents that are not accepted at the LLWDF. Any free-standing water in the contaminated material will have to be dried prior to disposal. Waste material would have to meet all acceptance criteria for the off-site LLWDF identified in Section 3.5.6. It also may be difficult to obtain permits to transport the waste across state lines to get to the existing facilities. Resources required to excavate and transport the waste material are readily available. Options for disposing contaminated waste at off-site facilities are limited:

- Nevada Test Site (currently accepting FEMP low-level waste)
- Envirocare (not yet authorized to accept FEMP low-level waste)

Using either of these options for the disposal of contaminated material would probably require the construction of a new waste cell at that facility. An off-site low level radioactive waste cell could be developed in conjunction with other FEMP remedial efforts.

Approval must be gained from the DOE headquarters (Washington - EM1) and the off-site facility prior to off-site disposal of contaminated material. Also, the use of other DOE facilities to dispose of contaminated material may be politically difficult to implement.

Cost - When compared to other off-site disposal options, an off-site LLWDF has a high capital cost and a low O&M cost.

Conclusion - Retain the option of using an off-site LLWDF for further consideration.

Truck Transportation

Effectiveness - Truck transport is effective for short distances, but is not as effective as rail transport for the distances required for the off-site disposal option at NTS or other facilities depending on the availability of rail spurs. Truck transport is a highly reliable means of transporting contaminated material. Truck transport would be required for on-site disposal and off-site disposal to facilities without rail spurs.

Implementability - Truck transport would be easily implemented at the site. Notification to state and local agencies along the transport route would be required.

Cost - When compared to rail transportation, truck transportation has a moderate capital cost and a high O&M cost.

Conclusion - Retain the option of using truck transportation for further consideration.

Rail Transportation

Effectiveness - Rail transportation is effective for transportation of contaminated material to off-site disposal facilities with railroad spurs and NTS. Rail transportation allows large volumes of contaminated material to be transported at one time. Typically, fewer accidents occur on a per-trip basis by rail than by truck. However, should an accident occur, much larger quantities of contaminated material could be exposed to the public. Rail transport is highly reliable. Rail transport would be applicable to off-site disposal options at facilities with rail spurs and in combination with truck transport for disposal at NTS.

Implementability - Rail transport is readily implementable because the FEMP site has an existing on-site rail spur. However, rail transport is susceptible to route availability and coordination with state and local agencies along the route. In addition, special packaging of waste would be required for rail transport.

Cost - When compared to truck transportation, rail transportation has a high capital cost and low O&M costs.

Conclusion - Retain the option of using rail transportation for further consideration.

3.7.3 Inactive Flyash Pile

The technologies and process options for the Inactive Flyash Pile remaining after the initial screening are evaluated based on effectiveness, implementability, and cost.

3.7.3.1 No Action

Effectiveness - No action does not meet the remediation goals identified in the RAOs. No action would not reduce the risk to human health associated with direct exposure to the soil/flyash/waste. No action would not provide any protection of the environment, as contaminants would continue to migrate from the soil/flyash/waste to the underlying soil and groundwater.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated with no action.

Conclusion - Retain no action for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.7.3.2 Institutional Actions

Physical Barriers

Effectiveness - Physical barriers would be an effective method for isolating and defining the area required to handle, treat, or dispose of contaminated material contained at the Inactive Flyash Pile. 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 as contaminants could continue to migrate into the environment through groundwater, soil, surface water, and the atmosphere; however, 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 impact to both 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, physical barriers can be breached during acts of vandalism or vagrancy.

Implementability - Physical barriers are administratively feasible and require no special permitting to implement. Physical barriers are currently in place; however, security and maintenance activities would be required for long-term implementation.

Cost - When compared to the deed restriction process option, physical barriers would have a moderate capital cost and a moderate O&M cost. O&M costs include both security and maintenance activities.

Conclusion - Retain physical barriers for further consideration in conjunction with containment and on-site disposal technologies.

Security Guards

Effectiveness - Security guards are effective in supplementing physical barriers. Security forces would monitor the physical barriers for breaches. Random patrols would discourage vandalism or vagrancy. Security guards would physically remove trespassers that did breach the barriers. Security guards provide no reduction in toxicity, mobility, or volume of contaminants. Security guards are effective in protecting human health by restricting public access to the waste site. Security guards are a reliable and proven method of restricting access of the general public to a waste site.

Implementability - Security guards are administratively feasible. Security forces are currently on site. Physical barriers would be required for long term implementation.

Cost - Security guards have a low capital cost and moderate O&M cost. These costs are included in the cost of physical barriers.

Conclusion - Retain security guards for further consideration. Use with physical barriers in conjunction with containment and on-site disposal technologies.

Deed Restrictions

Effectiveness - Deed restrictions would be effective in placing legal restraints on the future usage or development of areas used to contain or dispose of contaminated material contained at the Inactive Flyash Pile. Deed restrictions can be effective in protecting human health by restraining agricultural, construction, or other usage or development activities that could increase public exposure to the

contaminated material. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

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. However, deed restrictions could prevent the drilling of wells that could allow or increase the migration of waste into and through the underlying soil and groundwater. Deed restrictions are a reliable method for placing legal restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to the waste site.

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 - When compared to physical barriers, deed restrictions have both low capital and O&M costs.

Conclusion - Retain deed restrictions for further consideration. Use in conjunction with in situ containment and on-site disposal technologies in which contaminants remain on site.

3.7.3.3 <u>In Situ Containment</u>

<u>Composite Cap</u>

Effectiveness - A composite cap would be able to effectively cover the area containing contaminated material in the Inactive Flyash Pile. A composite cap would be an effective method for reducing the infiltration rate of surface water through 76,800 cu m (100,400 cu yd) of material containing uranium-234, uranium 235/236, uranium-238, radium-228- thorium-228, arsenic, and beryllium. A composite cap would also be effective at limiting the release of radon and biogenic gases to the atmosphere. Construction of a composite cap would be effective in meeting the remediation goals, since it would reduce the migration of the contaminants (EPA, 1988).

During construction, significant volumes of cobbles may have to be hauled from off-site sources to the site. Dust and truck traffic on local highways and roads can be mitigated by using dust

suppressants, limiting truck traffic during rush hours, and enforcing traffic laws. This would decrease the possibility of traffic accidents.

A composite cap would be designed to provide an effective life of 1,000 years with a minimum life of 200 years. The longevity of composite caps is not well proven because all of the caps currently existing have been recently constructed; therefore, the effective life 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 assure 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 - Retain composite cap for further consideration.

Surface Water Controls

Effectiveness - Surface water controls can be very effective in managing and directing surface water around areas required to handle, treat, or dispose of contaminated material contained in the Inactive Flyash Pile. Surface water controls are effective in meeting remediation goals by reducing the migration of contaminants through surface water. Surface water controls are effective in protecting both human health and the environment by reducing the quantity of contaminants migrating along with surface water to areas outside the site. 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 unvegetated soils and by using dust suppressants. Surface water control technology is well proven and understood, and is a reliable method for controlling surface water.

Implementability - Surface water controls are administratively feasible, although some controls may require obtaining approval from the COE and other governmental agencies and departments having relevant jurisdiction. Resources required to construct the surface water controls are readily available. Surface water controls are appropriate for use with containment options.

Cost - Surface water controls have low capital and low O&M costs.

Conclusion - Retain surface water controls for further consideration with containment technologies.

3.7.3.4 Removal

Mechanical Excavation

Effectiveness - Mechanical excavation can be very effective in moving, excavating, and handling large quantities of soil or flyash, and in excavating localized areas of elevated contaminant concentrations. However, excavation is not, by itself, a primary remediation technology. Therefore, the use of mechanical excavation alone is not effective in meeting remediation goals, or in protecting either human health or the environment. During implementation, risks to human health would be mitigated by observing excavation safety procedures and by using dust suppressants. Excavation is a reliable method for material handling or earth moving operations, when used in support of other remediation technologies.

Implementability - The use of mechanical excavation is administratively feasible at the site. Both resources and services required to provide excavation and earth moving operations are readily available.

Cost - When compared to other removal options, the use of mechanical excavation has moderate capital and O&M costs.

Conclusion - Retain mechanical excavation for further consideration as a support action to other primary technologies.

Sorting/Separation

Effectiveness - Sorting/separation would be an effective technology for handling the volumes of contaminated material present at the Inactive Flyash Pile. Sorting/separation would be effective for minimizing the total amount of contaminated material that would have to be treated or disposed. The use of sorting/separation is not effective by itself in meeting remediation goals. However, it is effective when used in conjunction with other process options. During construction, risks to site workers using field screening equipment can be mitigated by using safe work practices. Sorting/separation is reliable for visually identifying flyash from other fill soils and sorting using

mechanical excavators. The identification process for separating radiologically contaminated material from non-radiologically contaminated material is relatively slow.

Implementability - Sorting/separation is administratively feasible if conservative sorting decisions are made in the field. A method of quality assurance will need to be developed to calibrate the field readings with laboratory analysis to ensure that material sorted as non-contaminated is, in fact, clean. The resources for sorting using mechanical excavators are readily available. The currently available resources for sorting contaminated material are slow. Devices that can identify large quantities of radiologically contaminated material relatively quickly are currently being developed. A site demonstration is currently planned for 1994.

Cost - When compared to other removal options, sorting/separation has a moderate capital cost and a high O&M cost.

Conclusion - Retain sorting/separation for further consideration as a support action to other technologies that require contaminated material to be separated prior to treatment of off-site disposal.

Revegetation

Effectiveness - Revegetation can be effective in stabilizing surface soils when used in conjunction with removal technologies that excavate the entire contents of the Inactive Flyash Pile. Revegetation is effective in helping achieve the remediation goal of protecting the environmental by reducing the migration of surface soils into streams. Revegetation is effective at controlling wind and surface water erosion. Revegetation is a reliable method for surface stabilization; however, revegetation is not a reliable method for surface stabilization in areas where strong erosion forces, steep grades, ponding conditions, infertile soil, or surface contaminants exist.

Implementability - Revegetation is administratively feasible and requires no special permitting to implement. Both resources and services required to place a vegetative cover are readily available.

Cost - When compared to other surface controls options, revegetation has a moderate capital cost and low O&M cost.

Conclusion - Retain revegetation for further consideration with removal technologies.

3.7.3.5 Ex Situ Treatment

Soil Washing

Effectiveness - Soil washing can be an effective process option for treating approximately 11,900 cu m (15,500 cu yd) of soil contaminated with uranium at the Inactive Flyash Pile. The soil needs to 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. Currently, the residual waste stream would be dried and sent to an off-site low level radioactive waste disposal facility.

During construction and operation of the soil washing facility, there would only be a minimal 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 practiced to minimize this risk. Soil washing is effective in the long term because the uranium can be separated from the soils leaving behind the majority of the soil as non-contaminated material. The soil washing technology has been used in both ore mining and cleanup of contaminated sites. The Inactive Flyash Pile contains material contaminated with uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, arsenic, and beryllium; however, the soil washing program underway at the FEMP has only been shown to extract uranium. An ongoing treatability study will determine the most effective extraction solution and the effectiveness of soil washing for other COCs.

Implementability - Soil washing is administratively feasible when used in conjunction with other technologies. Soil washing uses mining and earth moving 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 will have high concentrations of contaminants that may require disposal options that are not currently considered for the Inactive Flyash Pile. Actual soil washing tests will have to be done on the soil at the South Field to determine the concentration of contaminants in the concentrated waste stream. Off-site disposal facilities would not be willing to accept the concentrated contaminant waste stream without additional post 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 - Retain soil washing for alternative evaluation.

Stabilization/Solidification

Effectiveness - Stabilization/solidification can be effective in reducing the mobility of the contaminants for 45,306 cu m (59,200 cu yd) of soil/flyash from the Inactive Flyash Pile. The contaminants include uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, arsenic, and beryllium. Mixing the flyash with lime sludge would also create an effective low permeability backfill. A stabilized block of soil meets the remediation goals by preventing human contact with the contaminants and minimizing the potential for leaching of contaminants to the environment. Stabilization/solidification processes do not reduce the toxicity of contaminants in a soil or waste and there is a net volume increase (EPA, 1988). Stabilization/solidification is effective in the long term because the mobility of the radiological contaminants can be reduced. The reliability and effectiveness of these processes on materials containing heavy metals and radioactive material is well proven (EPA, 1988).

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/pozzolan-based processes involves traditional cement mixing equipment that is widely available and supplied by many vendors. Some sorting/separation of the soils/flyash would be required to produce an acceptable feedstock to the stabilization/solidification process. A treatability study for the flyash/lime sludge will be required to determine effectiveness and optimum mixing ratios. 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 solid/stable form for ease in handling and transporting. 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 - Retain stabilization/solidification for alternative evaluation.

Thermoplastic Encapsulation

Effectiveness - Thermoplastic encapsulation can be effective in reducing the mobility of the radiological contaminants (uranium-234, uranium-235/236, uranium-238, radium-228, and thorium-228) present in the soil/sediment/flyash at the Inactive Flyash Pile; however, the volume of material to be disposed would increase due to the addition of thermoplastic material. Encapsulated contaminated material meets the remediation goals by preventing human contact with the contaminants and minimizing the potential for leaching to the environment. In the encapsulation process, the contaminated materials do not react chemically with the encapsulation material; therefore, this technology does not reduce the toxicity of the contaminated material.

During construction and operation of the thermoplastic encapsulation facility, impacts to human health and the environment can be mitigated through the use of sound construction safety practices when handling the contaminated materials or the molten encapsulation material.

Thermoplastic encapsulation is moderately effective in the long term because the mobility of the radiological COCs can be reduced. The reliability and effectiveness of this process on inorganic metals have only been proven on pilot scale studies. In general, there has been limited treatment of low-level radioactive waste materials and contaminated soils using thermoplastic encapsulation. Because of limited information, laboratory and bench scale studies would have to be performed on the waste to assure the technology can treat the waste. The performance of thermoplastic encapsulation is highly waste specific, requiring thorough physical and chemical characterization of the contaminated material to determine the most suitable encapsulation material and mixing ratios. Also, special material handling requirements and pretreatment methods may be needed in the process.

Implementability - Implementation of the thermoplastic encapsulation process is administratively feasible. This technology involves specialized polymer mixing equipment that is only supplied by a few vendors. Thermoplastic encapsulation is not a proven technology for immobilizing low level

radioactive wastes. Availability of contractors and skilled workers that have performed the encapsulation process on waste material will be limited.

Cost - When compared to other physical/chemical treatment options, thermoplastic encapsulation has high capital and O&M costs.

Conclusion - Eliminate thermoplastic encapsulation for further consideration based on a lack of proven capabilities and the associated large volume increases. Stabilization/solidification will be retained because it provides a similar effectiveness, is easier to implement, and has a lower cost than thermoplastic encapsulation.

Crushing/Shredding

Effectiveness - Crushing/shredding would be effective as a pretreatment step for reducing the size and improving the material handling characteristics of large pieces of waste debris, construction debris, containers, etc. found in the Inactive Flyash Pile. Approximately 3,100 cu m (4,000 cu yd) of debris will require crushing/shredding. This process would help meet the remediation goals for the site by allowing contaminated debris to be treated by one of the other treatment steps.

During construction, potential impacts to workers can be mitigated through the use of sound construction safety practices when operating the crushing and shredding equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated. Crushing and shredding processes are well proven. Shredders are commonly used at resource recovery centers as a pretreatment step for incinerators.

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 ex situ physical/chemical treatment options, crushing/shredding has low capital and O&M costs.

Conclusion - Retain crushing/shredding for alternative evaluation.

Drying

Effectiveness - Drying would be effective as a pretreatment step for material preparation for other treatment processes and as a primary treatment step to dry the radiologically contaminated material for shipment off-site without any other treatment. Drying of 5,300 cu m (6,900 cu yd) would be required for material at the Inactive Flyash Pile. Drying would also be effective as a post treatment step to be used to reduce the water content of soil washing residues or flocculated material from a water pretreatment process.

During construction, potential impacts to workers can be mitigated through the use of sound construction safety practices when operating the drying equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated or disposed. "Off-gases" and dust may be created by drying, but their impacts will be mitigated through the use of the appropriate controls (e.g., HEPA filters). Drying processes are well proven. Filter presses are commonly used for sludge dewatering at wastewater treatment plants. Pulse drying and kiln drying have been used successfully for drying soils, sediments, and ash.

Implementability - Drying is administratively feasible as either a pretreatment, primary treatment, or post treatment step. The equipment and labor to operate this equipment is readily available.

Cost - When compared to other physical/chemical treatment options, drying has moderate capital and O&M costs.

Conclusion - Retain drying for alternative evaluation.

Ex Situ Vitrification

Effectiveness - Vitrification would be an effective method of treating the contaminated materials after they have been excavated and sorted from the non-contaminated materials (EPA, 1992). Vitrification would help meet the remediation goals by destroying organics and immobilizing inorganics and radionuclides in a glass matrix. The molten glass process can potentially achieve high destruction removal efficiencies (over 99 percent) for hazardous organic contaminants. The metals and other resulting ash are immobilized by either dissolving or becoming suspended in the glass matrix. Upon cooling, the glass product 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. Vitrification would be performed on 12,300 cu m (16,100 cu yd) of material containing uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, arsenic, and beryllium.

During operation, the vitrification is limited by the capacity of the "off-gas" system which can become overloaded by gas generation of organics as they volatize. To control the generation of these gases, the waste may need pretreating to reduce the organic and moisture contents. The materials would have to be excavated and handled, which may increase airborne concentrations of contaminants. During construction, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented. Emission controls could include a scrubber systems with HEPA filters. Potential impacts to workers operating the vitrification equipment can be mitigated by using safe work practices during the material handling and vitrification processes. The process is reliable and its primary application would be for encapsulation of contaminated material.

Implementability - Vitrification is administratively feasible. Equipment requirements, in addition to the molten glass furnace, include waste handling and storage facilities, as well as pollution control equipment such as scrubbers for acid gas removal and a demister/filter unit for particulate and mist removal. Mobile equipment has not been fully developed; however, a treatability study on site will be used to evaluate this technology's ability to treat the contaminated material at the FEMP. Contractors, skilled workers, and proven mobile equipment will be limited.

Cost - When compared to other ex situ thermal treatment options, ex situ vitrification has high capital and O&M costs.

Conclusion - Retain ex situ vitrification for alternative evaluation.

3.7.3.6 Disposal

On-Site Disposal Facility

Effectiveness - An on-site disposal facility would be effective in containing the 76,800 cu m (100,400 cu yd) of contaminated material from the Inactive Flyash Pile and would be effective in meeting the remediation goals by reducing the potential for migration of any of the contaminants. The toxicity, mobility, or volume of the contaminants would not be reduced. An on-site disposal cell

would be effective in protecting human health by reducing public exposure to the contaminated material (EPA, 1988). An on-site disposal cell would be effective in protecting the environment by reducing wildlife exposure to the contaminated material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas. The disposal cell would be designed for a minimum life of 200 years in accordance with 40 CFR 192 and DOE Order 5400.5. A disposal cell would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces; however, the 1,000 year effective life has not yet been proven on any existing disposal cell.

During construction and filling of an on-site disposal cell, potential impacts to workers can be mitigated through the use of sound construction safety practices. The contaminated materials would have to be transported and compacted, which may increase airborne contamination; however, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented.

Implementability - Implementation of an on-site disposal cell 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 can be readily constructed by several experienced civil contractors and skilled workers. Resources required to construct the disposal cell are readily available. The placement of the geomembrane liners requires a skilled labor force to assure proper installation and seaming of the liners. 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 cell has high capital and high O&M costs.

Conclusion - Retain an on-site disposal cell for alternative development.

Off-Site Disposal Facility

Effectiveness - An off-site disposal facility would be effective in containing the 24,200 cu m (31,600 cu yd) of non-radiologically contaminated flyash from the Inactive Flyash Pile and would be very effective in meeting the remediation goals by reducing the migration of the contaminants. However, the toxicity, mobility, or volume of the contaminants would not be reduced. An off-site

disposal facility would be effective in protecting human health by reducing public exposure to the flyash. An off-site disposal facility would be effective in protecting the environment by reducing wildlife exposure to the flyash, reducing surface water infiltration, reducing leachate generation, and reducing groundwater contamination. The off-site disposal facility would have a minimum effective life of 30 years post closure.

During excavation and transportation of flyash to an off-site disposal facility, potential impacts to workers can be mitigated through the use of sound construction safety practices. The materials would have to be handled and compacted at the off-site facility, which may increase airborne contamination; however, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented. An increase in truck traffic, required to haul the material off site, could be mitigated by using off-peak hours. An off-site disposal facility would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces.

Implementability - The administrative feasibility of using an off-site disposal facility may be difficult to implement. In order to dispose of flyash off site, it must be shown with reasonable certainty that the flyash has not been contaminated with either radiological or hazardous materials. It may be difficult to prove that the flyash has not been contaminated with radiological or hazardous materials during on-site storage. Approval must be gained from the OEPA, DOE headquarters (Washington - EM1), and the owner of the off-site facility prior to off-site disposal of any flyash. Resources required to excavate and transport the flyash are readily available. Facilities that provide off-site disposal services for flyash are numerous; however, finding a facility that will accept material from a DOE/CERCLA site will be difficult.

Cost - When compared to other disposal options, an off-site disposal facility has a moderate capital cost and a low O&M cost.

Conclusion - Retain the option of using an off-site disposal facility for alternative development.

Off-Site Low Level Radioactive Waste Disposal Facility

Effectiveness - An off-site LLWDF would be effective in containing 78,800 cu m (103,000 cu yd) of contaminated material from the Inactive Flyash Pile and would be effective in meeting the remediation

goals by reducing the migration of contaminants at the subunit. However, the toxicity, mobility, or volume of the contaminants would not be reduced. An off-site LLWDF would be effective in protecting human health at the FEMP by reducing public exposure to the contaminated material. An off-site LLWDF would be effective in protecting the environment by reducing wildlife exposure to the contaminated material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas.

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. A LLWDF would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces.

Implementability - Using an off-site LLWDF is administratively feasible; however, it must be proven that the material has not been contaminated with hazardous constituents that are not accepted at the LLWDF. Any free-standing water in the contaminated material will have to be dried prior to disposal. Waste material would have to meet all acceptance criteria for the off-site LLWDR identified in Section 3.5.6. It also may be difficult to obtain permits to transport the waste across state lines to get to the existing facilities. Resources required to excavate and transport the waste material are readily available. Options for disposing contaminated material at off-site facilities are limited:

- Nevada Test Site (currently accepting FEMP low-level waste)
- Envirocare (not yet authorized to accept FEMP low-level waste)

Using either of these options for the disposal of contaminated material would probably require the construction of a new waste cell at that facility. An off-site low-level waste cell could be developed in conjunction with other FEMP remedial efforts.

Approval must be gained from the DOE headquarters (Washington - EM1) and the off-site facility prior to off-site disposal of contaminated material. Also, the use of other DOE facilities to dispose of contaminated material may be difficult to implement.

Cost - When compared to other off-site disposal options, an off-site LLWDF has high capital cost and a low O&M cost.

Conclusion - Retain the option of using an off-site LLWDF for alternative development.

Truck Transportation

Effectiveness - Truck transport is effective for short distances, but is not as effective as rail transport for the distances required for the off-site disposal option at NTS or other facilities depending on the availability of rail spurs. Truck transport is a highly reliable means of transporting contaminated material. Truck transport would be required for on-site disposal and off-site disposal to facilities without rail spurs.

Implementability - Truck transport would be easily implemented at the site. Notification to state and local agencies along the transport route would be required.

Cost - When compared to rail transportation, truck transportation has a moderate capital cost and a high O&M cost.

Conclusion - Retain the option of using truck transportation for further consideration.

Rail Transportation

Effectiveness - Rail transportation is effective for transportation of contaminated material to off-site disposal facilities with railroad spurs and NTS. Rail transportation allows large volumes of contaminated material to be transported at one time. Typically, fewer accidents occur on a per-trip basis by rail than by truck. However, should an accident occur, much larger quantities of contaminated material could be exposed to the public. Rail transport is highly reliable. Rail transport would be applicable to off-site disposal options at facilities with rail spurs and in combination with truck transport for disposal at NTS.

Implementability - Rail transport is readily implementable because the FEMP site has an existing on-site rail spur. However, rail transport is susceptible to route availability and coordination with state and local agencies along the route. In addition, special packaging of waste would be required for rail transport.

Cost - When compared to truck transportation, rail transportation has a high capital cost and low O&M costs.

Conclusion - Retain the option of using rail transportation for further consideration.

3.7.4 South Field

The technologies and process options for the South Field remaining after the initial screening are evaluated based on effectiveness, implementability, and cost.

3.7.4.1 No Action

Effectiveness - No action does not meet the remediation goals identified in the RAOs. No action would not reduce the risk to human health associated with direct exposure to the soil/waste. No action would not provide any protection of the environment, as contaminants would continue to migrate from the soil/waste to the underlying soil and groundwater.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated with no action.

Conclusion - Retain no action for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.7.4.2 Institutional Controls

Physical Barriers

Effectiveness - Physical barriers would be an effective method for isolating and defining the areas required to handle, treat, or dispose of contaminated material contained at the South Field. 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 as contaminants could continue to migrate into the environment through groundwater, soil, surface water, and the atmosphere; however,

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 impact on both 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, physical barriers can be breached during acts of vandalism or vagrancy.

Implementability - Physical barriers are administratively feasible and require no special permitting to implement. Physical barriers are currently in place; however, security and maintenance activities would be required for long-term implementation.

Cost - When compared to the deed restriction process option, physical barriers would have a moderate capital cost and a moderate O&M cost. O&M costs include both security and maintenance activities.

Conclusion - Retain physical barriers for further consideration to be used in conjunction with containment and on-site disposal technologies.

Security Guards

Effectiveness - Security guards are effective in supplementing physical barriers. Security forces would monitor the physical barriers for breaches. Random patrols would discourage vandalism or vagrancy. Security guards would physically remove trespassers that did breach the barriers. Security guards provide no reduction in toxicity, mobility, or volume of contaminants. Security guards are effective in protecting human health by restricting public access to the waste site. Security guards are a reliable and proven method of restricting access of the general public to a waste site.

Implementability - Security guards are administratively feasible. Security forces are currently on site. Physical barriers would be required for long term implementation.

Cost - Security guards have a low capital cost and moderate O&M cost. These costs are included in the cost of physical barriers.

Conclusion - Retain security guards for further consideration. Use with physical barriers in conjunction with containment and on-site disposal technologies.

Deed Restrictions

Effectiveness - Deed restrictions would be effective in placing legal restraints on the future usage or development of areas used to contain or dispose of contaminated material contained at the South Field. Deed restrictions can be effective in protecting human health by restraining agricultural, construction, or other usage or development activities that could increase public exposure to the contaminated material. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

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. However, deed restrictions could prevent the drilling of wells that could allow or increase the migration of contaminants into and through the underlying soil and groundwater. Deed restrictions are a reliable method for placing legal restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to a waste site.

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 - When compared to physical barriers, deed restrictions have both low capital and O&M costs.

Conclusion - Retain deed restrictions for further consideration. Use in conjunction with in situ containment and on-site disposal technologies in which contaminants remain on site.

3.7.4.3 Containment

Composite Cap

Effectiveness - A composite cap would be able to effectively cover the area containing contaminated material in the South Field. A composite cap would be an effective method for reducing the infiltration rate of surface water through the 28,900 cu m (37,800 cu yd) of material containing uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, thorium-230, arsenic, beryllium, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene. A composite cap would also be effective at

limiting the release of radon and biogenic gases to the atmosphere. Construction of a composite cap would be effective in meeting the remediation goals, since it would reduce the migration of the contaminants (EPA, 1988).

During construction, significant volumes of cobbles may have to be hauled from off-site sources to the site. Dust and truck traffic on local highways and roads can be mitigated by using dust suppressants, limiting truck traffic during rush hours, and enforcing traffic laws. This would decrease the possibility of traffic accidents.

A composite cap would be designed to provide an effective life of 1,000 years with a minimum life of 200 years. Composite caps are not well proven because all of the caps currently existing have been recently constructed; therefore, the effective life 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 assure 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 - Retain composite cap for further consideration.

Surface Water Controls

Effectiveness - Surface water controls can be very effective in managing and directing surface water around areas required to handle, treat, or dispose of contaminated material contained in the South Field. Surface water controls are effective in meeting remediation goals by reducing the migration of contaminants through surface water. Surface water controls are effective in protecting both human health and the environment by reducing the quantity of contaminants migrating along with surface water to areas outside the site. During implementation of surface water controls, risks to human health and the environment due to the possible disturbance of the contaminated material and the migration of airborne contaminants in construction dust can be mitigated by minimizing areas of unvegetated soils, and by using dust suppressants. Surface water control technology is well proven and understood, and is a reliable method for controlling surface water.

Implementability - Surface water controls are administratively feasible, although some controls may require obtaining approval from the COE and other governmental agencies and departments having relevant jurisdiction. Resources required to construct the surface water controls are readily available. Surface water controls are appropriate for use with containment options.

Cost - Surface water controls have low capital and O&M costs.

Conclusion - Retain surface water controls for further consideration with containment technologies.

3.7.4.4 Removal

Mechanical Excavation

Effectiveness - Mechanical excavation can be very effective in moving, excavating and handling large quantities of soil, rock, or construction debris; and in excavating localized areas of elevated contaminant concentrations. However, excavation is not, by itself, a primary remediation technology. Therefore, the use of mechanical excavation alone is not effective in meeting remediation goals, or in protecting either human health or the environment. During implementation, risks to human health would be mitigated by observing excavation safety protocol and by using dust suppressants. Excavation is a reliable method for material handling or earth moving operations, when used in support of other remediation technologies.

Implementability - The use of mechanical excavation is administratively feasible at the site. Both resources and services required to provide excavation and earth moving operations are readily available.

Cost - When compared to other removal options, the use of mechanical excavation has moderate capital and O&M costs.

Conclusion - Retain mechanical excavation for further consideration as a support action to other primary technologies.

Sorting/Separation

Effectiveness - Sorting/separation would be an effective technology for handling the volume of contaminated material present at the South Field. Sorting/separation would be effective for

minimizing the total amount of contaminated material that would have to be treated or disposed. The use of sorting/separation is not effective by itself in meeting remediation goals. However, it is effective when used in conjunction with other process options. During construction, risks to site workers using field screening equipment can be mitigated by using safe work practices. Sorting/separation is reliable for visually identifying construction debris and sorting it from soils using mechanical excavators. It is also reliable for separating materials by particle size using mechanical screening techniques. The identification process for separating radiologically contaminated material from non-radiologically contaminated material is relatively slow.

Implementability - Sorting/separation is administratively feasible if conservative sorting decisions are made in the field. A method of quality assurance will need to be developed to calibrate the field readings with laboratory analysis to ensure that material sorted as non-contaminated is, in fact, clean. The resources for sorting using mechanical excavators and mechanical screening are readily available. The currently available resources for sorting radiological contamination are slow. Devices that can identify large quantities of radiologically contaminated material relatively quickly are currently being developed. A site demonstration is currently planned for 1994.

Cost - When compared to other removal options, sorting/separation has a moderate capital cost and a high O&M cost.

Conclusion - Retain sorting/separation for further consideration as a support action to other technologies that require contaminated material to be separated prior to treatment or off-site disposal.

Revegetation

Effectiveness - Revegetation can be effective in stabilizing surface soils when used in conjunction with removal technologies that excavate the contents of the South Field. Revegetation is effective in helping achieve the remediation goal of protecting the environment by reducing the migration of surface soils into streams. Revegetation is effective at controlling wind and surface water erosion. Revegetation is a reliable method for surface stabilization; however, revegetation is not a reliable method for surface stabilization in areas where strong erosion forces, steep grades, ponding conditions, infertile soil, or surface contaminants exist.

Implementability - Revegetation is administratively feasible and requires no special permitting to implement. Both resources and services required to place a vegetative cover are readily available.

Cost - When compared to other surface control options, revegetation has a moderate capital cost and a low O&M cost.

Conclusion - Retain revegetation for further consideration with removal technologies.

3.7.4.5 Ex Situ Treatment

Soil Washing

Effectiveness - Soil washing can be an effective process option for treating the 3,825 cu m (5,000 cu yd) of soil contaminated with uranium at the South Field. The excavated material needs to be sorted or crushed prior to treatment, to screen out or to improve the handling characteristics of construction debris and waste, and also to sort out non-radiologically contaminated materials. Soil washing would be effective in reducing the amount of uranium in the soil (Lockheed Environmental Systems and Technologies Company, 1993); however, a residual waste stream consisting of concentrated contaminants would have to be addressed. Currently, the residual waste stream would be dried and sent to an off-site low-level radioactive waste disposal facility.

During construction and operation of the soil washing facility, there would only be minimal risks 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 safety procedures would be practiced to minimize this risk. Soil washing is effective in the long term because the uranium can be separated from the soils leaving behind the majority of the soil as non-contaminated material. The soil washing technology has been used in both ore mining and cleanup of contaminated sites. The South Field contains uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, thorium-230, arsenic, beryllium, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene; however, the soil washing program underway at the FEMP has only been shown to extract uranium. An ongoing treatability study will determine the most effective extraction solution and determine the effectiveness of removing other COCs.

Implementability - Soil washing is administratively feasible when used in conjunction with other technologies. Soil washing uses mining and earth moving equipment that have been used in large

scale operations at other facilities. Trained FERMCO employees are available to operate the soil washing equipment. The concentrated waste stream generated from soil washing will have high concentrations of contaminants that may require disposal options that are not currently considered for the South Field. Actual soil washing tests will have to be done on the soil at the South Field to determine the concentration of contaminants in the concentrated waste stream. Off-site disposal facilities would not be able to accept the concentrated contaminant waste stream without additional post treatment steps such as residue drying, vitrification, or stabilization.

Cost - When compared to other physical/chemical treatment options, soil washing has high capital and O&M costs.

Conclusion - Retain soil washing for alternative evaluation.

Stabilization/Solidification

Effectiveness - Stabilization/solidification can be effective in reducing the mobility of the inorganic and radiological contaminants present in the 3,825 cu m (5,000 cu yd) of media at the South Field. A stabilized block of soil meets the remediation goals by preventing human contact with the contaminants (uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, thorium-230, arsenic, and beryllium) and minimizing the potential for leaching of contaminants to the environment. This process has been used to stabilize lead and other metals in sludges and soils that are similar to the South Field's contaminated material and soils. Most stabilization/solidification processes do not reduce the toxicity of contaminants in a material, and there is a net volume increase. Stabilization/solidification is effective in the long term because the mobility of the radiological contaminants can be reduced. The reliability and effectiveness of these processes on wastes containing heavy metals and radioactive material is well proven (EPA, 1988).

During construction and operation of the stabilization/solidification facility, impacts to human health and the environment can be mitigated by using safe work 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/pozzolan-based processes involves traditional cement mixing equipment that is widely available and supplied by many vendors.

Some sorting/separation and/or crushing of the contaminated material 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 and would be in a solid/stable form for ease in handling and transporting. The final product would meet requirements for disposal at an on-site facility.

Cost - When compared to other physical/chemical treatment options, stabilization/solidification has moderate capital and O&M costs.

Conclusion - Retain stabilization/solidification for alternative evaluation.

Thermoplastic Encapsulation

Effectiveness - Thermoplastic encapsulation can be very effective in reducing the mobility of the inorganic and radiological contaminants (uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, thorium-230, arsenic, and beryllium) present in the material at the South Field; however, the volume of material to be disposed would increase due to the addition of the thermoplastic material. Encapsulated waste material meets the remediation goals by preventing human contact with the contaminants and minimizing the potential for leaching to the environment. In the encapsulation process, the contaminated materials do not react chemically with the encapsulation material; therefore, this technology does not reduce the toxicity of the contaminated material.

During construction and operation of the thermoplastic encapsulation facility, impacts to human health and the environment can be mitigated through the use of safe work procedures when handling the contaminated materials or the molten encapsulation material.

Thermoplastic encapsulation is effective in the long term because the mobility of the radiological COCs can be reduced. The reliability and effectiveness of this process on metals have only been proven on pilot scale studies. In general, there has been limited treatment of low-level radioactive waste materials and contaminated soils using thermoplastic encapsulation. The performance of the thermoplastic encapsulation is highly material specific, requiring thorough physical and chemical characterization of the contaminated material to determine the most suitable encapsulation material and ratios. Because of limited information, laboratory and bench scale studies would have to be

performed on the contaminated material to assure the technology can treat the waste. Also, special material handling requirements and pretreatment methods may be needed in the process. A large percentage of the contaminated material in the South Field is construction debris that, even after crushing, may be too large for micro-encapsulation processes.

Implementability - Implementation of the thermoplastic encapsulation process is administratively feasible. This technology involves specialized polymer mixing equipment that is only supplied by a few vendors. The mixing equipment requires a homogeneous, small particle size feed material that would be very difficult to achieve using the material in the South Field. Thermoplastic encapsulation is not a well proven technology for immobilizing low-level radioactive wastes. Contractors and skilled workers that have performed the encapsulation process on contaminated material will be limited.

Cost - When compared to other physical/chemical treatment options, thermoplastic encapsulation has high capital and O&M costs.

Conclusion - Eliminate thermoplastic encapsulation for further consideration based on a lack of proven capabilities, the associated large volume increases, and the heterogeneous nature of the contaminated material in the South Field. Stabilization/solidification will be retained because it provides a similar effectiveness, is easier to implement, and has a lower cost than thermoplastic encapsulation.

Crushing/Shredding

Effectiveness - Crushing/shredding would be effective as a pretreatment step for reducing the size and improving the material handling characteristics of large pieces of concrete or construction debris found in the South Field. Approximately 5,000 cu m (6,500 cu yd) of debris would require crushing/shredding. This process would help meet the remediation goals for the site by allowing contaminated concrete and debris to be treated by one of the other treatment steps.

During construction, potential impacts to workers can be mitigated by using safe work procedures when operating the crushing and shredding equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated. Crushing and

shredding processes are well proven. Concrete crushers are commonly used on highway construction projects. Shredders are commonly used at resource recovery centers as a pretreatment step.

Implementability - Crushing/shredding is administratively feasible as a pretreatment step. Special permits would not be required. The equipment and labor to operate this equipment are readily available.

Cost - When compared to other physical/chemical treatment options, crushing/shredding has low capital and O&M costs.

Conclusion - Retain crushing/shredding for alternative evaluation.

Drying

Effectiveness - Drying would be effective as a pretreatment step for material preparation for other treatment processes and as a primary treatment step to dry the contaminated material for shipment off-site without any other treatment. Drying is required for 8,400 cu m (11,000 cu yd) of material at the South Field. Drying would also be effective as a post treatment step to be used to reduce the water content of soil washing residues or flocculated material from a water pretreatment process.

During construction, potential impacts to workers can be mitigated by using safe work procedures when operating the drying equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated or disposed. Off-gases and dust may be created by drying, but their impacts will be mitigated through the use of the appropriate controls (e.g., HEPA filters). Drying processes are well proven. Filter presses are commonly used for sludge dewatering at wastewater treatment plants. Pulse drying and kiln drying have been used successfully for drying soils, sediments, and debris.

Implementability - Drying is administratively feasible as either a pretreatment, primary treatment or post treatment step. The equipment and labor to operate this equipment is readily available.

Cost - When compared to other physical/chemical treatment options, drying has moderate capital and O&M costs.

Conclusion - Retain drying for alternative evaluation.

Ex Situ Vitrification

Effectiveness - Vitrification would be an effective method of treating 5,100 cu m (6,700 cu yd) of contaminated materials after they have been excavated and sorted from the non-contaminated materials. Vitrification would be effective in meeting the remediation goals by destroying organics, and immobilizing inorganics and radionuclides in a glass matrix (EPA, 1992). The molten glass process can potentially achieve high destruction removal efficiencies (over 99 percent) for hazardous organic contaminants. The radionuclides, metals and other resulting ash are immobilized by either dissolving or becoming suspended in the glass matrix. Upon cooling, the glass product 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 a volume increase would be noticed. Vitrification would be effective for the following contaminants: uranium-234, uranium-235/236, uranium-238, radium-228, thorium-228, thorium-230, arsenic, beryllium, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene.

During operation, the vitrification is limited by the capacity of the "off-gas" system which can become overloaded by gas generation of organics as they volatize. To control the generation of these gases, the waste may need pretreating to reduce the organic and moisture content. The materials would have to be excavated and handled, which may increase airborne concentrations of contaminants. During construction, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented. Emission controls could include a scrubber systems with HEPA filters. Potential impacts to workers operating the vitrification equipment can be mitigated by using safe work practices during the material handling and vitrification processes. The process is reliable and its primary application would be for encapsulation of contaminated material.

Implementability - Vitrification is administratively feasible. Equipment requirements, in addition to the molten glass furnace, include waste handling and storage facilities, as well as pollution control equipment such as scrubbers for acid gas removal and a demister/filter unit for particulate and mist removal. Mobile equipment has not been fully developed; however, a treatability study on site will be used to evaluate this technology's ability to treat the contaminated material at the FEMP. The South Field soils and contaminated material are heterogeneous and will require thorough sorting to

provide an acceptable feedstock to the vitrification facility. Some contaminated material will not be able to be vitrified based on its particle size, and would require other treatment or disposal technologies to be used for that fraction. Contractors, skilled workers, and proven mobile equipment will be limited.

Cost - When compared to other ex situ thermal treatment options, ex situ vitrification has high capital and O&M costs.

Conclusion - Retain ex situ vitrification for alternative evaluation.

3.7.4.6 Disposal

On-Site Disposal Facility

Effectiveness - An on-site disposal facility would be effective in containing the 37,700 cu m (49,300 cu yd) of contaminated material from the South Field and would be effective in meeting the remediation goals by reducing the migration of the contaminants. The toxicity, mobility, or volume of the contaminants would not be reduced. An on-site disposal cell would be effective in protecting human health by reducing public exposure to the contaminated material (EPA, 1988). An on-site disposal cell would be effective in protecting the environment by reducing wildlife exposure to the waste material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas. The disposal facility would be designed for a minimum life of 200 years in accordance with 40 CFR 192 and DOE Order 5400.5. A disposal cell would be reliable in minimizing the exposure of contaminated material to surface water, groundwater, wind, and other environmental forces; however, the 1,000 year effective life has not yet been proven on any existing disposal cell.

During construction and filling of a disposal cell, potential impacts to workers can be mitigated through the use of sound construction safety practices. The contaminated materials would have to be transported and compacted, which may increase airborne contamination; however, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented.

Implementability - Implementation of an on-site disposal cell 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 can be readily constructed by several experienced civil contractors and skilled workers. Resources required to construct the disposal cell are readily available. The placement of the geomembrane liners requires a skilled labor force to assure proper installation and seaming of the liners. The required materials and equipment are commonly used in the construction industry.

Cost - When compared to other disposal options, an on-site disposal cell has high capital and O&M costs.

Conclusion - Retain the option of using an on-site disposal cell.

Off-Site Hazardous Waste Disposal Facility

Effectiveness - An off-site hazardous waste disposal facility would be effective in containing the 230 cu m (300 cu yd) of lead-contaminated soil from the firing range. The facility would also be effective in meeting the remediation goals by reducing the migration of the lead. Additionally, the disposal facility will perform treatment of the lead-contaminated soil prior to disposal, thus reducing the toxicity and mobility of the lead to be disposed. However, the volume would increase from treatment. An off-site hazardous waste disposal facility would be effective in protecting human health at the FEMP by reducing public exposure to the waste material. An off-site hazardous waste disposal facility would be effective in protecting the environment at the site by reducing wildlife exposure to the waste material, reducing surface water infiltration, reducing leachate generation, and reducing groundwater contamination. A hazardous waste disposal facility would be reliable in minimizing exposure of the waste to surface water, groundwater, wind, and other environmental forces.

During excavation and transportation of the hazardous waste, potential impacts to workers can be mitigated through the use of sound construction safety practices. The hazardous materials would have to be handled at the off-site facility, which may increase airborne contamination; however, air monitoring would be performed to determine if emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures would be implemented. A minor increase in truck traffic required to haul the waste material off site can be mitigated by transporting material during off-peak times.

Implementability - The administrative feasibility of using an off-site hazardous waste disposal facility may be difficult to implement. In order to dispose of material off site, it must be shown with reasonable certainty that the material is not contaminated with unacceptable levels of radionuclides. It may be difficult to prove that the waste was not contaminated with radionuclides during on-site storage. Approval must be obtained from the 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 hazardous waste. Also, such an action may be politically difficult to implement. Resources required to excavate the lead-contaminated soil are readily available. Facilities that provide off-site treatment and disposal services for lead-contaminated soil are also readily available; however, finding a facility that will accept hazardous waste from a DOE/CERCLA site will be difficult.

Cost - When compared to other disposal options, an off-site hazardous waste disposal facility has a moderate capital cost and a low O&M cost.

Conclusion - Retain the option of using an off-site hazardous waste disposal facility for further consideration.

Off-Site Low-level Radioactive Waste Disposal Facility

Effectiveness - An off-site LLWDF would be effective in containing the 165,900 cu m (216,800 cu yd) of contaminated material from the South Field and would be effective in meeting the remediation goals by reducing the migration of contaminants at the subunit. However, the toxicity, mobility, or volume of the contaminants would not be reduced. An off-site LLWDF would be effective in protecting human health at the FEMP by reducing public exposure to the contaminated material. An off-site LLWDF would be effective in protecting the environment at the site by reducing wildlife exposure to the contaminated material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas.

During excavation and transportation of the contaminated waste, 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. A LLWDF would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces.

Implementability - Using an off-site LLWDF is administratively feasible, however it must be proven that the contaminated material has not been contaminated with hazardous constituents that are not accepted at the LLWDF. Any free-standing water in the contaminated material will have to be dried prior to disposal. Waste material would have to meet all acceptance criteria of the off-site LLWDF identified in Section 3.5.6. It also may be difficult to obtain permits to transport the waste across state lines to get to the existing facilities. Resources required to excavate and transport the waste material are readily available. Options for disposing contaminated material at off-site facilities are limited:

- Nevada Test Site (currently accepting FEMP low-level waste)
- Envirocare (not yet authorized to accept FEMP low-level waste)

Using either of these options for the disposal of contaminated material would probably require the construction of a new waste cell at that facility. An off-site low-level waste cell could be developed in conjunction with other FEMP remedial efforts.

Approval must be gained from the DOE headquarters (Washington - EM1) and the off-site facility prior to off-site disposal of contaminated material. Also, the use of other DOE facilities to dispose of contaminated material may be difficult to implement.

Cost - When compared to other disposal options, an off-site LLWDF has a high capital cost and a low O&M cost.

Conclusions - Retain the option of using an off-site LLWDF for alternative development.

Truck Transportation

Effectiveness - Truck transport is effective for short distances, but is not as effective as rail transport for the distances required for the off-site disposal option at NTS or other facilities depending on the availability of rail spurs. Truck transport is a highly reliable means of transporting contaminated material. Truck transport would be required for on-site disposal and off-site disposal to facilities without rail spurs.

Implementability - Truck transport would be easily implemented at the site. Notification to state and local agencies along the transport route would be required.

Cost - When compared to rail transportation, truck transportation has a moderate capital cost and a high O&M cost.

Conclusion - Retain the option of using truck transportation for further consideration.

Rail Transportation

Effectiveness - Rail transportation is effective for transportation of contaminated material to off-site disposal facilities with railroad spurs and NTS. Rail transportation allows large volumes of contaminated material to be transported at one time. Typically, fewer accidents occur on a per-trip basis by rail than by truck. However, should an accident occur, much larger quantities of contaminated material could be exposed to the public. Rail transport is highly reliable. Rail transport would be applicable to off-site disposal options at facilities with rail spurs and in combination with truck transport for disposal at NTS.

Implementability - Rail transport is readily implementable because the FEMP site has an existing on-site rail spur. However, rail transport is susceptible to route availability and coordination with state and local agencies along the route. In addition, special packaging of waste would be required for rail transport.

Cost - When compared to truck transportation, rail transportation has a high capital cost and low O&M costs.

Conclusion - Retain the option of using rail transportation for further consideration.

3.7.5 Active Flyash Pile

The technologies and process options for the Active Flyash Pile remaining after the initial screening are evaluated based on effectiveness, implementability, and cost.

3.7.5.1 No Action

Effectiveness - No action does not meet the remediation goals identified in the RAOs. No action would not reduce the risk to human health associated with direct exposure to the soil/sediment/flyash. No action would not provide any protection of the environment, as contaminants would continue to migrate from the soil/sediment/flyash to the underlying soil and groundwater.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated with no action.

Conclusion - Retain no action for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.7.5.2 Institutional Actions

Physical Barriers

Effectiveness - Physical barriers would be an effective method for isolating and defining the area required to handle, treat, or dispose of contaminated material contained at the Active Flyash Pile. 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 as contaminants could continue to migrate into the environment through groundwater, soil, surface water, and the atmosphere; however, 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 impact to both 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, physical barriers can be breached during acts of vandalism or vagrancy.

Implementability - Physical barriers are administratively feasible and require no special permitting to implement. Physical barriers are currently in place, however security and maintenance activities would be required for long-term implementation.

Cost - When compared to the deed restriction process option, physical barriers would have moderate capital and O&M costs. O&M costs include both security and maintenance activities.

Conclusion - Retain physical barriers for further consideration in conjunction with containment and on-site disposal technologies.

Security Guards

Effectiveness - Security guards are effective in supplementing physical barriers. Security forces would monitor the physical barriers for breaches. Random patrols would discourage vandalism or vagrancy. Security guards would physically remove trespassers that did breach the barriers. Security guards provide no reduction in toxicity, mobility, or volume of contaminants. Security guards are effective in protecting human health by restricting public access to the waste site. Security guards are a reliable and proven method of restricting access of the general public to a waste site.

Implementability - Security guards are administratively feasible. Security forces are currently on site. Physical barriers would be required for long term implementation.

Cost - Security guards have a low capital cost and moderate O&M cost. These costs are included in the cost of physical barriers.

Conclusion - Retain security guards for further consideration. Use with physical barriers in conjunction with containment and on-site disposal technologies.

Deed Restrictions

Effectiveness - Deed restrictions would be effective in placing legal restraints on the future usage or development of areas required to contain or dispose of contaminated material contained at the Active Flyash Pile. Deed restrictions can be effective in protecting human health by restraining agricultural, construction, or other usage or development activities that could increase public exposure to the contaminated material. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

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. However, deed restrictions could prevent the drilling of wells that could allow or increase the migration of contaminants into and through the underlying soil and groundwater. Deed restrictions are a reliable method for placing legal restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to a waste site.

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 both low capital and O&M costs.

Conclusion - Retain deed restrictions for further consideration. Use in conjunction with in situ treatment, containment, and on-site disposal technologies in which contaminants remain on site.

3.7.5.3 <u>In Situ Containment</u>

<u>Clay Cap</u>

Effectiveness - A clay cap would be an effective method for reducing the infiltration rate of surface water through 54,900 cu m (71,700 cu yd) of flyash/soil in the Active Flyash Pile. A clay cap would be effective in meeting the remediation goals, since it would reduce the migration of the contaminants. A clay cap would be effective in reducing public exposure to the flyash (EPA, 1988).

During construction, significant volumes of fill soils may be hauled from on-site and/or off-site sources to the Active Flyash Pile area. Dust from truck traffic can be mitigated by using dust suppressants. A clay cap would be effective in protecting the environment by reducing the infiltration rate of surface water through the fill material and soil, by reducing dust migration, and by reducing leachate generation.

Clay caps are widely used to close non-toxic flyash piles and are highly reliable for 30 years post closure if periodic inspections and maintenance are performed.

Implementability - The construction of a clay cap is administratively feasible. Resources and services required to construct a clay cap are readily available. There are many contractors who have experience constructing clay caps. The required materials and equipment are commonly used in the construction industry.

Cost - When compared to other containment options, this option has moderate capital and O&M costs.

Conclusion - Retain clay cap for further consideration.

Surface Water Controls

Effectiveness - Surface water controls can be very effective in managing and directing surface water around areas required to handle, treat, or dispose of contaminated material contained in the Active Flyash Pile. Surface water controls are effective in meeting remediation goals by reducing the migration of contaminants through surface water. Surface water controls are effective in protecting both human health and the environment by reducing the quantity of contaminants migrating along with surface water to areas outside the site. During implementation of surface water controls, risks to both human health and the environment due to the possible disturbance of the contaminated material and the proliferation of air-borne contaminants in construction dust can be mitigated by minimizing areas of unvegetated soils, and by using dust suppressants. Surface water control technology is well proven and understood, and is a reliable method for controlling surface water.

Implementability - Surface water controls are administratively feasible, although some controls may require obtaining approval from the COE and other governmental agencies and departments having relevant jurisdiction. Resources required to construct the surface water controls are readily available. Surface water controls are appropriate for use with containment technologies.

Cost - Surface water controls have low capital and O&M costs.

Conclusion - Retain surface water controls for further consideration.

3.7.5.4 Removal

Mechanical Excavation

Effectiveness - Mechanical excavation can be very effective in moving, excavating, and handling large quantities of soil or flyash, and in excavating localized areas of elevated contaminant concentrations. However, excavation is not, by itself, a primary remediation technology. Therefore, the use of mechanical excavation alone is not effective in meeting remediation goals or in protecting either human health or the environment. During implementation, risks to human health would be mitigated by observing proper excavation and construction safety practices and by using dust suppressants. Excavation is a reliable method for flyash handling or earth moving operations, when used in support of other remediation technologies.

Implementability - The use of mechanical excavation is administratively feasible at the site. Both resources and services required to provide excavation and earth moving operations are readily available.

Cost - When compared to other removal options, the use of mechanical excavation has a moderate capital cost and O&M costs.

Conclusion - Retain mechanical excavation for further consideration as a support action to other primary technologies.

Sorting/Separation

Effectiveness - Sorting/separation would be an effective technology for handling the volume of soil/flyash present at the Active Flyash Pile. Sorting/separation would be effective for minimizing the total amount of material that would have to be treated or disposed. The use of sorting/separation is not effective by itself in meeting remediation goals. However, it is effective when used in conjunction with other process options. During construction, risks to site workers using field screening equipment can be mitigated by using safe work practices. Sorting/separation is reliable for visually identifying flyash from soil and sorting using mechanical excavators. The identification process for separating radiologically contaminated material from non-radiologically contaminated materials is relatively slow.

Implementability - Sorting/separation is administratively feasible if conservative sorting decisions are made in the field. A method of quality assurance will need to be developed to calibrate the field readings with laboratory analysis to ensure that material sorted as non-contaminated is, in fact, clean. The resources for sorting using mechanical excavators are readily available. The currently available resources for sorting radiological contamination are slow. Devices that can identify large quantities of radiologically contaminated material relatively quickly are currently being developed. A site demonstration is currently planned for 1994.

Cost - Sorting/separation has a moderate capital cost and a high O&M cost.

Conclusion - Retain sorting/separation for further consideration as a support action to other technologies that require contaminated material to be separated prior to treatment or off-site disposal.

Revegetation

Effectiveness - Revegetation can be effective in stabilizing surface soils when used in conjunction with removal technologies that excavate the contents of the Active Flyash Pile. Revegetation is effective in helping to achieve the remediation goal of protecting the environment by reducing the migration of surface soils into streams. Revegetation is effective at controlling wind and surface water erosion. Revegetation is a reliable method for surface stabilization; however, revegetation is not a reliable method for surface stabilization in areas where strong erosion forces, steep grades, ponding conditions, infertile soils, or surface contaminants exist.

Implementability - Revegetation is administratively feasible. Both resources and services required to place a vegetative cover are readily available.

Cost - Revegetation has both low capital and O&M costs.

Conclusion - Retain revegetation for further consideration with removal technologies.

3.7.5.5 Ex Situ Treatment

Stabilization/Solidification

Effectiveness - Stabilization/solidification can be very effective for creating a stabilized backfill material when the flyash is mixed with lime sludge. Stabilization/solidification would be performed

on 49,700 cu m (65,000 cu yd) of flyash containing uranium-234, uranium-238, radium-226, radium-228, thorium-228, arsenic, and beryllium. A stabilized block of soil meets the remediation goals by minimizing the potential for leaching of contaminants to the environment. Stabilization/solidification would not reduce the toxicity of contamination in the flyash. Stabilization/solidification is effective in the long term because the mobility of the contaminants of concern can be reduced (EPA, 1988).

During construction and operation of the stabilization/solidification facility, impacts to human health and the environment can be mitigated by using sound construction safety practices when handling the flyash and lime sludge.

Implementability - Stabilization/solidification is administratively feasible when used in conjunction with other technologies such as on-site disposal. Some sorting/separation of the soils/flyash may be required to produce an acceptable feed to the stabilization/ solidification process. The final stabilized material would be disposed on-site and would be in a solid/stable form for ease in handling and transporting. The final product would meet requirements for disposal at an on-site facility.

Cost - Stabilization/Solidification has a moderate capital cost and O&M costs.

Conclusion - Retain stabilization/solidification for alternative evaluation.

Drying

Effectiveness - Drying would be effective as a pretreatment step for material preparation for other treatment processes and as a primary treatment step to dry the contaminated waste for shipment off-site without any other treatment. Drying would be required for 540 cu m (700 cu yd) of material at the Active Flyash Pile.

During construction, potential impacts to workers can be mitigated through the use of construction safety procedures when operating the drying equipment. After implementation, this process would have a positive effect because it would enable the contaminated materials to be treated or disposed. "Off-gases" and dust may be created by drying, but their impacts will be mitigated through the use of the appropriate controls (e.g., HEPA filters). Drying processes are well proven. Pulse drying and kiln drying have been used successfully for drying soils, sediments, and debris.

Implementability - Drying is administratively feasible as either a pretreatment or primary treatment. The equipment and labor to operate this equipment is readily available.

Cost - When compared to other ex situ chemical/physical treatment options, drying has moderate capital and O&M costs.

Conclusion - Retain drying for alternative evaluation.

3.7.5.6 Disposal

On-Site Disposal Facility

Effectiveness - An on-site disposal facility would be effective in containing the 54,900 cu m (71,700 cu yd) of flyash/soil material from the Active Flyash Pile and would be effective in meeting the remediation goals by reducing the potential for migration of all of the contaminants. The toxicity, mobility, or volume of the contaminants would not be reduced. An on-site disposal facility would be effective in protecting human health by reducing public exposure to the contaminated material (EPA, 1988). An on-site disposal facility would be effective in protecting the environment by reducing wildlife exposure to the contaminated material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas. An on-site disposal cell would be designed for a minimum life of 200 years in accordance with 40 CFR 192 and DOE Order 5400.5. An on-site disposal cell would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces; however, the 1,000 year effective life has not yet been proven on any existing disposal facility.

During construction and filling of an on-site disposal cell, potential impacts to workers can be mitigated through the use of sound construction safety practices. The contaminated materials would have to be transported and compacted, which may increase airborne contamination; however, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented.

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 can be readily constructed by several experienced civil contractors and skilled workers. Resources required to construct the disposal facility are readily

available. The placement of the geomembrane liners requires a skilled labor force to assure proper installation and seaming of the liners. The required materials and equipment are commonly used in the construction industry.

Cost - When compared to other disposal options, an on-site disposal facility has high capital and O&M costs.

Conclusion - Retain the option of using an on-site disposal facility.

Off-Site Disposal Facility

Effectiveness - An off-site disposal facility would be effective in containing 49,700 cu m (65,000 cu yd) of non-radiologically contaminated flyash from the Active Flyash Pile and would be very effective in meeting the remediation goals by reducing the migration of the contaminants. However, the toxicity, mobility, or volume of the contaminants would not be reduced. An off-site disposal facility would be effective in protecting human health by reducing public exposure to the flyash. An off-site disposal facility would be effective in protecting the environment by reducing wildlife exposure to the flyash, reducing surface water infiltration, reducing leachate generation, and reducing groundwater contamination. An off-site disposal facility would have a minimum effective life of 30 years post closure.

During excavation and transportation of the flyash, potential impacts to workers can be mitigated through the use of sound construction safety practices. The flyash would have to be handled and compacted at the off-site facility, which may increase airborne contamination; however, air monitoring would be required to determine if air emissions are a concern. If emissions exceed acceptable levels, then appropriate emission control procedures will be implemented. An increase in truck traffic required to haul the material off-site could be mitigated by using off-peak hours. An off-site disposal facility would be reliable in minimizing the exposure of flyash to surface water, groundwater, wind, and other environmental forces.

Implementability - The administrative feasibility of using an off-site disposal facility may be difficult to implement. In order to dispose flyash off-site, it must be shown with reasonable certainty that the flyash has not been contaminated with either radiological or hazardous materials. It will be difficult to prove that the flyash has not been contaminated with radiological or hazardous materials during on-

site storage. Approval must be gained from the OEPA, DOE headquarters (Washington - EM1), and the owner of the off-site facility prior to off-site disposal of any flyash. Also, such an action may be politically difficult to implement. Resources required to excavate and transport the flyash are readily available. Facilities that provide off-site disposal services for flyash are numerous; however, finding a facility that will accept flyash from a DOE/CERCLA site will be difficult.

Cost - When compared to other disposal options, an off-site disposal facility has a moderate capital cost and a low O&M cost.

Conclusion - Retain the option of using an off-site disposal facility for further consideration.

Off-Site Low-Level Radioactive Waste Disposal Facility

Effectiveness - An off-site LLWDF would be effective in containing 57,600 cu m (75,300 cu yd) of contaminated material from the Active Flyash Pile and would be effective in meeting the remediation goals by reducing the migration of contaminants at the subunit. However, the toxicity, mobility, or volume of the contaminants would not be reduced. An off-site LLWDF would be effective in protecting human health at the FEMP by reducing public exposure to the contaminated material. An off-site LLWDF would be effective in protecting the environment at the site by reducing wildlife exposure to the contaminated material, reducing surface water infiltration, reducing leachate generation, reducing groundwater contamination, and reducing releases of radon gas.

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. A LLWDF would be reliable in minimizing the exposure of waste to surface water, groundwater, wind, and other environmental forces.

Implementability - Using an off-site LLWDF is administratively feasible; however, it must be proven that the material has not been contaminated with hazardous constituents that are not accepted at the LLWDF. Any free-standing water in the contaminated material will have to be dried prior to disposal. Waste material would have to meet all acceptance criteria for the off-site LLWDF identified in Section 3.5.6. It also may be difficult to obtain permits to transport the waste across state lines to

get to the existing facilities. Resources required to excavate and transport the waste material are readily available. Options for disposing contaminated material at off-site facilities are limited:

- Nevada Test Site (currently accepting FEMP low-level waste)
- Envirocare (not yet authorized to accept FEMP low-level waste)

Using either of these options for the disposal of contaminated material would probably require the construction of a new waste cell at that facility. An off-site low-level waste cell could be developed in conjunction with other FEMP remedial efforts.

Approval must be gained from the DOE headquarters (Washington - EM1) and the off-site facility prior to off-site disposal of contaminated material. Also, the use of other DOE facilities to dispose of contaminated material may be difficult to implement.

Cost - When compared to other disposal options, an off-site LLWDF has high capital cost and a low O&M cost.

Conclusion - Retain the option of using an off-site LLWDF for alternative development.

Truck Transportation

Effectiveness - Truck transport is effective for short distances, but is not as effective as rail transport for the distances required for the off-site disposal option at NTS or other facilities depending on the availability of rail spurs. Truck transport is a highly reliable means of transporting contaminated material. Truck transport would be required for on-site disposal and off-site disposal to facilities without rail spurs.

Implementability - Truck transport would be easily implemented at the site. Notification to state and local agencies along the transport route would be required.

Cost - When compared to rail transportation, truck transportation has a moderate capital cost and a high O&M cost.

Conclusion - Retain the option of using truck transportation for further consideration.

Rail Transportation

Effectiveness - Rail transportation is effective for transportation of contaminated material to off-site disposal facilities with railroad spurs and NTS. Rail transportation allows large volumes of contaminated material to be transported at one time. Typically, fewer accidents occur on a per-trip basis by rail than by truck. However, should an accident occur, much larger quantities of contaminated material could be exposed to the public. Rail transport is highly reliable. Rail transport would be applicable to off-site disposal options at facilities with rail spurs and in combination with truck transport for disposal at NTS.

Implementability - Rail transport is readily implementable because the FEMP site has an existing on-site rail spur. However, rail transport is susceptible to route availability and coordination with state and local agencies along the route. In addition, special packaging of waste would be required for rail transport.

Cost - When compared to truck transportation, rail transportation has a high capital cost and low O&M costs.

Conclusion - Retain the option of using rail transportation for further consideration.

3.8 EVALUATION OF TECHNOLOGIES FOR GROUNDWATER/CONSTRUCTION WATER

The technologies and process options remaining after the initial screening for the groundwater media are evaluated based on the aforementioned screening criteria; i.e., effectiveness, implementability, and cost, as described in Section 3.7. The evaluation of the remedial technologies and process options will be conducted based on the requirements of individual subunits. This approach has been taken because different contaminants of concern, hydrogeological, and geological characteristics exist for the different subunits which may preclude the use of various remediation options. The representative process option(s) that is selected for each technology type will be retained for incorporation into the remedial action alternatives.

3.8.1 Solid Waste Landfill

The technologies and process options for the perched groundwater and construction water from the Solid Waste Landfill remaining after the initial screening are evaluated based on effectiveness, implementability, and cost.

3.8.1.1 No Action

Effectiveness - The no action response will not achieve any of the remedial action objectives. Effectiveness of this response action depends on the groundwater's natural attenuation ability to lower contaminant concentrations through physical, chemical, and biological processes within the groundwater regime. Uranium is the primary COC, and it has a half-life of 4.5 billion years. This response action does not reduce risk to human health or the environment.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated with no action.

Conclusion - Retain the no action option for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.8.1.2 Institutional Actions

Deed Restrictions

Effectiveness - Deed restrictions would be partially effective in placing legal restraints on the usage of the perched groundwater below the Solid Waste Landfill. Deed restrictions can be effective in protecting human health by restricting agricultural, construction, or other usage or development activities that could increase public exposure to the groundwater. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

Deed restrictions by themselves would not be effective in meeting remediation goals. Deed restrictions alone would provide no 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 restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to a waste site.

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 both low capital and O&M costs.

Conclusion - Retain deed restrictions for further consideration.

Groundwater Monitoring Wells

Effectiveness - The use of groundwater monitoring wells will not achieve any of the remediation goals; however, they are effective in determining underground contaminant migration and in evaluating the effectiveness of other remedial actions. When used in conjunction with other technologies, monitoring wells are effective in meeting the remediation goals. The use of monitoring wells will have a negligible impact on human health if proper health and safety procedures are followed during sampling and analytical testing of the groundwater. The impact to the environment from the installation of monitoring wells is also negligible if proper installation techniques are used. Correct installation techniques will mitigate the potential for contaminant migration from the Solid Waste Landfill to the underlying aquifer through the wells. Monitoring wells are very reliable in tracking the underground waste migration.

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 a moderate capital and O&M cost.

Conclusion - Retain monitoring wells for further consideration.

3.8.1.3 Removal

Excavation Dewatering

Effectiveness - Excavation dewatering would be an effective method for pumping out the volumes of construction water that can accumulate in an excavation. This process is effective in 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 both human health and the environment by reducing lateral or downward contaminants migration and by removing contaminants for treatment and disposal.

During excavation activities, impacts to human health will 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 will 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 a low capital and O&M costs.

Conclusion - Retain excavation dewatering for further consideration to be used in conjunction with soil/waste removal technologies.

3.8.1.4 Treatment

Sedimentation

Effectiveness - Sedimentation, also known as clarification, is an effective way to remove particulates from construction water. Settling tanks can be sized to handle the volumes of construction water required for treatment. The tanks could also be effective for providing temporary storage capacity in order to eliminate surges at the treatment facility. Sedimentation would be effective in meeting remediation goals by reducing contaminant volume. Contaminated suspended solids can be partially removed by sedimentation. The remaining contaminants would be treated at the AWWT facility.

Sedimentation is effective in protecting both human health and the environment by reducing the concentration of contaminants in the construction water.

The construction of settling tanks would have a negligible impact on both human health and the environment, since construction of the tanks would not require any disturbance to the contaminated materials. The sedimentation process is a proven and reliable technology for the separation of particles that are heavier than water from water.

Implementability - The use of sedimentation is administrative feasible when used in conjunction with other treatment and disposal technologies. The uranium and other contaminants in the construction water at the Solid Waste Landfill will require further treatment before it is disposed. The settling tanks will also be used as holding tanks for wastewater storage until the wastewater can be pumped to the AWWT facility for treatment. Both the resources and services required to install and operate settling tanks are readily available.

Cost - When compared to other treatment options, sedimentation has moderate capital and O&M costs.

Conclusion - Retain sedimentation as a pretreatment to other water treatment technologies.

Advanced Wastewater Treatment

Effectiveness - The AWWT facility would be very effective at handling the volume of construction water from the Solid Waste Landfill. The AWWT facility will have the capacity to accept and treat the remediation water from the Operable Unit 2 subunits. Transferring water to the AWWT facility from the Solid Waste Landfill will have to be coordinated with the other Operable Unit 2 subunits as well as the water from Operable Units 1, 4 and 5. Adequate storage capacity will be necessary at the Solid Waste Landfill to hold the water until it can be treated by the AWWT facility. This storage capacity can be incorporated into the sedimentation tanks. The AWWT facility would be very effective at meeting the remediation goals because the treatment processes would reduce the toxicity and volume of the contaminated construction water.

During construction of the facility, potential impacts to human health could be mitigated using standard construction safety practices. Operation of the AWWT facility would have a positive impact

to human health and the environment by treating the water. The AWWT facility would be a reliable method of treating the construction water if it is used in conjunction with a pretreatment step to remove suspended solids specific to the Solid Waste Landfill.

Implementability - Using the AWWT facility is administratively feasible. NPDES permits would be required. The facility is currently under construction and is scheduled to begin accepting Operable Unit 2's construction water in June 1996.

Cost - When compared to other treatment options, using the AWWT facility would have low capital and O&M costs because the facility will have already been constructed.

Conclusions - Retain the option of using the AWWT facility for treating the groundwater and construction water from the Solid Waste Landfill.

3.8.1.5 Disposal

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. Discharge of treated effluent to the Great Miami River meets the remediation goals by removing the treated water from the site enabling future site use. There would be no impacts to human health and the environment during construction of the discharge pipeline because the work has already been completed. There would be no significant impacts to the human health and the environment during operation because the water being discharged would be treated to acceptable levels. Discharge of treated wastewater to the Great Miami River is the current disposal method at the FEMP which 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 current NPDES permit; however, it is regulated by internal DOE DCGs. 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 a viable process option. Retain this process option for further consideration.

Discharge to Paddys Run

Effectiveness - Discharge of treated construction water to Paddys Run would be an effective method for disposing the extracted construction water. This option would require construction of a new pipeline from the AWWT facility to Paddys Run. Impacts to human health during construction could be mitigated by using sound construction safety practices and complying with OSHA trenching standards. There would be minimal impacts to the environment during implementation because the water being discharged would have already been treated. Discharge of treated wastewater to Paddys Run is not currently used at the FEMP because there is an existing pipeline and NPDES permit for discharge to the Great Miami River.

Implementability - This discharge option may be administratively difficult to implement. A new NPDES discharge permit would be required. Also, due to the intermittent nature of Paddys Run, more stringent discharge limits would likely be required. This option would also be administratively difficult to justify because there already is an existing pipeline with a NPDES permit for discharge to the Great Miami River.

Cost - When compared to other disposal options, discharge of treated wastewater to Paddys Run has a high capital and a moderate O&M cost.

Conclusions - Even though discharge to Paddys Run should be effective and implementable, it is not being retained because the existing discharge pipeline and NPDES permit for the Great Miami river is already in place.

3.8.2 Lime Sludge Ponds

The technologies and process options for the construction water from the Lime Sludge Ponds remaining after the initial screening are evaluated based on effectiveness, implementability and cost.

3.8.2.1 No Action

Effectiveness - The no action response will not achieve any of the remedial action objectives. Effectiveness of this response action depends on the groundwater's natural attenuation ability to lower

contaminant concentrations through physical, chemical, and biological processes within the groundwater regime. Uranium is the primary COC and it has a half-life of 4.5 billion years. This response action does not reduce risk to human health or the environment.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated with no action.

Conclusion - Retain the no action option for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.8.2.2 Institutional Actions

Deed Restrictions

Effectiveness - Deed restrictions would be effective in placing legal restraints on the usage of the perched groundwater below the Lime Sludge Ponds. Deed restrictions can be effective in protecting human health by restricting agricultural, construction, or other usage or development activities that could increase public exposure to the groundwater. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

Deed restrictions by themselves would not be effective in meeting remediation goals. Deed restrictions alone would provide no 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 restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to a waste site.

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 both low capital and O&M costs.

Conclusion - Retain deed restrictions for further consideration.

Groundwater Monitoring Wells

Effectiveness - The use of groundwater monitoring wells will not achieve any of the remediation goals; however, they are effective in determining underground contaminant migration and in evaluating the effectiveness of other remedial actions. When used in conjunction with other technologies, monitoring wells are effective in meeting the remediation goals. The use of monitoring wells will have a negligible impact on human health if proper health and safety procedures are followed during sampling and analytical testing of the groundwater. The impact to the environment from the installation of monitoring wells is also negligible if proper installation techniques are used. Correct installation techniques will mitigate the potential for contaminant migration from the Lime Sludge Ponds to the underlying aquifer through the wells. Monitoring wells are very reliable in tracking the underground waste migration.

Implementability - The use of monitoring wells are 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 a moderate capital and O&M cost.

Conclusion - Retain monitoring wells for further consideration.

3.8.2.3 Removal

Excavation Dewatering

Effectiveness - Excavation dewatering would be an effective method for pumping out the volumes of construction water that can accumulate in an excavation. This process is effective in 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 both human health and the

environment by reducing lateral or downward contaminants migration and by removing contaminants for treatment and disposal.

During excavation activities, impacts to human health will 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 will 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 a low capital and O&M cost.

Conclusion - Retain excavation dewatering for further consideration to be used in conjunction with soil/waste removal technologies.

3.8.2.4 Treatment

Sedimentation

Effectiveness - Sedimentation, also known as clarification, is an effective way to remove particulates from construction water. Settling tanks can be sized to handle the volumes of construction water required for treatment. The tanks could also be effective for providing temporary storage capacity in order to eliminate surges at the treatment facility. Sedimentation would be effective in meeting remediation goals by reducing contaminant volume. Contaminated suspended solids can be partially removed by sedimentation. The remaining contaminants would be treated at the AWWT facility. Sedimentation is effective in protecting both human health and the environment by reducing the concentration of contaminants in the groundwater and construction water.

The construction of settling tanks would have a negligible impact on both human health and the environment, since construction of the tanks would not require any disturbance to the contaminated materials. The sedimentation process is a proven and reliable technology for the separation of particles that are heavier than water from water.

Implementability - The use of sedimentation is administrative feasible when used in conjunction with other treatment and disposal technologies. The uranium and other contaminants in the construction water at the Lime Sludge Ponds will require further treatment before it is disposed. The settling tanks will also be used as holding tanks for wastewater storage until the wastewater can be pumped to the AWWT facility for treatment. Both the resources and services required to install and operate settling tanks are readily available.

Cost - When compared to other treatment options, sedimentation has a moderate capital and O&M cost.

Conclusion - Retain sedimentation as a pretreatment to other water treatment technologies.

Advanced Wastewater Treatment

Effectiveness - The AWWT facility would be very effective at handling the volume of construction water from the Lime Sludge Ponds. The AWWT facility will have the capacity to accept and treat water from the Operable Unit 2 subunits. Transferring water to the AWWT facility from the Lime Sludge Ponds will have to be coordinated with the other Operable Unit 2 subunits as well as the water from Operable Units 1, 4, and 5. Adequate storage capacity will be necessary at the Lime Sludge Ponds to hold the water until it can be treated by the AWWT facility. This can be incorporated into the sedimentation tanks. The AWWT facility would be very effective at meeting the remediation goals because the treatment processes would reduce the toxicity and volume of the contaminated construction water.

During construction of the facility, potential impacts to human health could be mitigated using standard construction safety practices. Operation of the AWWT facility would have a positive impact to human health and the environment by treating the water. The AWWT facility would be a reliable method of treating the construction water if it is used in conjunction with a pretreatment step to remove suspended solids specific to the Lime Sludge Ponds.

Implementability - Using the AWWT facility is administratively feasible. NPDES permits would be required. The facility is currently under construction and is scheduled to begin accepting Operable Unit 2's construction water in June 1996.

Cost - When compared to other treatment options, using the AWWT facility would have a low capital and O&M cost because the facility will have already been constructed.

Conclusion - Retain the option of using the FEMP AWWT facility for treating the groundwater and construction water from the Lime Sludge Ponds.

3.8.2.5 Disposal

Discharge to Great Miami River

Effectiveness - Direct discharge of treated 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 extracted construction water. Discharge of treated effluent to the Great Miami River meets the remediation goals by removing the treated water from the site enabling future site use. There would be no impacts to human health or the environment during construction of the discharge pipeline because the work has already been completed. There would be no significant impacts to the human health and the environment during operation because the water being discharged would be treated to acceptable levels. Discharge of treated wastewater to the Great Miami River is the current disposal method at the FEMP which 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 current NPDES permit; however, it is regulated by internal DOE DCGs. This option will require modification of the existing NPDES permit for the added flow.

Cost - When compared to other disposal options, this option has a low capital and O&M cost.

Conclusion - Discharge of treated wastewater to the Great Miami River via the existing pipeline is a viable process option. Retain this process option for further consideration.

Discharge to Paddys Run

Effectiveness - Discharge of treated construction water to Paddys Run would be an effective method for disposing the extracted construction water. This option would require construction of a new pipeline from the AWWT facility to Paddys Run. Impacts to human health during construction could

be mitigated by using sound construction safety practices and complying with OSHA trenching standards. There would be minimal impacts to the environment during implementation because the water being discharged would have already been treated. Discharge of treated wastewater to Paddys Run is not currently used at the FEMP because there is an existing pipeline and NPDES permit for discharge to the Great Miami River.

Implementability - This discharge option may be administratively difficult to implement. A new NPDES discharge permit would be required. Also, due to the intermittent nature of Paddys Run, more stringent discharge limits would likely be required. This option would also be administratively difficult to justify because there already is an existing pipeline with a NPDES permit for discharge to the Great Miami River.

Cost - When compared to other disposal options, discharge of treated wastewater to Paddys Run has a high capital and moderate O&M cost.

Conclusion - Even though discharge to Paddys Run should be effective and implementable, it is not being retained because the existing discharge pipeline and NPDES permit for the Great Miami River is already in place.

3.8.3 Inactive Flyash Pile/South Field/Active Flyash Pile

The technologies and process options for the groundwater and construction water from the Inactive Flyash Pile/South Field/Active Flyash Pile remaining after the initial screening are evaluated based on effectiveness, implementability, and cost.

3.8.3.1 No Action

Effectiveness - The no action response will not achieve any of the remedial action objectives. Effectiveness of this response action depends on the groundwater's natural attenuation ability to lower contaminant concentrations through physical, chemical, and biological processes within the groundwater regime. Uranium is the primary COC and it has a half-life of 4.5 billion years. This response action does not reduce risk to human health or the environment.

Implementability - There are no implementability considerations associated with the no action scenario.

Cost - There are no costs associated with no action.

Conclusion - Retain the no action option for further consideration. Use as a baseline for comparison to other technologies as required by the NCP.

3.8.3.2 Institutional Actions

Deed Restrictions

Effectiveness - Deed restrictions would be effective in placing legal restraints on the usage of the groundwater below the Inactive Flyash Pile/South Field/Active Flyash Pile. Deed restrictions can be effective in protecting human health by restricting agricultural, construction, or other usage or development activities that could increase public exposure to the groundwater. Deed restrictions can also be used to reduce public access to a waste site; however, deed restrictions are only minimally effective at limiting public access unless used with other technologies (i.e., physical barriers).

Deed restrictions by themselves would not be effective in meeting remediation goals. Deed restrictions alone would provide no 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 restraints on the usage or development of property; however, deed restrictions are only moderately reliable at reducing public access to a waste site.

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 both low capital and O&M costs.

Conclusion - Retain deed restrictions for further consideration.

Groundwater Monitoring Wells

Effectiveness - The use of groundwater monitoring wells will not achieve any of the remediation goals; however, they are effective in determining underground contaminant migration and in

evaluating the effectiveness of other remedial actions. When used in conjunction with other technologies, monitoring wells are effective in meeting the remediation goals. The use of monitoring wells will have a negligible impact on human health if proper health and safety procedures are followed during sampling and analytical testing of the groundwater. The impact to the environment from the installation of monitoring wells is also negligible if proper installation techniques are used. Correct installation techniques will mitigate the potential for contaminant migration from the Inactive Flyash Pile/South Field/Active Flyash Pile to the underlying aquifer through the wells. Monitoring wells are very reliable in tracking the underground waste migration.

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 a moderate capital and O&M cost.

Conclusion - Retain monitoring wells for further consideration.

3.8.3.3 Containment Control

Slurry Walls

Effectiveness - A keyed in slurry wall would be effective in containing the volumes of perched groundwater underlying the Inactive Flyash Pile/South Field/Active Flyash Pile. Slurry walls are effective in meeting remediation goals by protecting both human health and the environment by reducing lateral contaminant migration. The slurry wall process option is a containment technology and does not reduce the toxicity, mobility, and volume of the contaminants. For long-term management of residual radioactive waste, the effectiveness of the slurry wall is unproven for containment due to the geochemical attenuation of uranium. Additionally, the ability of a slurry wall to resist uranium leachate for a 200 year minimum life is unproven. During construction, potential impacts to human health and the environment can be mitigated by using safe work practices.

Implementability - Slurry walls are administratively feasible; however, then can be difficult to install if located too close to the waste media. Slurry walls are considered implementable based on the depth

of the perched groundwater zone. The slurry walls would be designed to key in the low permeability clay interbed underlying the perched groundwater zone. Hanging slurry walls would not be appropriate due to the presence of contaminants that do not readily float. Both the resources and services required to construct a slurry wall are readily available.

Costs - When compared to other containment options, slurry walls have a moderate capital cost and a low O&M cost.

Conclusion - Eliminate slurry walls for alternative development based on the geochemical attenuation of uranium and the unproven resistance to uranium leachate for 200 years.

Grout Curtain

Effectiveness - A grout curtain would be effective in containing the volumes of perched groundwater underlying the Inactive Flyash Pile/South Field/Active Flyash Pile. Grout curtains are effective in meeting remediation goals and in protecting both human health and the environment by reducing lateral contaminant migration. For long-term management of residual radioactive waste, the effectiveness of the grout curtain is unproven for containment due to the geochemical attenuation of uranium. Additionally, the ability of a grout curtain to resist uranium leachate for a 200 year minimum life is unproven. Grout curtains do not reduce the toxicity, mobility, and volume of the contaminants. The impact to both human health and the environment during construction of a grout curtain is minimal. Grout curtains are primarily effective at inhibiting groundwater flows through highly permeable soils (i.e.: gravel, fractured clays, or fractured rock) where grout can readily flow through the subsurface media to fill voids and cracks. Grout curtains are less effective at controlling subsurface groundwater flows for soils with low permeabilities (non-fractured clays, silt, and sands) due to the uneven and incomplete placement of the grout. Grout curtains would only be moderately reliable for containing and controlling groundwater in the hydrogeologic conditions that exist under the Inactive Flyash Pile/South Field/Active Flyash Pile. It would be difficult to ensure the continuous integrity of a grout curtain.

Implementability - Grout curtains are administratively feasible; however, the construction of a grout curtain is considered more difficult than the construction of a slurry wall. Extensive drilling of soils and pressure injection of grout is required to implement an effective curtain. The injection of grout

may be difficult to achieve, depending on hydrogeologic conditions. Both the resources and services required to construct a grout curtain are readily available.

Cost - When compared to other containment options, grout curtains have a high capital cost and a low O&M cost.

Conclusion - Eliminate grout curtain from further consideration. The long-term management of uranium due to geochemical attenuation as well as the unproven resistance to uranium leachate for 200 years.

3.8.3.4 Removal

French Drain/Interception Trenches

Effectiveness - The use of french drains/interception trenches is effective in removing the volumes of groundwater located close to the surface and in shallow perched aquifers. The use of french drains/interception trenches is effective in meeting remediation goals by reducing the migration of the contaminants in the groundwater. The use of french drains/interception trenches is effective in protecting both human health and the environment by reducing lateral contaminant migration and by removing contaminants for treatment and disposal.

Impacts to human health during installation of french drains/interception trenches can be mitigated by using sound construction safety practices. OSHA trenching safety standards will have to be utilized to maintain worker safety. The use of french drains/interception trenches is a reliable technology for localized containment of groundwater, controlling subsurface flows, and removing groundwater; however, it is only effective as long as the pumping system is operating properly. Allowing the system to drain passively by gravity flow also requires construction and use of collection sumps. The system may have to be backflushed occasionally to prevent clogging of the drains.

Implementability - french drains/interception trenches are administratively feasible when used in conjunction with other treatment and disposal technologies. Both the resources and services required to install french drains/interception trenches are readily available.

Cost - When compared to other removal options, french drains/interception trenches have a moderate capital and O&M cost.

Conclusion - Retain french drains/interception trenches for further consideration.

Excavation Dewatering

Effectiveness - Excavation dewatering would be an effective method for pumping out the volumes of construction water that can accumulate in an excavation. This process is effective in 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 both human health and the environment by reducing lateral or downward contaminant migration and by removing contaminants for treatment and disposal.

During excavation activities, impacts to human health will 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 will 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 - When compared to other removal options, excavation dewatering has a low capital and O&M cost.

Conclusion - Retain excavation dewatering for further consideration to be used in conjunction with soil/waste removal technologies.

3.8.3.5 Treatment

Sedimentation

Effectiveness - Sedimentation, also known as clarification, is an effective way to remove particulates from groundwater and construction water. Settling tanks can be sized to handle the volumes of groundwater required for treatment. The tanks could also be effective for providing temporary storage capacity in order to eliminate surges at the treatment facility. Sedimentation would be effective in meeting remediation goals by reducing contaminant volume. Contaminated suspended

solids can be partially removed by sedimentation. The remaining contaminants would be treated at the AWWT facility. Sedimentation is effective in protecting both human health and the environment by reducing the concentration of contaminants in the groundwater and construction water.

The construction of settling tanks would have a negligible impact on both human health and the environment, since construction of the tanks would not require any disturbance to the contaminated materials. The sedimentation process is a proven and reliable technology for the separation of particles, heavier than water, from water.

Implementability - The use of sedimentation is administratively feasible when used in conjunction with other treatment and disposal technologies. The uranium and other contaminants in the groundwater/construction water at the Inactive Flyash Pile/South Field/Active Flyash Pile will require further treatment before it is disposed. The settling tanks will also be used as holding tanks for wastewater storage until the wastewater can be pumped to the AWWT facility for treatment. Both the resources and services required to install and operate settling tanks are readily available.

Cost - When compared to other treatment options, sedimentation has a moderate capital and O&M cost.

Conclusions - Retain sedimentation as a pretreatment to other water treatment technologies.

Advanced Wastewater Treatment

Effectiveness - The AWWT facility would be very effective at handling the volume of groundwater and construction water from the Inactive Flyash Pile/South Field/Active Flyash Pile. The AWWT facility will have the capacity to accept and treat the remediation water from all of the Operable Unit 2 subunits. Transferring water to the AWWT facility from the Inactive Flyash Pile/South Field/Active Flyash Pile will have to be coordinated with the other Operable Unit 2 subunits as well as the water from Operable Units 1, 4, and 5. Adequate storage capacity will be necessary at the Inactive Flyash Pile/South Field/Active Flyash Pile to hold the water until it can be treated by the AWWT facility. This can be incorporated into the sedimentation tanks. The AWWT facility would be very effective at meeting the remediation goals because the treatment processes would reduce the toxicity and volume of the contaminated groundwater and construction water.

During construction of the facility, potential impacts to human health could be mitigated using standard construction safety practices. Operation of the AWWT facility would have a positive impact to human health and the environment by treating the water. The AWWT facility would be a reliable method of treating the groundwater and construction water if it is used in conjunction with a pretreatment step to remove suspended solids specific to the Inactive Flyash Pile/South Field/Active Flyash Pile.

Implementability - Using the AWWT facility is administratively feasible. NPDES permits would be required. The facility is currently under construction and is currently scheduled to begin accepting Operable Unit 2's groundwater and construction water in June 1996.

Cost - When compared to other treatment options, using the AWWT facility would have a low capital and O&M cost because the facility will have already been constructed.

Conclusion - Retain the option of using the AWWT facility for treating the groundwater and construction water from the Inactive Flyash Pile/South Field/Active Flyash Pile.

3.8.3.6 Disposal

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 extracted groundwater/construction water. Discharge of treated effluent to the Great Miami River meets the remediation goals by removing the treated water from the site enabling future site use. There would be no impacts to human health or the environment during construction of the discharge pipeline because the work has already been completed. There would be no significant impacts to human health and the environment during operation because the water being discharged would be treated to acceptable levels. Discharge of treated wastewater to the Great Miami River is the current disposal method at the FEMP which 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 current NPDES permit; however, it is

regulated by internal DOE DCGs. This option will require modification of the existing NPDES permit for the added flow.

Cost - When compared to other disposal options, this option has a low capital and O&M cost.

Conclusion - Discharge of treated wastewater to the Great Miami River via the existing pipeline is a viable process option. Retain this process option for further consideration.

Discharge to Paddys Run

Effectiveness - Discharge of treated groundwater and construction water to Paddys Run would be an effective method for disposing the extracted groundwater/construction water. This option would require construction of a new pipeline from the AWWT facility to Paddys Run. Impacts to human health during construction could be mitigated by using sound construction safety practices and complying with OSHA trenching standards. There would be minimal impacts to the environment during implementation because the water being discharged would have already been treated. Discharge of treated wastewater to Paddys Run is not currently used at the FEMP because there is an existing pipeline and NPDES permit for discharge to the Great Miami River.

Implementability - This discharge option may be administratively difficult to implement. A new NPDES discharge permit would be required. Also, due to the intermittent nature of Paddys Run, more stringent discharge limits would likely be required. This option would also be administratively difficult to justify because there already is an existing pipeline with a NPDES permit for discharge to the Great Miami River.

Cost - When compared to other disposal options, discharge of treated wastewater to Paddys Run has a high capital and moderate O&M cost.

Conclusion - Even though discharge to Paddys Run should be effective and implementable, it is not being retained because the existing discharge pipeline and NPDES permit for the Great Miami River is already in place.

3.9 SUMMARY OF TECHNOLOGY EVALUATIONS AND SELECTION OF REPRESENTATIVE TECHNOLOGIES

This section presents a summary of the remedial technologies and process options remaining after they were evaluated based on effectiveness, implementability and cost. As a result of this evaluation process, several of the potentially applicable process options have been removed from further consideration. The technologies that were evaluated in this step are shown in Tables 3-14 through 3-18 for soil/sediment/waste, and in Tables 3-19 through 3-21 for groundwater/construction water. The technologies screened in this phase are shown in shaded areas. The technologies remaining after this screening will be combined into the remedial alternatives potentially applicable for remediation of the Operable Unit 2 subunits.

This section also selects representative technologies for different process options that are relatively equal in terms of effectiveness, implementability, and cost. Selection of one process over another as a representative process does not preclude the use of either process during remedial design. A representative process is selected only to avoid development of alternatives which are similar and cannot effectively be distinguished from one another with the detailed analysis evaluation criteria.

3.9.1 Summary of Technology Evaluations for Soil/Sediment/Waste

The summaries of the technologies remaining after the evaluation screening are listed by their corresponding subunit.

3.9.1.1 Solid Waste Landfill

As shown in Table 3-14, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Physical Barriers
- Security Guards
- Deed Restrictions
- Composite Cap
- Surface Water Controls
- Mechanical Excavation
- Sorting/Separation
- Revegetation
- Crushing/Shredding
- Drying
- On-site Disposal Facility

TABLE 3-14

EVALUATION OF TECHNOLOGIES FOR SOLID WASTE LANDFILL SOIL/SEDIMENT/SOLID WASTE MEDIA

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective.	No consideration.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Effective at isolating waste. 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/ Moderate O&M	Retain for further consideration.
		Security Guards	Effective as supplement to physical barriers at isolating waste.	Readily implementable.	Low Capital Moderate O&M included in physical barriers.	Retain for further consideration.
		Deed Restrictions	Effective in placing legal restraints on land usage 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 law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
In Situ Containment	Cap	Composite Cap	Effective in preventing exposure to soils/landfill contents and at miminizing infiltration.	Readily implementable to construct.	High Capital/ High O&M	Retain for further consideration.
	Surface Controls	Surface Water Controls	Effective in controlling surface water and in minimizing water erosion. May impact nearby wetlands.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.
Removal	Excavation	Mechanical Excavation	Very effective in removing soil, solid wastes and low level radioactive wastes. Does not treat waste.	Readily implementable.	Moderate Capital/Moderate O&M	Retain for further consideration.
		Sorting/ Separation	Effective at minimizing the total amount of material that would have to be treated or disposed. Does not treat waste.	Physical methods are readily implementable. Radiological sorting method is slow.	Moderate Capital/High O&M	Retain for further consideration.
	Surface Controls	Revegetation	Effective in controlling erosion, in stabilizing the surface of backfilled areas, and at land reclamation.	Readily implementable.	Moderate Capital/ Low O&M	Retain for further consideration.

TABLE 3-14
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Ex Situ Treatment	Physical/ Chemical	Crushing/ Shredding	Effective for improving material handling characteristics.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.
		Drying	Effective as pretreatment, treatment or post treatment when used with other technologies.	Readily implementable.	Moderate Capital/Moderate O&M	Retain for further consideration.
Disposal	On-site Disposal	On-Site Disposal Facility	Effective at containing the solid waste and reducing migration of the contaminants. Reduces surface water infiltration and leachate generation.	Readily implementable to construct. However, siting requirements may cause difficulty in implementation because the FEMP is located over a sole-source aquifer.	High Capital/ High O&M	Retain for further consideration.
	Off-site Disposal	Low-Level Radioactive Waste Disposal Facility	Effective disposal of dried, radiologically contaminated wastes.	Readily implementable, provided access to NTS remains available. 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	Retain for further consideration.
	Transportation	Truck Transportation	Effective for on-site and off-site disposal.	Readily implementable, must notify state and local agencies and comply with applicable transportation regulations.	Moderate Capital/High O&M	Retain for further consideration
		Rail Transportation	Effective for off-site disposal at facilities with rail spurs and in combination with truck transport for disposal at the NTS.	Readily implementable. An extension to the existing rail spur at the FEMP would be required. Additionally, notification to applicable state and local agencies along the travel routes would be required. Special packaging of waste would also be required.	High Capital/Low O&M	Retain for further consideration

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TABLE 3-15

EVALUATION OF TECHNOLOGIES FOR THE LIME SLUDGE PONDS SOIL/LIME SLUDGE/WASTE MEDIA

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective	No implementation required.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Effective at isolating waste. 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/ Moderate O&M	Retain for further consideration.
		Security Guards	Effective as supplement to physical barriers at isolating waste.	Readily implementable.	Low Capital Moderate O&M included in physical barriers.	Retain for futher consideration.
		Deed Restrictions	Effective in placing legal restraints on land usage 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 law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
In Situ Containment	Cap	Composite Cap	Effective in preventing exposure to soils/lime sludge and in minimizing infiltration.	Readily implementable to construct.	High Capital/ High O&M	Retain for further consideration.
	Surface Controls	Surface Water Controls	Effective in controlling surface water and in minimizing water erosion.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.

TABLE 3-15
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Removal	Excavation	Mechanical Excavation	Very effective in removing soil, lime sludge and low level radioactive wastes. Does not treat waste.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.
		Sorting/ Separation	Effective at minimizing the total amount of material that would have to be treated or disposed. Does not treat waste.	Physical methods are readily implementable. Radiological sorting is slow.	Moderate Capital/High O&M	Retain for further consideration.
	Surface Controls	Revegetation	Effective in controlling erosion, in stabilizing the surface of backfilled areas, and at reclaiming land.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.
Ex Situ Treatment	Physical/Chemical	Stabilization/ Solidification	Effective for immobilizing metals and radionuclides. The solidified matrix reduces exposed surface area and leachate generation. Some volume increase. Also effective for creating a stabilized backfill by mixing the lime sludge with flyash.	Moderately difficult to implement for contaminated material. Readily implementable for lime sludge/flyash stabilization.	Moderate Capital/ Moderate O&M	Retain for further consideration.
		Thermoplastic Encapsulation	Effective in stabilizing soluble, toxic wastes but not proven on large scale projects. Large volume increase due to addition of thermoplastic material.	Difficult to implement. Requires a highly specialized work force.	High Capital	Eliminate from further consideration.

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TABLE 3-15
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Ex Situ Treatment (Cont.)	Physical/Chemical (Cont.)	Crushing/ Shredding	Effective for improving material handling characteristics.	Readily implementable.	Low Capital/Low O&M	Retain for further consideration.
		Drying	Effective as a pretreatment, treatment or post treatment when used with other technologies.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.
Disposal	On-Site Diposal	On-Site Disposal Facility	Effective at containing the contaminated materials and reducing migration of the contaminants. Reduces surface water infiltration and leachate generation.	Readily implementable to construct.	High Capital/ High O&M	Retain for further consideration.
	Off-Site Disposal	Low-Level Radioactive Waste Disposal Facility	Effective disposal of dried low-level radioactive wastes.	Readily implementable, provided access to NTS remains available. 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	Retain for further consideration.
	Transportation	Truck Transportation	Effective for on-site and off-site disposal.	Readily implementable, must notify state and local agencies and comply with applicable transportation regulations.	Moderate Capital/High O&M	Retain for further consideration

TABLE 3-15
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Disposal (cont.)	Transportation (cont.)	Rail Transportation	Effective for off-site disposal at facilities with rail spurs and in combination with truck transport for disposal at the NTS.	Readily implementable. An extension to the existing rail spur at the FEMP would be required. Additionally, notification to applicable state and local agencies along the travel routes would be required. Special packaging of waste would also be required.	High Capital/ High O&M	Retain for further consideration

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TABLE 3-16

EVALUATION OF TECHNOLOGIES FOR THE INACTIVE FLYASH PILE SOIL/SEDIMENT/FLYASH/WASTE MEDIA

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective.	No consideration.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Effective at isolating waste. 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/ Moderate O&M	Retain for further consideration.
		Security Guards	Effective as supplement to physical barriers at isolating waste.	Readily implementable.	Low Capital Moderate O&M included in physical barriers.	Retain for further consideration.
		Deed Restrictions	Effective in placing legal restrains on land usage 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 law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
In Situ Containment	Cap	Composite Cap	Effective in preventing exposure to soils/flyash and at minimizing infiltration	Readily implementable to construct	High Capital/High O&M	Retain for further consideration.
	Surface Controls	Surface Water Controls	Effective in controlling surface water and in minimizing water erosion.	Readily implementable.	Low Capital/ Low &M	Retain for further consideration.

TABLE 3-16
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Removal	Excavation	Mechanical Excavation	Very effective in removing soil, flyash and solid wastes. Does not treat waste.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.
		Sorting/ Separation	Effective at minimizing the total amount of material that would have to be treated or disposed. Does not treat waste.	Physical methods are readily implementable. radiological sorting is slow.	Moderate Capital/ High O&M	Retain for further consideration.
	Surface Controls	Revegetation	Effective in controlling erosion, in stabilizing the surface of backfilled areas facilities and at land reclamation.	Readily implementable.	Moderate Capital/ Low O&M	Retain for further consideration.
Ex Situ Treatment	Physical/ Chemical	Soil Washing	Effective in removing uranium. This process requires pretreatment (separation) and post treatment (stabilization) of primary waste streams before disposal.	Moderately difficult to implement. Waste Streams are difficult to handle.	High Capital/ High O&M	Retain for further consideration.
		Stabilization/ Solidification	Effective for immobilizing metals and radionuclides. The solidified matrix reduces exposed surface area and leachate generation. Also effective for creating a stabilized backfill by mixing the flyash with lime sludge.	Moderately difficult to implement for contaminated material. Readily implementable for lime sludge/flyash stabilization.	Moderate Capital/ Moderate O&M	Retain for further consideration.

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TABLE 3-16
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Ex Situ Treatment (Cont.)	Physical/ Chemical (Cont.)	Thermoplastic Encapsulation	Effective in stabilizing soluble, non-toxic wastes but not proven on large scale projects. Waste may be incompatible with encapsulation matrix.	Difficult to implement. Requires a highly specialized work force.	High Capital/ High O&M	Eliminate from further consideration.
		Crushing/ Shredding	Effective for improving material handling characteristics.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.
		Drying	Effective as pretreatment, treatment or post treatment when used with other technologies.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.
	Thermal	Vitrification	Very effective in stabilizing contaminated material. The noncrystalline solid is very effective for reducing leachability.	Studies are required to determine if a stable glass/noncrystalline product can be readily fabricated from the soil waste matrix.	High Capital	Retain for further consideration.
Disposal	On-Site Disposal	On-Site Disposal Facility	Effective at containing the contaminated waste and reducing migration of the contaminants. Reduces surface water infiltration and leachate generation.	Readily implementable to construct.	High Capital/ High O&M	Retain for further consideration.

TABLE 3-16
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Disposal (Cont.)	Off-Site Disposal	Off-Site Waste Disposal Facility	Effective disposal for non-radiologically contaminated wastes.	Wastes must meet OAC 3745-27 and/or OEPA Policy 4.07 requirements. Must obtain approval from OEPA, DOE headquarters, and owner of off-site facility. Must prove that waste has not been contaminated with radiological or hazardous contaminants.	Moderate Capital/ Low O&M	Retain for further consideration.
		Low-Level Radioactive Waste Disposal Facility	Effective disposal for dried, contaminated wastes.	Readily implementable, provided access to NTS remains available. 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	Retain for further consideration.
	Transportation	Truck Transportation	Effective for on-site and off-site disposal.	Readily implementable, must notify state and local agencies and comply with applicable transportation regulations.	Moderate Capital/ High O&M	Retain for further consideration

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TABLE 3-16
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Disposal (Cont.)	Transportation (cont.)	Rail Transportation	Effective for off-site disposal at facilities with rail spurs and in combination with truck transport for disposal at the NTS.	Readily implementable. An extension to the existing rail spur at the FEMP would be required. Additionally, notification to applicable state and local agencies along the travel routes would be required. Special packaging of waste would also be required.	High Capital/ Low O&M	Retain for further consideration

TABLE 3-17

EVALUATION OF TECHNOLOGIES FOR THE SOUTH FIELD SOIL/SEDIMENT/WASTE MEDIA

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective.	No consideration.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Effective at isolating waste. 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/ Moderate O&M	Retain for further consideration.
		Security Guards	Effective as supplement to physical barriers at isolating waste.	Readily implementable.	Low Capital Moderate O&M included in physical barriers.	Retain for futher consideration.
		Deed Restrictions	Effective in placing legal restraints on land usage 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 law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
In Situ Containment	Cap	Composite Cap	Effective in preventing exposure to soils and at minimizing infiltration.	Readily implementable to construct.	High Capital/High O&M	Retain for further consideration.
	Surface Controls	Surface Water Controls	Effective in controlling surface water and in minimizing water erosion.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.

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TABLE 3-17
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Removal	Excavation	Mechanical Excavation	Very effective in removing soil, construction debris and low level radioactive wastes. Does not treat waste.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.
		Sorting/ Separation	Effective at minimizing the total amount of material that would have to be treated or disposed. Does not treat waste.	Physical methods are readily implementable. Radiological sorting is slow.	Moderate Capital/High O&M	Retain for further consideration.
	Surface Controls	Revegetation	Effective in controlling erosion, in stabilizing the surface of backfilled areas and at reclaiming land.	Readily implementable.	Moderate Capital/ Low O&M	Retain for further consideration.
Ex Situ Treatment	Physical/Chemical	Soil Washing	Effective in removing uranium. This process requires pretreatment (separation) and post treatment (stabilization) of primary waste streams before disposal.	Moderately difficult to implement. Waste streams are difficult to handle.	High Capital/High O&M	Retain for further consideration.
		Stabilization/ Solidification	Effective for immobilizing metals and radionuclides. The solidified matrix reduces exposed surface area and leachate generation.	Moderately difficult to implement.	Moderate Capital/ Moderate O&M	Retain for further consideration.

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TABLE 3-17
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Ex Situ Treatment (cont.)	Physical/Chemical (cont.)	Thermoplastic Encapsulation	Effective in stabilizing soluble, toxic wastes but not proven on large scale projects. Large volume increase due to addition of thermoplastic material.	Difficult to implement. Requires a highly specialized work force.	High Capital/High O&M	Eliminate from further consideration.
		Crushing/ Shredding	Effective for improving material handling characteristics.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.
		Drying	Effective pretreatment, treatment or post treatment when used with other technologies.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.
	Thermal	Vitrification	Effective in stabilizing contaminated material. The noncrystalline solid is very effective for reducing leachability.	Studies are required to determine if a stable glass/noncrystalline product can be readily fabricated from the soil/waste matrix.	High Capital/ High O&M	Retain for further consideration.
Disposal	On-Site Disposal	On-Site Disposal Facility	Effective at containing the contaminated material and reducing migration of the contaminants. Reduces surface water infiltration and leachate generation.	Readily implementable to construct.	High Capital/ High O&M	Retain for further consideration.
	Off-Site Disposal	Hazardous Disposal Facility	Effective at containing the hazardous wastes and reducing migration of the lead contamination. Reduces surface water infiltration and leachate generation.	Readily implementable to construct.	Moderate Capital/ Low O&M	Retain for further consideration.

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TABLE 3-17
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Disposal (Cont.)	Off-Site Disposal (Cont.)	Low-Level Radioactive Waste Disposal Facility	Effective disposal for dried contaminated wastes.	Readily implementable, provided access to NTS remains available. 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/ Low O&M	Retain for further consideration.
	Transportation	Truck Transportation	Effective for on-site and off-site disposal.	Readily implementable, must notify state and local agencies and comply with applicable transportation regulations.	Moderate Capital/High O&M	Retain for further consideration
		Rail Transportation	Effective for off-site disposal at facilities with rail spurs and in combination with truck transport for disposal at the NTS.	Readily implementable. An extension to the existing rail spur at the FEMP would be required. Additionally, notification to applicable state and local agencies along the travel routes would be required. Special packaging of waste would also be required.	High Capital/Low O&M	Retain for further consideration

TABLE 3-18

EVALUATION OF TECHNOLOGIES FOR THE ACTIVE FLYASH PILE SOIL/SEDIMENT/FLYASH MEDIA

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective.	No consideration.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Physical Barriers	Effective at isolating waste. 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/ Moderate O&M	Retain for further consideration.
		Security Guards	Effective as supplement to physical barriers at isolating waste.	Readily implementable.	Low Capital Moderate O&M included in physical barriers.	Retain for futher consideration.
		Deed Restrictions	Effective in placing legal restrains on land usage 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 law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
In Situ Containment	Cap	Clay Cap	Effective in preventing exposure to flyash.	Readily implementable to construct.	Moderate Capital/ Moderate O&M	Retain for further consideration.
	Surface Controls	Surface Water Controls	Effective in controlling surface water and in minimizing water erosion.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.
Removal	Excavation	Mechanical Excavation	Very effective in removing soil and flyash. Does not treat material.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.

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TABLE 3-18
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Removal (cont.)	Excavation (cont.)	Sorting/ Separation	Effective at minimizing the total amount of material that would have to be treated or disposed. Does not treat waste.	Physical methods are readily implementable. Radiological sorting is slow.	Moderate Capital/ High O&M	Retain for further consideration.
	Surface Controls	Revegetation	Effective in controlling erosion, in stabilizing the surface of waste disposal facilities, and at land reclamation.	Readily implementable.	Low Capital/ Low O&M	Retain for further consideration.
Ex Situ Treatment	Physical/Chemical	Stabilization/ Solidification	Effective for creating a stabilized backfill by mixing the flyash with lime sludge.	Readily implementable for lime sludge/flyash stabilization.	Moderate Capital/ Moderate O&M	Retain for further consideration.
		Drying	Effective pretreatment, treatment or post treatment when used with other technologies.	Readily implementable.	Moderate Capital/ Moderate O&M	Retain for further consideration.
Disposal	On-Site Disposal	On-Site Disposal Facility	Effective at containing the flyash and soil and reducing migration of the contaminants. Reduces surface water infiltration and leachate generation.	Readily implementable to construct.	High Capital/ High O&M	Retain for further consideration.

TABLE 3-18
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Disposal (Continued)	Off-Site Disposal	Off-Site Waste Disposal Facility	Effective disposal for non-radiologically contaminated flyash.	Wastes must meet OAC 3745-27 and/or OEPA 4.07 requirements. Must obtain approval from DOE headquarters and owner of off-site facility. Must prove that waste has not been contaminated with radiological or hazardous contaminants.	Moderate Capital/ Low O&M	Retain for further consideration.
		Low-Level Radioactive Waste Disposal Facility	Effective disposal of dried radiologically contaminated wastes.	Readily implementable, provided access to NTS remains available. 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	Retain for further consideration.
	Transportation	Truck Transportation	Effective for on-site and off-site disposal.	Readily implementable, must notify state and local agencies and comply with applicable transportation regulations.	Moderate Capital/High O&M	Retain for further consideration
		Rail Transportation	Effective for off-site disposal at facilities with rail spurs and in combination with truck transport for disposal at the NTS.	Readily implementable. An extension to the existing rail spur at the FEMP would be required. Additionally, notification to applicable state and local agencies along the travel routes would be required. Special packaging of waste would also be required.	High Capital/Low O&M	Retain for further consideration

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TABLE 3-19

EVALUATION OF TECHNOLOGIES FOR GROUNDWATER/CONSTRUCTION WATER AT SOLID WASTE LANDFILL

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective	No implementation required.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Deed Restrictions	Effective in placing legal restraints on ground water usage. Will not treat or stabilize waste, but mitigate potential public exposure by prohibiting the installation of production wells for agriculture or consumption purposes.	Readily implementable. Susceptible to changes in law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
	Monitoring	Groundwater Monitoring Wells	Effective in determining underground contaminant migration and in 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	Retain for further consideration.
Removal	Extraction	Excavation Dewatering	Effective for safely removing stormwater runoff and groundwater seepage.	Readily implementable.	Low Capital and O&M	Retain for further consideration.
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	Retain for further consideration.

TABLE 3-19
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Treatment (Continued)	Physical/ Chemical Treatment	FEMP AWWT	Very effective in 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	Retain for further consideration.
Disposal	Discharge	Discharge to Great Miami River	Effective disposal of treated waste water.	Implementable. Requires modification to NPDES permit.	Low Capital and O&M	Retain for further consideration.
		Discharge to Paddys Run	Effective disposal of treated waste water.	Requires new NPDES permit, and a new discharge pipeline.	High Capital and Moderate O&M	Eliminate from further consideration.

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TABLE 3-20

EVALUATION OF TECHNOLOGIES FOR GROUNDWATER/CONSTRUCTION WATER AT LIME SLUDGE PONDS

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective	No implementation required.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Deed Restrictions	Effective in placing legal restraints on ground water usage. Will not treat or stabilize waste, but mitigate potential public exposure by prohibiting the installation of production wells for agriculture or consumption purposes.	Readily implementable. Susceptible to changes in law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
	Monitoring	Groundwater Monitoring Wells	Effective in determining underground contaminant migration and in 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	Retain for further consideration.
Removal	Extraction	Excavation Dewatering	Effective for safely removing stormwater runoff and groundwater seepage.	Readily implementable.	Low Capital and O&M	Retain for further consideration.
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	Retain for further consideration.

TABLE 3-20
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Treatment (Continued)	Physical/ Chemical Treatment	FEMP AWWT	Very effective in 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	Retain for further consideration.
Disposal	Discharge	Discharge to Great Miami River	Effective disposal of treated waste water.	Implementable. Requires modification to NPDES permit.	Low Capital and Moderate O&M	Retain for further consideration.
		Discharge to Paddys Run	Effective disposal of treated waste water.	Requires new NPDES permit, new discharge pipeline.	High Capital and Moderate	Eliminate from further consideration.

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TABLE 3-21

EVALUATION OF TECHNOLOGIES FOR GROUNDWATER/CONSTRUCTION WATER AT INACTIVE FLYASH PILE, SOUTH FIELD, AND ACTIVE FLYASH PILE

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	Not Applicable	Not effective	No implementation required.	None	Required as a baseline consideration by NCP.
Institutional Actions	Access Restrictions	Deed Restrictions	Effective in placing legal restraints on ground water usage. Will not treat or stabilize waste, but mitigate potential public exposure by prohibiting the installation of production wells for agriculture or consumption purposes.	Readily implementable. Susceptible to changes in law governing transference of property, and to deed adherence and enforcement.	Low Capital/ Low O&M	Retain for further consideration.
	Monitoring	Groundwater Monitoring Wells	Effective in determining underground contaminant migration and in 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	Retain for further consideration.
Containment/Control	Subsurface Barriers/ Controls	Slurry Wall	Effectiveness unproven with regard to geochemical attenuation of uranium. Preventing uranium migration through slurry wall for 200 year minimum design life is questionable.	Readily implementable. Can be keyed in to low permeability clay layer beneath perched groundwater.	Moderate Capital and Low O&M	Estimate from further consideration

TABLE 3-21
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Containment/Control (Cont.)	Subsurface Barriers/ Controls (Cont.)	Grout Curtain	Effectiveness unproven with regard to geochemical attenuation of uranium. Preventing uranium migration through slurry wall for 200 year minimum design life is questionable.	Difficult to implement due to uneven placement of grout.	High Capital and Low O&M	Eliminate from further consideration.
Removal	Extraction	French Drains/ Interception Trenches	Effective in removing contaminated groundwater near surface and in shallow perched aquifers.	Readily implementable.	Moderate Capital and O&M	Retain for further consideration.
		Excavation Dewatering	Effective for safely removing storm water runoff and groundwater seepage.	Readily implementable.	Low Capital and O&M	Retain for further consideration.
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	Retain for further consideration.
	Physical/ Chemical Treatment	FEMP AWWT	Very effective in 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	Retain for further consideration.
Disposal	Discharge	Discharge to Great Miami River	Effective disposal of treated waste water.	Implementable. Requires modification to NPDES permit.	Low Capital and O&M	Retain for further consideration.

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TABLE 3-21
(Continued)

General Response Action Component	Remedial Technology	Process Options	Effectiveness	Implementability	Cost	Screening Comments
Disposal (Cont.)	Discharge (Cont.)	Discharge to Paddys Run	Effective disposal of treated wastewater.	Requires new NPDES permit, new discharge pipeline.	High Capital and Moderate O&M	Eliminate from further consideration.

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- Off-site Low-level Radioactive Waste Disposal Facility
- Truck Transportation
- Rail Transportation

3.9.1.2 Lime Sludge Ponds

As shown in Table 3-15, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Physical Barriers
- Security Guards
- Deed Restrictions
- Composite Cap
- Surface Water Controls
- Mechanical Excavation
- Sorting/Separation
- Revegetation
- Stabilization/Solidification
- Crushing/Shredding
- Drying
- On-site Disposal Facility
- Off-site Low-level Radioactive Waste Disposal Facility
- Truck Transportation
- Rail Transportation

3.9.1.3 Inactive Flyash Pile

As shown in Table 3-16, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Physical Barriers
- Security Guards
- Deed Restrictions
- Composite Cap
- Surface Water Controls
- Mechanical Excavation
- Sorting/Separation
- Revegetation
- Soil Washing
- Stabilization/Solidification
- Crushing/Shredding
- Drying
- Vitrification
- On-site Disposal Facility
- Off-site Waste Disposal Facility

- Off-site Low-level Radioactive Waste Disposal Facility
- Truck Transportation
- Rail Transportation

3.9.1.4 South Field

As shown in Table 3-17, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Physical Barriers
- Security Guards
- Deed Restrictions
- Composite Cap
- Surface Water Controls
- Mechanical Excavation
- Sorting/Separation
- Revegetation
- Soil Washing
- Stabilization/Solidification
- Crushing/Shredding
- Drying
- Vitrification
- On-site Disposal Facility
- Off-site Hazardous Waste Disposal Facility
- Off-site Low-level Radioactive Waste Disposal Facility
- Truck Transportation
- Rail Transportation

3.9.1.5 Active Flyash Pile

As shown in Table 3-18, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Physical Barriers
- Security Guards
- Deed Restrictions
- Clay Cap
- Surface Water Controls
- Mechanical Excavation
- Sorting/Separation
- Revegetation
- Stabilization/Solidification
- Drying

- On-site Disposal Facility
- Off-site Waste Disposal Facility
- Off-site Low-level Radioactive Waste Disposal Facility
- Truck Transportation
- Rail Transportation

3.9.2 Summary of Technology Evaluations for Groundwater/Construction Water

The summaries of the technologies remaining after the evaluation screening are listed by their corresponding subunit.

3.9.2.1 Solid Waste Landfill

As shown in Table 3-19, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Deed Restrictions
- Groundwater Monitoring Wells
- Excavation Dewatering
- Sedimentation
- AWWT Facility
- Discharge to Great Miami River

3.9.2.2 Lime Sludge Ponds

As shown in Table 3-20, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Deed Restrictions
- Groundwater Monitoring Wells
- Excavation Dewatering
- Sedimentation
- AWWT Facility
- Discharge to Great Miami River

3.9.2.3 Inactive Flyash Pile/South Field/Active Flyash Pile

As shown in Table 3-21, the following process options are remaining after the evaluation screening and will be used for alternative development:

- No Action
- Deed Restrictions
- Groundwater Monitoring Wells
- French Drains/Interception Trenches

- Excavation Dewatering
- Sedimentation
- AWWT Facility
- Discharge to Great Miami River

3.9.3 Selection of Representative Technologies

Several of the remedial technologies that remain after the evaluation screening can be considered for alternative development using representative technologies. This procedure is suggested in the EPA Guidance Document for Conducting Remedial Investigations and Feasibility Studies under CERCLA.

The technology and corresponding process options which are suitable for being grouped together are off-site low-level radioactive waste disposal facilities. Two options are available for off-site disposal of radiologically contaminated material. The waste could either be sent to NTS which is a government owned facility, or to Envirocare which is a privately owned facility. Either facility would provide effective disposal of dried radiologically contaminated material. Using NTS would be more readily implementable because it is a government owned facility, which would limit the DOE's liability. Both options would have similar capital costs.

Selection of a representative process prevents development of similar alternatives. NTS and Envirocare would be similar with regards to the detailed analysis criteria evaluated in this FS when compared to other alternatives which do not include off-site disposal.

For purposes of alternative development, radiologically contaminated material will be disposed at NTS, because it is more readily implementable. Selection of NTS as a representative process does not preclude Envirocare from being selected during remedial design.

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