DECLARATION STATEMENT

SITE NAME AND LOCATION

Fernald Environmental Management Project (FEMP) Site -- Operable Unit 4,
Fernald, Hamilton County, Ohio

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for Operable Unit 4 of the Fernald Site in Fernald, Ohio. This remedial action was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable 40 Code of Federal Regulations (CFR) Part 300, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

For Operable Unit 4 at the FEMP, DOE has chosen to complete an integrated CERCLA/NEPA process. This decision was based on the longstanding interest on the part of local stakeholders to prepare an Environmental Impact Statement (EIS) on the restoration activities at the FEMP and on the recognition that the draft document was issued and public comments received. Therefore, this single document is intended to serve as DOE's Record of Decision (ROD) for Operable Unit 4 under both CERCLA and NEPA; however, it is not the intent of the DOE to make a statement on the legal applicability of NEPA to CERCLA actions.

The decision presented herein is based on the information available in the administrative record for Operable Unit 4 and maintained in accordance with CERCLA. The major documents prepared through the CERCLA process include the Remedial Investigation (RI), the Feasibility Study (FS), and the Proposed Plan (PP) for Operable Unit 4. The FS and the PP also comprised DOE's draft EIS and were made available for public review and comment. This decision is also based on the public hearing held on March 21, 1994, in Harrison, Ohio, and the public meeting held on May 11, 1994, in Las Vegas, Nevada following the issuance of the Feasibility Study/Proposed Plan-Draft Environmental Impact Statement (FS/PP-DEIS). DOE has considered all comments received during the public comment period on the FS/PP-DEIS and following issuance of the final EIS in the preparation of this ROD.

The State of Ohio concurs with the remedy and the applicable or relevant and appropriate requirements (ARARs) put forth in this ROD for Operable Unit 4.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from Operable Unit 4, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE REMEDY

This is the selected remedial action for Operable Unit 4, one of five operable units at the FEMP. The materials within Operable Unit 4 exhibit a wide range of properties. Most notable would be the elevated direct radiation associated with the K-65 residues versus the much lower direct radiation associated with cold metal oxides in Silo 3. Even more significant would be the much lower levels of contamination associated with the soils and building materials, like concrete, within the Operable Unit 4 Study Area. To account for these differences and for the varied cleanup alternatives applying to each waste type, Operable Unit 4 was segmented into three subunits. These subunits are described as follows:

Subunit A: Silos 1 and 2 contents (K-65 residues and bentonite clay) and the sludge in the decant sump tank

Subunit B: Silo 3 contents (cold metal oxides)

Subunit C: Silos 1, 2, 3, and 4 structures; contaminated soils within the Operable Unit 4 boundary, including surface and subsurface soils and the earthen berm around Silos 1 and 2; the decant sump tank; the radon treatment system; the concrete pipe trench and the miscellaneous concrete structures within Operable Unit 4, any debris (i.e., concrete, piping, etc.) generated through implementing cleanup for Subunits A and B, and any perched groundwater encountered during remedial activities.

On the basis of the evaluation of final alternatives, the selected remedy addressing Operable Unit 4 at the FEMP is a combination of Alternatives 3A.1/Vit - Removal, Vitrification, and Off-site Disposal - Nevada Test Site (NTS); 3B.1/Vit - Removal, Vitrification, and Off-site Disposal - NTS; and 2C - Demolition, Removal and On-Property Disposal. These alternatives apply to Subunits A, B, and C respectively. The major components of the selected remedy include:

- Removal of the contents of Silos 1, 2, and 3 (K-65 residues and cold metal oxides) and the decant sump tank sludge.

- Vitrification (glassification) to stabilize the residues and sludges removed from the silos and decant sump tank.

- Off-site shipment for disposal at the NTS of the vitrified contents of Silos 1, 2, 3, and the decant sump tank.

- Demolition of Silos 1, 2, 3, and 4 and decontamination, to the extent practicable, of the concrete rubble, piping, and other generated construction debris.

- Removal of the earthen berms and excavation of contaminated soils within the boundary of Operable Unit 4, to achieve remediation levels. Placement of clean backfill to original grade following excavation.

- Demolition of the vitrification treatment unit and associated facilities after use. Decontamination or recycling of debris prior to disposition.

- On-property interim storage of excavated contaminated soils and contaminated debris in a manner consistent with the approved Work Plan for Removal Action 17 (improved storage of soil and debris) pending final disposition in accordance with the Records of Decision for Operable Units 5 and 3, respectively.

- Continued access controls and maintenance and monitoring of the stored wastes inventories.

- Institutional controls of the Operable Unit 4 area such as deed and land use restrictions.

- Potential additional treatment of stored Operable Unit 4 soil and debris using Operable Unit 3 and 5 waste treatment systems.

- Pumping and treatment as required of any contaminated perched groundwater encountered during remedial activities.

- Disposal of Operable Unit 4 contaminated debris and soils consistent with the Records of Decision for Operable Units 3 and 5, respectively.

The remedy specifies off-site disposal of vitrified contents of Silos 1, 2 and 3 at the NTS. At the time of the signing of this ROD, The Department of Energy - Nevada Operations Office (DOE-NV) is in the process of preparing a site-wide environmental impact statement (EIS) under NEPA for the NTS. Shipments of Operable Unit 4 vitrified waste are not proposed to begin until after the planned completion of the EIS for the NTS.

The planned date of completion of the EIS for the NTS is December 1995, at which time a Record of Decision is expected to be issued. Shipments of low-level waste generated from the remediation of Operable Unit 4 are not proposed to begin until mid-1997, which should be after the planned completion of the NTS site-wide EIS. Given these timeframes, DOE does not anticipate the NTS EIS schedule will negatively impact the Operable Unit 4 remediation schedule discussed in the ROD.

The containerized vitrified product will require interim storage at the FEMP prior to its transportation to the NTS for disposal. The purpose of this interim storage is two-fold; first, the vitrified product will require verification sampling in order to certify that each production lot has met specific performance and waste disposal criteria; and second, to provide the Fernald waste shipping program a buffer staging area where the material can be safely managed prior to its shipment to NTS in accordance with DOE as low as reasonably achievable (ALARA) principles, ARARs identified and included in the Operable Unit 4 ROD, as well as in a manner protective of human health and the environment. It has been anticipated that the interim storage area will be needed to accommodate the interim handling of approximately 90 days of vitrification production.

The decision regarding the final disposition of the remaining Operable Unit 4 contaminated soil and debris will be placed in abeyance, until completion of the Records of Decision for Operable Units 3 and 5 remedial actions, in order to take full advantage of planned and in progress waste minimization treatment processes by these operable units. Further, this strategy enables the integration of disposal decisions for contaminated soils and debris on a site-wide basis.

In the unlikely event unforeseen circumstances preclude the integration of Operable Unit 4 soil and debris into the Operable Unit 3 and/or Operable Unit 5 treatment and disposal decisions, the disposal decision for Operable Unit 4 contaminated soils and debris will be documented in a ROD amendment for Operable Unit 4 in accordance with Section 117(c) of CERCLA and United States Environmental Protection Agency (EPA) guidance. The ROD amendment will provide the public and the EPA further opportunity to review and comment on the final disposal option for Operable Unit 4 soils and debris. A ROD amendment to the Operable Unit 4 ROD will not be necessary in the event the Operable Unit 3 remedy for debris and the Operable Unit 5 remedy for contaminated soils can be feasibly implemented for Operable Unit 4.

In reaching the decision to implement this remedial alternative, DOE evaluated other alternatives for each subunit, in addition to no action. The other alternatives are: (a) *Subunit A - Silos 1 and 2 Contents*: (1) Removal, Cement Stabilization, Off-Site Disposal at Nevada Test Site; (b) *Subunit B - Silo 3 Contents*: (1) Removal, Vitrification, On-Property Disposal; (2) Removal, Cement Stabilization, On-Property Disposal; (3) Removal, Cement Stabilization, Off-Site Disposal at Nevada Test Site; (c) *Subunit C - Silos*

1, 2, 3, and 4 Structures, Soils, and Debris: (1) Demolition, Removal, Off-Site Disposal at Nevada Test Site; (2) Demolition, Removal, Off-Site Disposal at Permitted Commercial Facility.

A description of the alternatives is provided in the Decision Summary of the ROD, hereby incorporated by reference for DOE's NEPA ROD, and is available in the Administrative Record. CERCLA's nine criteria set forth in 40 CFR Part 300, the National Oil and Hazardous Substances Pollution Contingency Plan were used to evaluate the alternatives. The selected remedy represents the best balance among the alternatives with respect to these criteria and is the environmentally preferable alternative.

The preferred alternative for Operable Unit 4 provides the best performance when compared with the other alternatives, with respect to the evaluation criteria. This remedy will achieve substantial risk reduction by removing the sources of contamination, treating the material which poses the highest risk, shipping the treated residues off-site for disposal, managing the remaining contaminated soils and debris consistent with the site-wide strategy. The selected treatment alternative both reduces the mobility of the hazardous constituents and results in significant reduction in the volume of materials requiring disposal. The selected remedy also provides the highest degree of long-term protectiveness for human health and the environment

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment, and also reduce toxicity, mobility, or volume as a principal element. This remedy will result in contaminated debris and soil being dispositioned by Operable Units 3 and 5, respectively. Because this remedy will result in hazardous substances (i.e., contaminated soil and debris) remaining on site, above health-based levels, a review will be conducted every five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

All practical means to avoid or minimize environmental harm from implementation of the selected remedy have been adopted During excavation activities, sediment controls will be implemented to eliminate potential surface water runoff and sediment deposition to Paddys Run. Final site layout and design will include all practicable means (e.g., sound engineering practices and proper construction practices) to minimize environmental impacts.

____________________ ________
Regional Administrator, Date
U.S. Environmental Protection Agency Region V

Richard J. Guimond ____ 11-3-94
for Assistant Secretary for Environmental Management Date
U.S. Department of Energy

FINAL

RECORD OF DECISION

FOR REMEDIAL ACTIONS AT

OPERABLE UNIT 4

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

NOVEMBER 1994

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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AEA	Atomic Energy Act
AEC	Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIS	Characterization Investigation Study
CFR	Code of Federal Regulations
CMSA	Consolidated Metropolitan Statistical Area
COC	Constituents of Concern
COE	United States Army Corps of Engineers
CT	central tendency
DOE	United States Department of Energy
DOE-FN	United States Department of Energy - Fernald Field Office
DOE-NV	United States Department of Energy - Nevada Operations Office
DOT	U. S. Department of Transportation
EIS	Environmental Impact Statement
EP	Extraction Procedure
EPA	United States Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
FRESH	Fernald Residents for Environment, Safety, and Health
FS	Feasibility Study
FS/PP-DEIS	Feasibility Study/Proposed Plan - Draft Environmental Impact Statement
FS/PP-FEIS	Feasibility Study/Proposed Plan - Final Environmental Impact Statement
HEAST	Health Effects Assessment Summary Table
HEPA	High-Efficiency Particulate Air (filter)
HI	Hazard Index
HQ	Hazard Quotient
IARC	International Agency for Research on Cancer
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
ISA	Initial Screening of Alternatives

LRA	leading remedial alternative
MCL	maximum containment level
MCLG	maximum containment level goal
MCW	Mallinckrodt Chemical Works
MSL	mean sea level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NOEL	No Observed Effect Level
NOI	Notice of Intent
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRHP	National Register of Historic Places
NTS	Nevada Test Site
O&M	operation and maintenance
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
ORC	Office of Regional Council
PAH	polyaromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyls
PEIC	Public Environmental Information Center
Po	polonium
PP	Proposed Plan
PRG	proposed remediation goals
PRL	proposed remediation level
Ra	radium
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
Rn	radon
ROD	Record of Decision

ACRONYM LIST
(Continued)

RTS	radon treatment system
SARA	Superfund Amendment and Reauthorization Act
SDWA	Safe Drinking Water Act
TBC	to be considered
TCLP	Toxicity Characteristic Leaching Procedure
Th	thorium
U	uranium
USDA	United States Department of Agriculture
VOC	volatile organic compounds

LIST OF WEIGHTS AND MEASURES

cm	centimeter
ft	feet
ha	hectare
in	inch
kg	kilogram
km	kilometer
km^2	square kilometers
L	liters
m	meter
m^3	cubic meters
$\mu g/l$	micrograms per liter
M	million
mi	miles
mi^2	square miles
mg	milligram
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram day
mg/l	milligrams per liter
pCi/l	picoCuries per liter
pCi/g	picoCuries per gram
ppb	parts per billion
yd^3	cubic yards

1.0 SITE LOCATION AND DESCRIPTION

1.1 LOCATION

The Fernald Environmental Management Project (FEMP) site is a 425 hectare (ha) (1050 acres), government-owned facility located in southwestern Ohio, approximately 29 kilometers (km) (18 miles) northwest of downtown Cincinnati. The facility is located just north of Fernald, Ohio, a small farming community, and lies on the boundary between Hamilton and Butler counties (Figure 1-1).

In accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the FEMP was placed on the National Priorities List (NPL) in November 1989 as a result of environmental impacts caused by facility operations.

From 1952 until 1989, the FEMP site provided high-purity uranium metal products to support United States defense programs. Uranium production was halted in 1989 due to declining demand and a recognized need to commit available resources to environmental remediation. Former uranium operations at the FEMP site were limited to a fenced 55 ha (136 acres) tract of land known as the former Production Area located near the center of the site. The former Production Area consists of plant buildings, scrap metals, equipment, and drummed inventories all of which are components of Operable Unit 3. Large quantities of liquid and solid wastes were generated by the various production operations at the FEMP site. Prior to 1984, solid and slurried wastes received from off site sources and generated from FEMP processes were stored or disposed in the Waste Storage Area. This area, located west of the production facilities, includes: six low-level radioactive waste storage pits, two earthen-bermed concrete silos containing K-65 residues, one concrete silo containing metal oxides, one unused concrete silo, two lime sludge ponds, a burn pit, a clearwell, and a solid waste landfill. The Waste Storage Area, shown graphically in Figure 1-2, is addressed under FEMP Operable Units 1, 2, and 4. The former Production Area and Waste Storage Area are fenced and closed to the general public. Operable Unit 5 consists of all environmental media not associated with the preceding operable units. The remaining FEMP site areas consist of forest and pasture lands, a portion on which a nearby dairy farmer is authorized to graze livestock.

A sixth operable unit, known as the Comprehensive Site-Wide Operable Unit, was added as a provision of the Amended Consent Agreement (signed in 1991). This is not a specific site area; rather, it was created to enable DOE, the EPA, and the public to make a final assessment from a site-wide perspective that ongoing planned remedial actions identified in the Records of Decision for

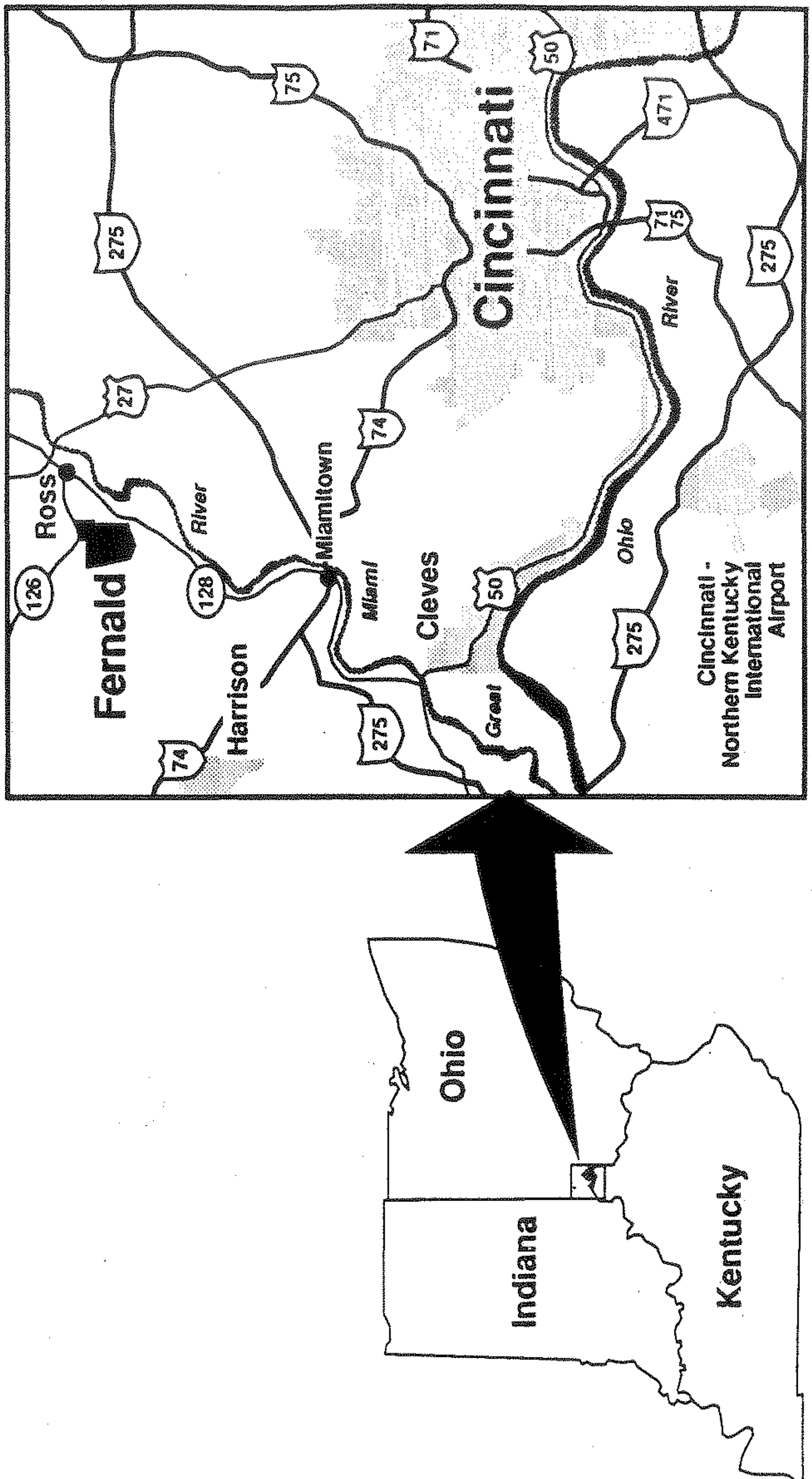

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FIGURE 1-1. FEMP FACILITY LOCATION MAP

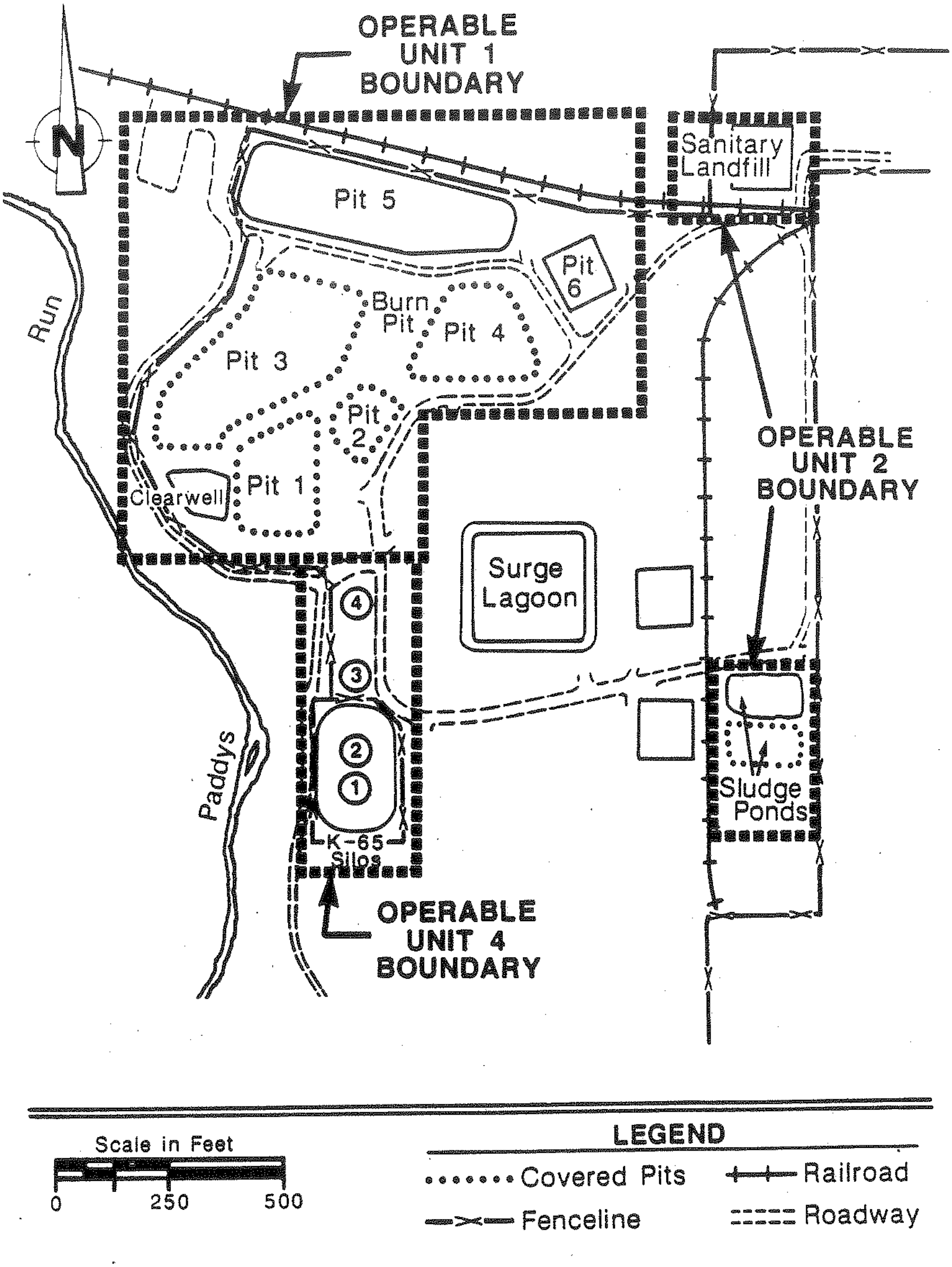

FIGURE 1-2. WASTE STORAGE AREA

the five operable units will provide a comprehensive remedy which is protective of human health and the environment.

This remedial action addresses Operable Unit 4 at the FEMP. Operable Unit 4 (Figure 1-3) is a 2.3 ha (5.8 acres) area located on the western side of the facility and is comprised of the following facilities and associated environmental media:

- Silos 1 and 2 and their contents (also termed K-65 silos);
- Silo 3 and its contents (termed cold metal oxide silo);
- Silo 4 (empty);
- The decant sump (an underground tank and its contents);
- A radon treatment system;
- A portion of a concrete pipe trench and other concrete structures;
- An earthen berm surrounding Silos 1 and 2;
- Soils beneath and immediately surrounding Silos 1, 2, 3, and 4;
- Perched groundwater in the vicinity of the silos that are encountered during the implementation of remedial actions;

Silos 1 and 2, the K-65 silos, contain 6,120 cubic meters (m^3) [8,005 cubic yards (yd^3)] of K-65 residues generated from the processing of high-grade uranium ore. The silos are large, cylindrical, above-grade, concrete vessels with post-tensioned steel reinforcing. Each of the domed silos is 24.4 meter (m) [80 feet (ft)] in diameter and 11 m (36 ft) high to the center of the dome.

The K-65 residues contain large activity concentrations of radionuclides, including radium and thorium. These radionuclides contribute to an elevated direct penetrating radiation field in the vicinity of the silos and to the chronic emission of significant quantities of the radioactive gas, radon, to the atmosphere from the silos. The K-65 residues are classified as by-product materials, consistent with Section 11(e)2 of the Atomic Energy Act (AEA), generated consequential to the processing of natural uranium ores.

Silo 3 contains 3,890 m^3 (5,088 yd^3) of residues, known as cold metal oxides, which were generated at the FEMP site during uranium extraction operations in the 1950s involving the previously

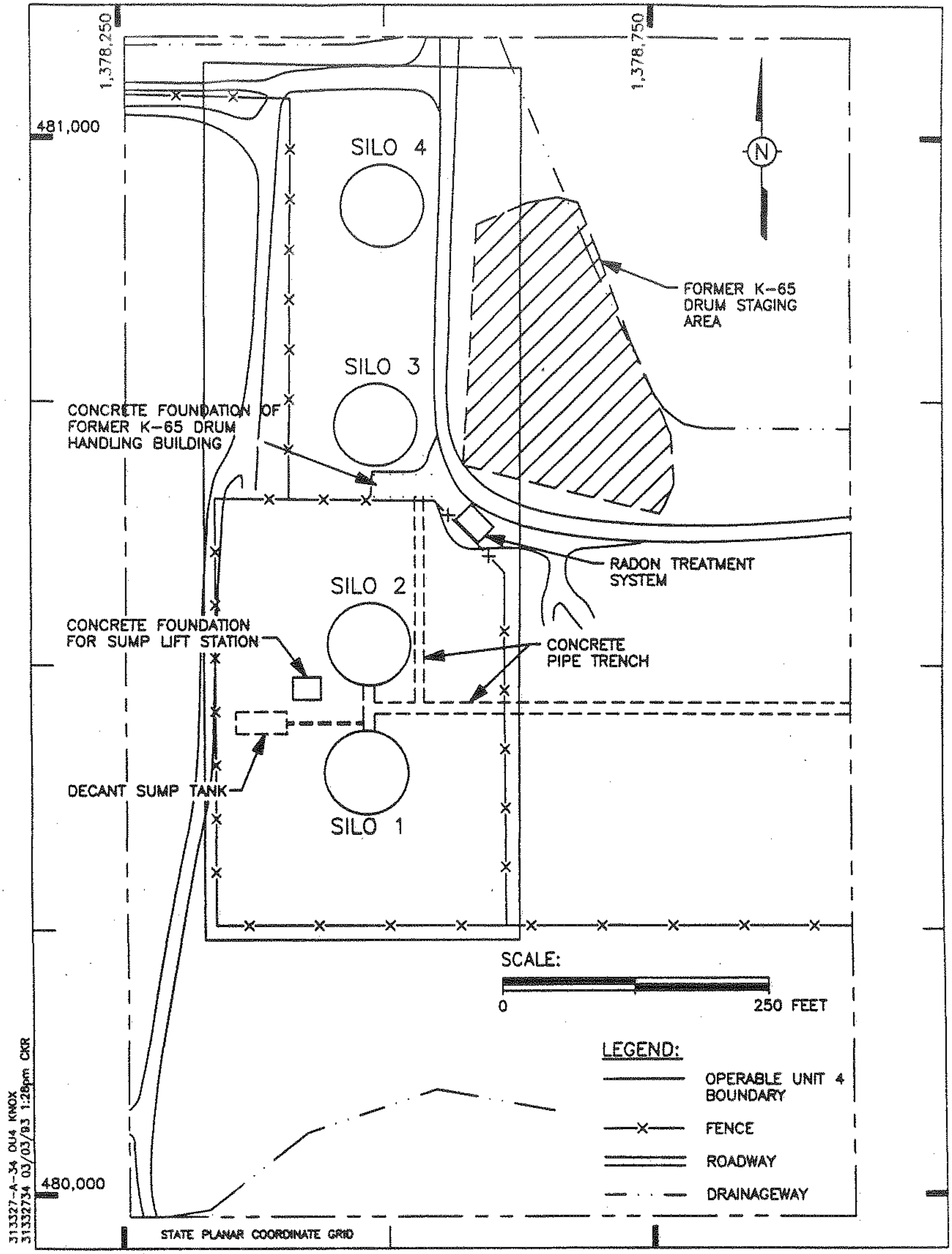

FIGURE 1-3. OPERABLE UNIT 4

mentioned uranium ores and ore concentrates received from a variety of uranium mills in the United States and abroad. Silos 3 and 4 are identical in design and construction to Silos 1 and 2. The residues within Silo 3 are similarly classified as by-product materials pursuant to Section 11(e)2 of the AEA. Silo 4 was never used for waste storage; however, rainwater has infiltrated the silo and has been removed in 1989 and again in 1991.

1.2 DEMOGRAPHICS AND LAND USE

The FEMP is located in the Cincinnati Consolidated Metropolitan Statistical Area (CMSA) which encompasses a regional area comprised of eight counties in Ohio, Kentucky, and Indiana. Population within the eight-county metropolitan area exceeded 1.7 million in 1990, and within a 5-mile radius of the FEMP site, there were an estimated 22,927 residents in 1990.

The on-property work population includes employees of DOE, it's site restoration management contractor, the Fernald Environmental Restoration Management Corporation (FERMCO), and other subcontractors. Physical structures are located on approximately 82 ha (203 acres) in the center of the FEMP site, in the administration area and in the former Production Area. The FEMP maintains strict access controls, including a security force and fences, which control public access to the site.

The land adjacent to the FEMP is primarily devoted to open land use such as agriculture and recreation. Scattered residences and several villages, including Fernald, New Baltimore, Ross, New Haven, and Shandon are located near the FEMP site. The nearest residence is within three quarters of a mile from the center of the facility. The nearest residences to the western FEMP property boundary (the boundary along the eastern side of Paddys Run Road) are located along the western side of Paddys Run Road. A dairy farm is located on Willey Road just outside the southeast corner of the FEMP property boundary. Several residences are located off Paddys Run Road approximately 2.4 km (1.5 mi) south of the FEMP property. These residences are in the vicinity of the South Plume, a portion of the Great Miami Aquifer that contains a plume of uranium contamination originating from the FEMP extending south of the property boundary for approximately three-quarters of a mile.

More than 160 ha (395 acres) of the open land on the FEMP property are leased to a nearby dairy farmer who grazes livestock on the property. Pine plantations are located to the northeast and southwest of the former Production Area. A considerable amount of the soils within the boundaries of the FEMP site are designated by the United States Department of Agriculture (USDA) as prime agricultural soil (USDA 1980, 1982). However, none of the land on the FEMP site is designated prime farmland under the Farm and Policy Protection Act regulations (7 CFR §658) of 1981. Because the area had been intensively used for agricultural purposes prior to the establishment of the FEMP facility, there is no land on or in the vicinity of the FEMP site where a pre-developed natural environment remains intact. The land closest to this description would be recreated prairie lands on the Miami Whitewater Forest Park, several miles south of the FEMP site.

The area surrounding the FEMP site has a large and diverse archaeological and historical resource base. According to records kept by the Miami Purchase Association for Historic Preservation, an unusually high percentage of the existing 19th century buildings in the area are historically important. Within the vicinity of the FEMP site [a 3.2 km (2 mi) radius from the boundary], there are properties listed on the National Register of Historic Places (NRHP) and a number of additional structures that have been judged eligible for inclusion in the listing. Six major archaeological sites lie within five miles of the FEMP site and five of these are included in the NRHP. No archaeological sites or properties on the NRHP are located in or adjacent to Operable Unit 4.

1.3 TOPOGRAPHY AND SURFACE WATER HYDROLOGY

The maximum elevation along the northern boundary of the FEMP property is a little more than 213 m (700 ft) above mean sea level (MSL). The former Production Area and Waste Storage Area rest on a relatively level plain at about 174 m (580 ft) above MSL. The plain slopes from 183 m (600 ft) above MSL along the eastern boundary of the FEMP to 174 m (570 ft) above MSL at the K-65 silos, and then drops off toward Paddys Run stream at an elevation of 168 m (550 ft) above MSL.

All drainage, including surface water on the FEMP site is generally from east to west towards Paddys Run, with the exception of the extreme northeast corner which drains east toward the Great Miami River. Major surface water bodies on and adjacent to the FEMP site include the Storm Sewer Outfall Ditch, Paddys Run, and the Great Miami River (see Figure 1-4). The Storm Sewer Outfall Ditch originates within the FEMP site and flows toward the southwest where it enters Paddys Run, which flows southward along the western boundary of the facility. Paddys Run is a tributary of the Great Miami River. The Great Miami River flows generally toward the southwest; however, locally it flows to the east and south of the FEMP site.

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 (1.4 mi) south of the southwest

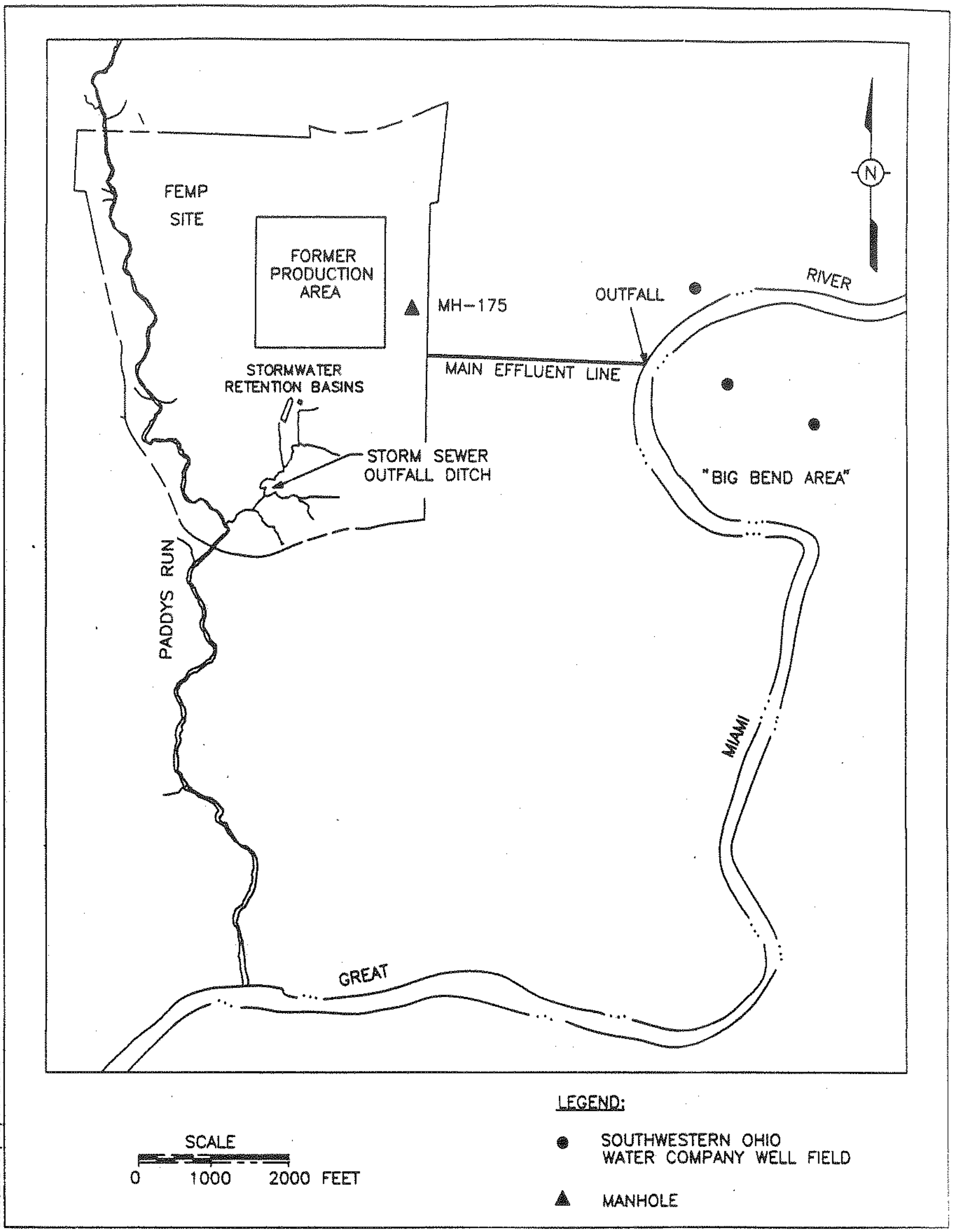

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FIGURE 1-4. SURFACE WATER HYDROLOGY

corner of the FEMP property. The stream is approximately 14 km (8.8 mi) long and drains an area of approximately 40.9 square kilometers (km^2) [15.8 square miles (mi^2)]. Due to the highly permeable channel bottom, the stream loses water to the underlying Great Miami Aquifer in some locations. In addition, the stream is ephemeral and is generally dry during the summer months.

The Great Miami River is the main surface water feature in the vicinity of the FEMP site, which receives effluent water from a National Pollutant Discharge Elimination System (NPDES) permitted discharge from the FEMP site. The river flows generally to the southwest and has a drainage area of approximately 8702 km^2 (3360 mi^2) at the Hamilton gauge, which is located about 16.1 km (10 mi) upstream from the FEMP site NPDES discharge outfall.

The river exhibits meandering patterns that result in sharp directional changes over distances of less than 900 m (2,953 ft). Directly east of the FEMP site and within the site-wide Remedial Investigation/Feasibility Study (RI/FS) Area, the river passes through a 180-degree curve known as the Big Bend. A 90-degree bend in the river also occurs near New Baltimore, approximately 3.2 km (2 mi) downstream from the FEMP site discharge outfall.

Surface water flow within Operable Unit 4 is directed through a series of trench drains, concrete curbs, and gutters to an inground concrete sump located in waste storage area. Water from these storm water control facilities are directed through existing site treatment systems prior to discharge through the FEMP effluent line to the Great Miami River.

1.4 GEOLOGY AND HYDROGEOLOGY

The FEMP overlies a 3.2 to 4.8 km (2 to 3 mi) wide buried Pleistocene valley known as the New Haven Trough. This valley was formed (eroded) by the ancestral Ohio River during the Pleistocene period and was subsequently filled with glacial outwash materials that were in turn covered by glacial overburden as glaciers advanced across the area. The outwash deposits under the FEMP are a part of the Great Miami Aquifer, which is a widely distributed buried valley aquifer. In addition to surface water, the valley fill aquifer system is the major source of drinking water in the southwestern Ohio area.

Since the last retreat of continental glaciers, the streams in the area have removed much of the glacial overburden and lacustrine strata left by the ice sheets. The Great Miami River has eroded through the glacial overburden and is now in direct contact with the outwash deposits that comprise the Great Miami Aquifer. Paddys Run is also in contact with these deposits in its lower reaches.

The Great Miami Aquifer is the principal aquifer within the FEMP Study Area and has been designated a sole-source aquifer under the provisions of the Safe Drinking Water Act (SDWA). The buried valley in which it occurs varies in width from about 0.8 km (0.5 mi) to more than 3.2 km (2 mi), having a U-shaped cross section with a broad, relatively flat bottom and steep valley walls. This valley is filled with extensive deposits of sand and gravel that range in thickness from 36 to 60 m (120 to 200 ft) in the valley to only several feet along the valley walls, along with scattered silt and clay deposits.

Contained within the sand and gravel that underlies much of the FEMP property is a relatively continuous, low-permeability clay interbed ranging from about 1.5 to 4.5 m (5 to 15 ft) in thickness. The clay interbed which exists below the Operable Unit 4, occurs at an approximate elevation of 140 m (460 ft) above MSL. This clay interbed divides the aquifer into upper and lower sand and gravel units, referred to as the Upper Great Miami Aquifer and the Lower Great Miami Aquifer.

Overlying the Great Miami Aquifer throughout most of the FEMP property, including Operable Unit 4, are a series of glacial overburden deposits. The glacial overburden is composed primarily of till, a dense, silty clay that contains discontinuous and isolated lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt. The glacial overburden exposed at the surface has relatively low permeability, so most of the precipitation that falls on it is lost to evaporation and surface water runoff. Within Operable Unit 4, sand and gravel outwash deposits of the buried valley are overlain by 1.5 to 3 m (5 to 10 ft) of till that is in turn overlain by 4.5 to 6 m (15 to 20 ft) of lacustrine sediments. The till is an unsorted mixture of clay, silt, sand, and pebble to cobble size material with 70 to 80 percent of the material falling in the clay and silt size range.

Erratically distributed pockets of silty sand and gravel within the glacial overburden contain zones of perched groundwater. Perched groundwater is separated from the underlying aquifer by the surrounding relatively impermeable clay and silt components of the overburden. These low-permeability units behave as an aquitard that can store groundwater, then transmit it slowly downward from one more porous saturated zone to another.

The conceptual model for groundwater flow in the glacial overburden in Operable Unit 4 indicates that the lacustrine strata have good, but slow, hydraulic communication and that the till that underlies the lacustrine strata acts as an aquitard. Groundwater within the approximately 6 m (20 ft) of lacustrine strata is predicted to flow at a lateral rate that is significantly greater than its downward rate. Therefore, groundwater is likely discharging westward to the bank of Paddys Run and southward in the east-west drainageway immediately south of Silo 1.

1.5 ECOLOGY

The FEMP site and surrounding areas lie in a transition zone between two distinct sections of the Eastern Deciduous Forest Province; the Oak-Hickory and the Beech-Maple. The dominant species are oaks, with an abundance of hickories. The fauna vary little between the two forest sections and include white-tailed deer, gray fox, gray squirrel, white-footed mouse, and short-tailed shrew; the cardinal, woodthrush, summer tanager, red-eyed vireo, and the hooded warbler; the box turtle, common garter snake, and timber rattlesnake.

The Indiana bat is listed as both a federally and state endangered species and occurs in Butler and Hamilton Counties. Surveys were conducted at the FEMP to determine the distribution and presence of the Indiana bat and to identify potential habitat on the FEMP and in the immediate vicinity. The Indiana bat has not been identified at the FEMP. Potential habitat for the Indiana bat occurs in portions of the riparian woodland associated with Paddys Run.

The Sloan's crayfish, a state listed threatened species, has been identified in Paddys Run in northern sections on property and southern sections off property in preliminary surveys in September 1993. Potential harm may occur as a result of siltation and runoff into Paddys Run.

The cave salamander, a state listed endangered species, has not been identified at the FEMP site. Moderate habitat has been identified in a well in the northeastern section of the FEMP and a ravine in the north woodlot.

A site-wide wetland delineation was conducted in February 1993, in accordance with the 1987 United States Army Corps of Engineers (COE) Wetlands Delineation Manual. A jurisdictional determination was approved in August 1993 by the COE that verified wetland boundaries and waters of the United States. Results from the site-wide delineation, subject to COE approval, indicate a total of 14.4 ha (35.9 acres) of wetlands that include 10.6 ha (26.6 acres) of palustrine forested wetlands, 2.8 ha

(7 acres) of drainage ditches/swales, and 0.95 ha (2.37 acres) of isolated emergent and emergent-scrub/shrub wetlands (see Figure 1-5).

Floodplains within the FEMP property are confined to the north-south corridor containing Paddys Run. Outside the boundaries of the FEMP site, the 100-year floodplain of the Great Miami River extends west nearly to the eastern boundary of the facility (see Figure 1-6). The 100-year floodplain of the river also extends northward along Paddys Run from the confluence of the two streams to a point about 180 m (600 ft) from the southern boundary of the FEMP site.

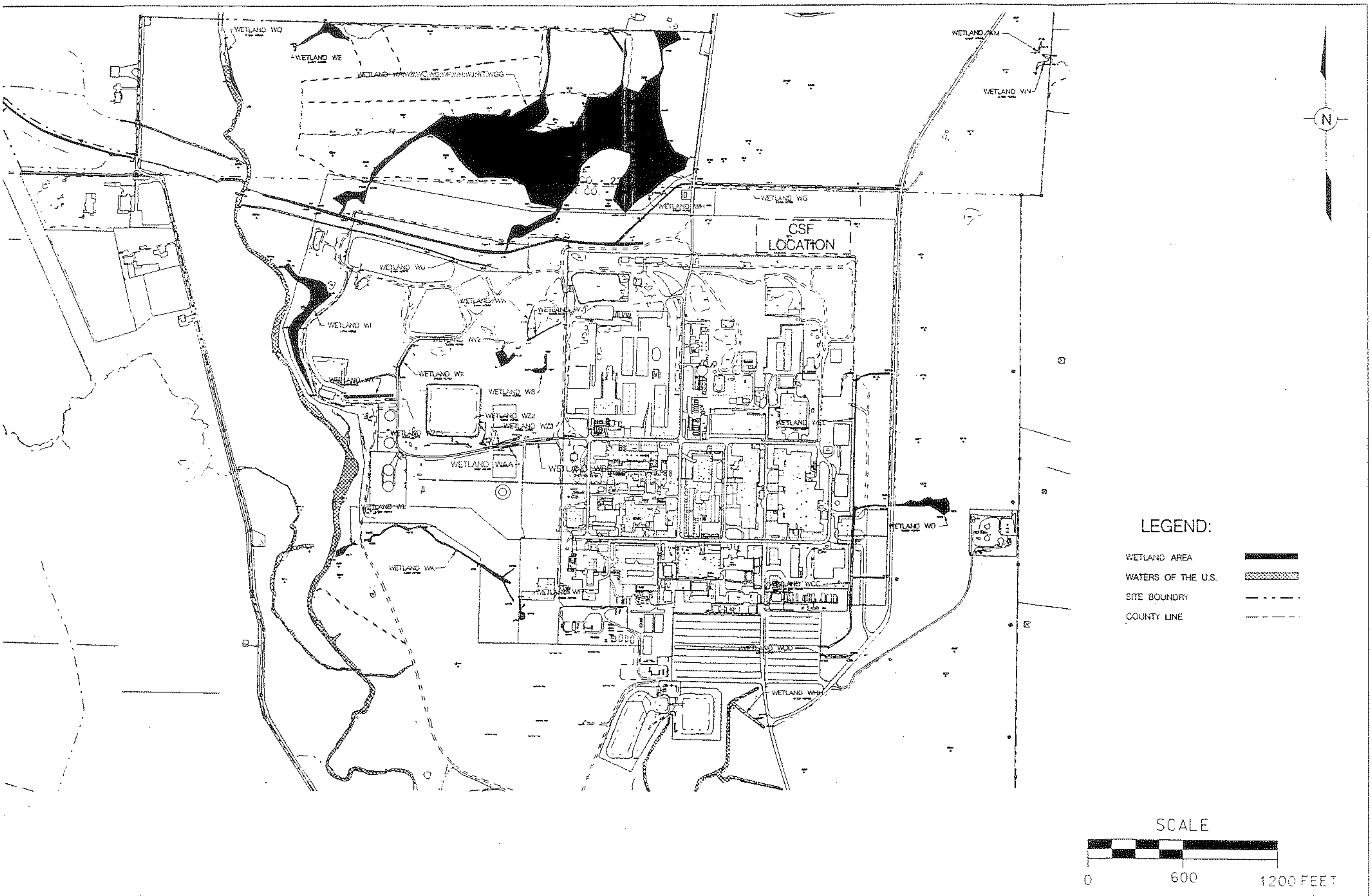

FIGURE 1-5 APPROXIMATE BOUNDARIES OF JURISDICTIONAL WETLANDS AT FEMP.

2.0 SITE AND OPERABLE UNIT 4 HISTORY AND ENFORCEMENT ACTIVITIES

2.1 SITE HISTORY

In January 1951, the New York Operations Office of the Atomic Energy Commission (AEC) proceeded on an expedited basis with the selection of a suitable site for the construction of a new feed material production center to supply high purity uranium products. Sixty-three sites were considered with a site near Fernald, Ohio being selected as best meeting established criteria. Construction operations were initiated in May 1951, on the 1050 acre site. The facility was designated the Feed Material Production Center (FMPC) prior to initiation of on-property pilot operations in October 1951. Production operations were initiated in 1952 and continued until July 1989, at which time operations were placed on standby to focus on environmental compliance and waste management initiatives. Following appropriate congressional authorizations, the facility was formally closed in June 1991. To reflect a new site mission focused on environmental restoration, the name of the facility was changed to the Fernald Environmental Management Project (FEMP) in August 1991.

On March 9, 1985, the EPA issued a Notice of Noncompliance to the DOE identifying EPA's concerns over potential environmental impacts associated with the FEMP's past and ongoing operations. On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) detailing actions to be taken by DOE to assess environmental impacts associated with the FEMP was signed by DOE and EPA. The FFCA was entered into pursuant to Executive Order 12088 (43 FR 47707). The purpose of the FFCA was to ensure compliance with existing environmental statutes and implementing regulations. Also, environmental impacts associated with past and present activities at the FEMP site would be thoroughly and adequately investigated so that appropriate response actions could be implemented. As required by the FFCA, a RI/FS was initiated in July 1986, pursuant to 42 U.S.C. 9601 et seq., CERCLA.

In November 1989, the FEMP was placed on the NPL for investigation and remediation under CERCLA. This placement, in addition to progressive findings in the RI/FS program, necessitated the amendment of the FFCA. The 1986 FFCA was superseded by a Consent Agreement under Sections 120 and 106(a) of CERCLA (Consent Agreement) providing for the implementation of operable units for the FEMP RI/FS and revising the milestone commitments for the RI/FS program without modifying the underlying objectives of the FFCA. The Consent Agreement also provided for the implementation of removal actions to address site conditions which pose an immediate threat to human health and the environment, including removal actions for Operable Unit 4, such as the K-65 Silos Removal Action. The Consent Agreement was signed on April 9, 1990, and became effective on June 29, 1990, following a period of public comment.

In October 1990, the first version of the RI Report for Operable Unit 4 was submitted to the EPA for review and comment. The EPA determined that the FMPC had not adequately characterized Operable Unit 4, and subsequently, issued a Notice of Violation (NOV) against the site. The EPA issued two other NOVs at approximately the same time regarding other components of the ongoing RI/FS. Following negotiations between the EPA and DOE, a resolution agreement was jointly signed by the EPA and DOE. Pursuant to the terms of this resolution agreement, DOE paid a financial penalty to EPA, agreed to perform a supplemental project beneficial to the environment surrounding the site, and also agreed to enter into negotiations with EPA to define new schedules for re-submittal of the RI/FS documents.

The Consent Agreement was amended in 1991 to revise the schedules for completing the RI/FS for the five identified operable units. This Amended Consent Agreement was signed on September 20, 1991, and became effective on December 19, 1991, following a period of public comment.

2.2 OPERABLE UNIT 4 HISTORY

Originally constructed in 1951 and 1952, three of the four reinforced concrete storage silos within Operable Unit 4 received by-product materials until 1960. Silos 1 and 2 received K-65 residues generated from the processing of high assay uranium ores, termed pitchblende ores, at the FEMP and the Mallinckrodt Chemical Works (MCW) in St. Louis, Missouri. The pitchblende ores processed at MCW and the vast majority of pitchblende ores processed at the FEMP came primarily from one mine, the Shinkolobwe Mine in the Belgian Congo (now Zaire).

The Shinkolobwe Mine was owned and operated by the African Metals Corporation. These ores contained relatively high concentrations of uranium oxides (U_3O_8) in the range of 40 to 50 percent as well as high concentrations of radium. Based on the high value of radium at the time, the agreement reached between the AEC and the African Metals Corporation stipulated that the African Metals Corporation would retain ownership of the radium within any processing residues; after the United States had processed the pitchblende ore to extract uranium, the residue would be returned to the African Metals Corporation.

The K-65 silos were constructed at the FEMP site to provide interim storage of the residues, pending the return of the materials to the country of origin. For more than 30 years, these materials remained in storage at the FEMP site, under the terms of the original agreement, awaiting transfer. In 1984, ownership of the K-65 residues was transferred to DOE.

As the drums were received by railroad car at the FEMP, from MCW, the drums were temporarily staged in an area to the east of Silos 3 and 4 (Figure 1-3). The drummed material was slurried in the Drum Handling Building, formerly located between Silos 2 and 3, and then pumped to Silos 1 and 2 for storage. Approximately 31,000 drums of residues generated through MCW processing operations were received at the FEMP. Approximately 24,000 of these drums were transferred to Silo 1, completely filling the structure in November 1953. The remaining 7,000 drums were transferred to Silo 2 for storage.

Additionally, Silo 2 received residues generated at the FEMP from the processing of pitchblende ores from the Shinkolobwe Mine and a small quantity of Australian ores from two mines, the Rum Jungle Mine and the Radium Hill Mine. The last residues were placed in Silo 2 in January 1959. Following the end of K-65 processing operations at the FEMP, approximately 150 drums of radium contaminated material, consisting of soils from drum staging areas, clean-up materials, and excess K-65 samples were placed into Silo 2 in June 1960.

Silos 3 and 4 were constructed in 1952 for storing metal oxides generated by the FEMP refinery. Unlike Silos 1 and 2, which received residues from the processing of ores from mainly one mine, Silo 3 received metal oxides generated from FEMP refinery operations from May 1954, until late 1957. During this period, the FEMP refinery processed the previously mentioned pitchblende ores and uranium ore concentrates received from a number of foreign and domestic uranium mills. Select refinery waste streams were first filtered to remove radium and subsequently directed to an evaporator and calciner. These finely powdered, dried refinery residues (termed cold metal oxides) were transferred to a surge hopper from where the materials were pneumatically conveyed through a pipeline to Silo 3.

Following a programmatic decision in early 1957 to utilize raffinate surface impoundments, the calcining systems were eventually abandoned. As a result of this decision, Silo 4 was never employed for the storage of cold metal oxides or other site materials and remains empty. Inspections completed on Silo 4 during the RI-related site investigations confirmed that no waste materials are present within the silo.

In 1963, it became visually obvious that Silos 1 and 2 were deteriorating. In 1964, site workers repaired the concrete coating around each silo and constructed an earthen berm around them to counterbalance the outward load from the silos contents. The berm also protected the silos walls from weathering and served as a radiation shield. This berm was expanded in 1983 to reduce soil erosion.

Other improvements to Silos 1 and 2 included: sealing the vents in the domes in 1979; installing plywood covers on the domes in 1986; and adding a polyurethane coating in 1987 to reduce weathering and to help lower radon emissions. This coincided with the installation of the radon treatment system (RTS), which was designed to draw air from the silos, remove moisture and radon through a charcoal-adsorption process, and recirculate clean air back into the silos. The RTS, which was upgraded in 1991, helped to lower radon emissions to allow workers to apply a layer of bentonite clay (November 1991) over the K-65 residues within the silos (K-65 Silo Removal Action No. 4).

The bentonite clay layer has reduced the amount of radon escaping from the silos into the environment and would help prevent the release of contaminants into the air if a natural disaster (e.g., a tornado) should occur or if the silo dome should collapse. An expedited removal action was conducted in December 1991 to remove the Silo 3 dust collector after an inspection had revealed significant deterioration of the dust collector (Removal Action No. 21). Also, in April 1991, a time-critical removal action was performed to remove approximately 30,300 liters (8000 gallons) of liquid from the decant sump (Removal Action No. 5).

3.0 COMMUNITY PARTICIPATION

Various forums has been used to provide information to the community, including a periodic newsletter, regular community meetings, and other availability sessions. Other activities included site tours, open houses, a speakers bureau, and fact sheets about the Fernald site. Several readings rooms, which later were consolidated into one facility near the Fernald site, were opened. This reading room contains information about all aspects of the RI/FS at Fernald. In 1990, DOE established an "Administrative Record" for the site; a copy of the Administrative Record also is maintained at the U.S. EPA's Region 5 offices in Chicago.

In November 1993, DOE implemented a public participation program at Fernald, in an attempt to involve community members and other interested parties in the Fernald decision-making process. The public involvement program at Fernald consists of three elements:

1. Public information
2. Management involvement
3. Person-to-person communication

These efforts, in concert with other community relations activities, such as publication of notices of availability, which are required by law, reflect DOE's new initiative to offer opportunities for interested parties to take part in the decision-making process at Fernald.

3.1 OPERABLE UNIT 4 PUBLIC INVOLVEMENT ACTIVITIES

To encourage stakeholders to review drafts of the Operable Unit 4 RI/FS documents, Notices of Availability for public inspection were published in April 1993 for the Operable Unit 4 RI Report and in September 1993 for the FS/PP-DEIS in three local newspapers: *The Cincinnati Enquirer*, the *Journal-News* and *The Harrison Press*. No public comments were received on the RI Report for Operable Unit 4.

On September 9, 1993, the FS/PP-DEIS were made available at the Public Environmental Information Center, and stakeholders were encouraged to provide informal comments on the preliminary documents. Encouraging public inspection and informal comment on these preliminary documents, prior to EPA approval, provided a genuine opportunity for stakeholders to identify issues, voice their concerns and learn about proposed cleanup plans for Operable Unit 4. The informal opportunity for the public to provide input enabled DOE to address some stakeholder questions and concerns in advance of the formal public comment period.

On October 14, 1993, approximately 29 stakeholders attended a public roundtable on "Proposed Plans and Technology for Operable Unit 4 Remediation." At the roundtable, attendees were invited to offer opinions on the draft final Proposed Plan and the preferred alternative for Operable Unit 4 remediation. These stakeholder comments were documented and evaluated during preparation of the final document.

In addition, a two-way information exchange on the Operable Unit 4 Risk Assessment occurred at the October 19, 1993, Science, Technology, the Environment and the Public (STEP) session on "Risk." Again, Fernald personnel addressed the stakeholders' questions and concerns presented at the meeting. Information about the Operable Unit 4 Remedial Investigation Report was also provided at DOE's October 21, 1993, RI/FS public meeting and at local township trustee meetings.

In response to stakeholder requests at the January 5, 1994, formal public hearing on the Operable Unit 3 (Production Area) Interim Record of Decision, a public roundtable to discuss integration of CERCLA and NEPA was held January 24, 1994. The roundtable included discussions on differences between environmental assessments and environmental impact statements; approximately 45 stakeholders attended.

On February 21, 1994, invitations to attend the March 21, 1994, formal public hearing on the FS/PP-DEIS were mailed to 2,000-plus Fernald stakeholders. The *Proposed Plan for Remedial Actions at Operable Unit 4* fact sheet was enclosed with each invitation.

On February 24, 1994, advance copies of the *Proposed Plan for Remedial Actions at Operable Unit 4* were mailed to several key stakeholders. Also on February 24, copies of the final FS/PP-DEIS and Proposed Plan fact sheets were mailed to the Nevada Operations Office and to Nevada environmental protection organizations. The DOE Operable Unit 4 Branch Chief personally distributed several advance copies of the Proposed Plan to attendees at the February 24, 1994, Fernald Residents for Environmental, Safety, and Health (FRESH) meeting. In addition, she provided an update on Operable Unit 4 activities, plans and progress, and was available for an informal question-and-answer session.

To encourage stakeholders to review and offer input on the final FS/PP-DEIS, a Notice of Availability for formal public comment was published in March 1994 in the *Federal Register* and three local newspapers: *The Cincinnati Enquirer*, the *Journal-News* and *The Harrison Press*. On March 1, 1994, the Proposed Plan, FS/PP-DEIS became available at the Public Environmental Information Center.

On March 2, 1994, Ohio EPA representatives discussed the FS/PP-DEIS with members of the Fernald Citizens Task Force and FRESH.

On March 4, 1994, a Fernald site news release titled "Key Fernald Cleanup Plan Receives Conditional U.S. EPA Approval" was sent to local electronic and print media, as well as local elected officials, FRESH and the Fernald Citizens Task Force. Articles were published in local newspapers.

On March 7, 1994, the formal 45-day public comment period on the final FS/PP-DEIS officially began.

On March 8, 1994, Fernald representatives met formally with officials of the DOE Nevada Operation Office and Nevada protection agencies.

On March 15, 1994, postcard reminders about the March 21, 1994, formal public hearing were mailed to Fernald stakeholders. In addition, courtesy phone calls were made to key stakeholders, inviting them to the formal public hearing.

Display advertisements announcing the March 21, 1994, formal public hearing were published in three local newspapers: *The Cincinnati Enquirer*, March 18 and March 20; *The Cincinnati Post*, March 18; and the *Journal-News*, March 18.

On March 21, 1994, approximately 80 people attended the formal public hearing on the Operable Unit 4 FS/PP-DEIS. Formal oral public comments were documented by a court reporter and are available in a transcript at the Public Environmental Information Center. In addition, several stakeholders submitted formal written comments. All formal written and oral stakeholder comments and questions asked informally during the March 21 public hearing, as well as DOE's responses, are documented in the Operable Unit 4 Responsiveness Summary.

The formal public comment period for the Operable Unit 4 FS/PP-DEIS was originally scheduled to conclude April 20, 1994. However, the public comment period was extended *30 days*, until May 20, 1994, in response to a request for a 60-day extension by a Nevada State Clearinghouse representative.

The extension request was made on behalf of a group of concerned Nevadans, affected indian tribes and local government officials, who, along with officials from the State of Nevada and DOE, jointly participated in the establishment of a site-specific advisory board for the U.S. Department of Energy -- Nevada Operations Office (DOE-NV) Environmental Restoration and Waste Management Program at the Nevada Test Site (NTS). "The Citizens Advisory Board for NTS Programs (CAB)" will play a key role in advising DOE-NV about stakeholder concerns involving major program decisions at NTS, such as those proposed for Fernald's Operable Unit 4 waste. CAB's first meeting was held March 8, 1994.

The National Contingency Plan, section 300.430(f) (3)(i) (C) states, " . . . Upon timely request, the lead agency will extend the public comment period by a minimum of 30 additional days. . . ." In accordance with the Amended Consent Agreement (1991), DOE and U.S. EPA concurred with a *30-day* extension of the formal public comment period to minimize impact to the Operable Unit 4 schedule, yet still provide what DOE and EPA considered adequate time for stakeholder review. A Notice of Availability was published May 4 in *The Cincinnati Enquirer*, the *Journal-News* and *The Harrison Press*.

On May 11, 1994, the DOE-NV conducted a public meeting in Las Vegas, Nevada. In attendance were members from the DOE, EPA (Region V), Ohio EPA, CAB and the public. This meeting was the first meeting of the newly-organized CAB. As part of the meeting's agenda, the DOE conducted two presentations. One of the presentations, furnished by the DOE-FN, discussed the Operable Unit 4 FS/PP-DEIS and summarized the proposal to transport and dispose of low-level radioactive waste, which would be generated by the cleanup and environmental restoration of the FEMP site as a whole (including Operable Unit 4), at the NTS. The other presentation was furnished by the DOE-NV which summarized the current low-level radioactive waste management program at the NTS. During the discussions following the presentation of the Operable Unit 4 FS/PP-DEIS, the CAB requested a second 30-day extension of the Operable Unit 4 formal public comment period. DOE and EPA concurred with the second extension of the formal public comment period, which finally concluded June 19, 1994. A Notice of Availability regarding the second 30-day extension was published May 25, 1994, in *The Cincinnati Enquirer*, the *Journal-News* and *The Harrison Press*.

During the Operable Unit 4 formal public comment period, stakeholders expressed concern regarding public participation opportunities and activities after the conclusion of the RI/FS Study process. In 1994, Records of Decision will be completed for Operable Unit 4 and Operable Unit 1 (Waste Pits), and an Interim Record of Decision will be completed for Operable Unit 3 (Production Area).

In 1994, Fernald's Community Relations Plan, which guides public involvement activities, was revised with input from stakeholders who participated in formal in-person and telephone "community assessment" interviews. Fernald's Community Relations Plan is located in the *RI/FS Work Plan, Volume III*, which is available at the Public Environmental Information Center, 10845 Hamilton-Cleves Highway, Harrison, Ohio (phone: 513-738-0164).

The community assessment interviews were conducted to ensure stakeholder participation in determining public involvement activities and programs during Remedial Design and Remedial Action at Fernald. Fernald's first community assessment was done in 1986, when Fernald's original Community Relations Plan was developed. In 1988, minor revisions were made to the Community Relations Plan and were reflected in the *RI/FS Work Plan, Volume III*. In 1989, a second community assessment was conducted, and the Community Relations Plan was again revised and approved in August 1990. In 1992, Fernald's Community Relations Plan was revised a fourth time; however, no community assessment was conducted in 1992.

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4.0 SCOPE AND ROLE OF REMEDIAL ACTION

The FEMP site and associated environmental issues have been segmented into five operable units. The operable unit concept at the FEMP site involves grouping waste areas or related environmental concerns in a manner so as to permit the more expedient completion of the RI/FS process. The five FEMP operable units are broadly defined as:

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

Separate RI/FS documentation and RODs are being issued for Operable Units 1 through 5. A sixth operable unit known as the Comprehensive Site-Wide Operable Unit was added as a provision of the Amended Consent Agreement. Operable Unit 6 is not a specified area; however, it was created to perform a final assessment from a site-wide perspective that ongoing or planned remedial actions identified in the RODs for the five operable units will provide a comprehensive remedy for the FEMP site which is protective of human health and the environment.

The primary focus of this remedial action is the permanent disposition of inventoried processing residues contained in three concrete silos and an underground sump at the FEMP. The scope also includes the disposition of contaminated building materials associated with the concrete silos and ancillary support facilities. The action further involves the disposition of contaminated soils, process wastewater and perched water encountered within the Operable Unit 4 Study Area. The nature of the residues, coupled with their potential threat of release from their present storage configuration and the potential threat of contaminant migration from the affected soils into the atmosphere and the underlying aquifer system, represent a potential threat to human health and the environment. The purpose of the remedial action is to prevent current and future exposure to the inventoried residues, contaminated soil and debris within Operable Unit 4, and remove the threat of release of hazardous substances into the environment.

Several removal actions are ongoing or have been completed within the Operable Unit 4 study area. These removal actions are summarized as follows:

- Installation of a bentonite clay layer over the K-65 residues in Silos 1 and 2.
- Removal and treatment of water from the K-65 decant sump tank at the FEMP advanced wastewater treatment plant. Water within the tank is removed whenever the liquid level in the sump reaches 80 percent of the tanks capacity.
- Removal of a deteriorated dust collector on the dome of Silo 3.
- Installation of a series of drainage control structures, swales, and culverts to direct surface runoff to the existing in-ground sump.

In addition to the removal actions listed above, polyurethane foam insulation was applied to the exterior of the dome surfaces of Silos 1 and 2 to inhibit wide temperature swings within the silos. These removal actions have been conducted to respond to contaminant releases and to mitigate health and safety threats in accordance with CERCLA. These actions have also been conducted in accordance with Council on Environmental Quality regulations for implementing the provisions of NEPA.

Cleanup decisions for groundwater beneath the Operable Unit 4 Study Area, sediment in Paddys Run, and soil and waste source areas outside the Operable Unit 4 Study Area are not included in the scope of this remedial action. Separate RI/FS and other remediation documentation will be prepared for these facilities and media by other FEMP operable units. These documents will be issued consistent with the terms of the Amended Consent Agreement.

4.1 INTEGRATION OF NEPA INTO CERCLA

For Operable Unit 4 at the FEMP, DOE has chosen to complete an integrated CERCLA/NEPA process. This decision was based on the longstanding interest on the part of local stakeholders to prepare an EIS on the restoration activities at the FEMP and on the recognition that the draft document was issued and public comments received. Therefore, an integrated Feasibility Study/Proposed Plan - Final Environmental Impact Statement (FS/PP-FEIS) has been completed which evaluates alternatives for the treatment and disposal of radioactive residues contained in storage silos at FEMP.

In accordance with both CERCLA and NEPA processes, this documentation was made available to the public for comment. The contents of the documents prepared for the remedial actions at the FEMP are not intended to represent a statement on the legal applicability of NEPA to remedial actions conducted under CERCLA.

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5.0 SUMMARY OF OPERABLE UNIT 4 CHARACTERISTICS

Several investigative studies were conducted to determine the characteristics of the contamination sources and the nature and extent of contamination within Operable Unit 4. These investigative activities focused on the following facilities and associated environmental media:

- Silos 1 and 2 and their contents (also termed the K-65 silos)
- Silo 3 and its contents (also termed the cold metal oxide silo)
- Silo 4
- K-65 decant sump tank, its contents, and associated piping
- A radon treatment system (RTS)
- A portion of a concrete pipe trench and other concrete structures
- An earthen berm surrounding Silos 1 and 2
- Soils beneath and immediately surrounding Silos 1, 2, 3, and 4
- Perched groundwater encountered in the vicinity of the silos during implementation of Operable Unit 4 cleanup activities. Note that groundwater within the Great Miami Aquifer underlying the silo area is not within the scope of Operable Unit 4, but it is within the scope of Operable Unit 5.

5.1 INVESTIGATIVE STUDIES

The Operable Unit 4 RI/FS sampling program was the primary source of the information utilized to characterize contamination sources and to evaluate the nature and extent of contamination associated with Operable Unit 4. Other investigative studies which provided characterization data for Operable Unit 4 include the Waste Pit Area Runoff Control Removal Action, the FEMP Environmental Monitoring Program, and the Characterization Investigation Study (CIS). Section 6 provides a list of the contaminants of concern which were identified and used to determine baseline risks attributable to Operable Unit 4.

5.2 SUMMARY DESCRIPTION OF CONTAMINATION SOURCES

5.2.1 Classification of Contamination Sources

The residues in Silos 1, 2, and 3 are classified as by-product material as defined under the AEA of 1954, and are therefore excluded from regulation as solid or hazardous waste under the Resource

Conservation and Recovery Act (RCRA), 40 CFR § 261.4(a)(4). By-product material, as defined by the AEA, includes tailings or wastes produced as a result of the extraction or concentration of uranium (U) and thorium (Th) from any ore processed primarily for its source material content (42 United States Code 2014).

Since the residues contained in the silos are excluded from regulation as solid or hazardous waste, the requirements under RCRA are not applicable to Operable Unit 4 remedial actions. However, analytical data for the silo residues indicate that these materials exceed Toxicity Characteristic Leaching Procedure (TCLP) limits for various metals, as defined under RCRA. The silo residues are therefore sufficiently similar to hazardous waste regulated under RCRA resulting in some RCRA requirements being appropriate for the conditions of release or potential release of hazardous constituents during disposal. As a result of this, the relevant and appropriate substantive requirements of RCRA are being applied as part of the Operable Unit 4 remedy for the silo residues.

5.2.2 Source Characteristics

Silos 1 and 2, known as the K-65 silos, contain approximately 6,796 m^3 (8,890 yd^3) of waste residues generated from processing high-grade uranium ores. As part of the remedial investigation, samples were collected from the contents of the silos. The waste materials within the silos are primarily a silty clay with an average moisture content of approximately 40 percent. Analytical results from these samples confirmed prior process knowledge and identified significant activity concentrations of radionuclides within the uranium decay series.

The average Silo 1 concentration of radium (Ra)-226 is 391,000 pCi/g, thorium (Th)-230 is 60,000 pCi/g, lead (Pb)-210 is 165,000 pCi/g and polonium (Po)-210 is 242,000 pCi/g. The average Silo 2 concentration of Ra-226 is 195,000 pCi/g, Th-230 is 48,300 pCi/g, Pb-210 is 145,000 pCi/g and Po-210 is 139,000 pCi/g. The two silos contain in excess of 3,700 Curies of Ra-226, 600 Curies of Th-230, and 1,800 Curies of Pb-210. It is also estimated that Silos 1 and 2 contain more than 28 metric tons of uranium.

Other significant metals include more than 118 metric tons of barium, 830 metric tons of lead, and 2.6 metric tons of arsenic. TCLP tests indicate that the lead is leachable with leach test concentrations from Silo 1 averaging 614 milligrams per liter (mg/l) and leach test concentrations from Silo 2 averaging 516 mg/l. The silos also contain elevated concentrations of the polychlorinated biphenyls (PCBs) Aroclor-1248 [1.2 milligrams per kilogram (mg/kg)], Aroclor-1257 (7.4 mg/kg), Aroclor-1260 (2.6 mg/kg), and tributylphosphate (15 mg/kg).

Silos 1 and 2 are equipped with a decant sump tank, which was first used to decant liquids from waste slurried into the silos. The system also served to collect silo leachate that entered the Silos 1 and 2 underdrain system. The tank is located beneath the silo berm, between Silos 1 and 2, at a depth approximately 0.6 m (2 ft) below the base of the silos. The decant sump tank is connected to the berm surface via a standpipe. In 1990, personnel noted 1.2 m (4 ft) of liquid in the standpipe. In 1991, and again in February 1993, the decant sump tank was emptied and sampled. Analytical results of the decant sump tank liquids are, in general, consistent with the contents of Silos 1 and 2.

The presence of significant quantities of liquid in the decant sump tank indicates that the system is collecting leachate from the silo underdrain system, as it was designed to do. Excess quantities of liquid in the decant sump tank, causing liquid to overflow into the standpipe, appear to provide a mechanism for leachate from the silos to enter perched groundwater.

Structural evaluations completed in 1986 on Silos 1 and 2 identified a significant loss of the load-carrying capability at the center portion of the domes on both structures. A protective barrier was placed over the deteriorated central portions of the silo domes in 1986 to minimize potential environmental impacts in the event of a catastrophic dome collapse. The remaining structures, Silos 3 and 4, like Silos 1 and 2, are beyond their original design life and show visible signs of deterioration due to the effects of weathering. However, based on the more recent February 1994 Silo Structural Integrity Report, the silos are considered to be more structurally sound than previously reported in the 1986 study by Camargo. The extensive non-destructive testing and computer analysis indicated that the silos are not in immediate danger of collapse.

As a natural consequence of the decay of the Ra-226 present in the Silo 1 and 2 waste materials, a radioactive gas, Rn-222, is generated. Samples collected in 1987 from the unfilled, upper portions of Silos 1 and 2 showed a maximum concentration of 30 million picocuries per liter (pCi/l). Average background concentrations of Rn-222 in ambient air are approximately 0.5 pCi/l. In 1991, a layer of bentonite clay was placed over the residues in Silos 1 and 2. This clay layer was installed to reduce the release of radon gas to the atmosphere. Samples collected following emplacement of the bentonite clay show a significant reduction in the Rn-222 present in the headspace of the silos.

The inventory of radionuclides present in the K-65 residues significantly elevates the direct penetrating radiation field in the vicinity of the silos. Measurements collected from the dome surfaces prior to the installation of the bentonite clay layer showed exposure rates in excess of 200 millirem per hour, or approximately 20,000 times natural background radiation levels. Measurements collected from the surfaces of the domes following bentonite installation showed a greater than 95 percent decrease in the direct radiation fields on the dome surfaces.

Silo 3 contains waste residues, known as cold metal oxides, which were generated at the FEMP site during uranium extraction operations in the 1950s. The residues in Silo 3 are substantially different than those in Silos 1 and 2. First, Silo 3 residues are dry, while the residues in Silos 1 and 2 are moist. Second, while the radiological constituents are similar to those in Silos 1 and 2, certain radionuclides, such as radium, are present in Silo 3 in much lower concentrations. Thus, Silo 3 exhibits a significantly lower direct radiation field and radon emanation rate than Silos 1 and 2.

Samples collected from the contents of Silo 3 confirmed process knowledge and indicated the presence of significant activity concentrations of the radionuclides within the uranium decay series. The predominant constituent identified within Silo 3 was Th-230, a radionuclide produced from the natural radioactive decay of U-238. Distributed within the 3,890 m^3 (5,088 yd^3) of waste residues inside Silo 3 is approximately 450 Curies of Th-230. Extraction Procedure (EP) Toxicity tests performed on samples of the Silo 3 residues to determine the leachability of inorganic substances present detected eight metals, with the highest mean concentrations being attributed to arsenic (9.48 mg/l), cadmium (0.85 mg/l), chromium (5.05 mg/l), and selenium (2.65 mg/l).

5.3 NATURE AND EXTENT OF CONTAMINATION

Investigations were performed as part of the RI and other site programs to examine the nature and extent of contamination present in environmental media associated with Operable Unit 4. These investigations included the collection and laboratory analysis of samples and the collection of direct field measurements. The investigations included examination of surface and subsurface soil, surface water and sediment, and groundwater.

5.3.1 Surface Soils

Sampling performed as part of the RI/FS and other site programs in the vicinity of Operable Unit 4 indicates the occurrence of above background concentrations of uranium, and to a lesser degree other radionuclides, in the surface soils within and adjacent to the Operable Unit 4 Study Area. Activity concentrations observed during the RI for the surface soils in the vicinity of Operable Unit 4 were as much as 20.8 picocuries per gram (pCi/g) for U-238, or 16 times natural background, and 4.8 pCi/g for Th-230, or two times background. These above background concentrations appear to be generally limited to the upper six inches of soil.

Of the inorganic constituents detected in the Operable Unit 4 surface soils, antimony, beryllium, chromium, copper, magnesium, nickel, silver, and sodium were consistently above background. The only volatile organic compounds detected consisted of common laboratory contaminants. With the exception of one sample collected at a depth of 0.5 to 0.6 m (1.5 to 2.0 ft), which contained elevated concentrations of a number of semivolatile organic compounds including benzo(a)pyrene, semivolatile organic compounds were at or only slightly above the contract required quantitation limit for the laboratory. Available sample data and process knowledge indicate no direct relationship between the surface soil contamination in the Operable Unit 4 Study Area and the silo contents. Further, more than 70 percent of the surface soil samples indicate that the uranium contamination in surface soils is depleted uranium (i.e., the uranium contains depleted percentages of U-235). The silo residues consist of natural uranium. Thus, the existence of these activity concentrations in the surface soils is attributed to air deposition resulting from the former Production Area and past plant production operations and/or waste handling practices in the waste pit area.

Soil samples were collected from the soils contained in the earthen embankment (berm) surrounding Silos 1 and 2. The highest concentrations of radionuclide constituents were detected in a sample taken at a location 9 m (30 ft) below the berm surface, near the base of Silo 1. This sample indicates the occurrence of either some spillage of silo residues during filling operations or seepage from the silo onto the original surface soils adjacent to the silo at that location. Analytical results from other berm samples showed the presence of radionuclides at relatively lower concentrations, with the majority of samples showing concentrations near background.

The concentration ranges for those constituents in relatively higher concentrations are 0.62 to 417 pCi/g for Pb-210; 1.03 to 943 for polonium (Po)-210; 0.62 to 876 pCi/g for Ra-226; 0.74 to 51.2 pCi/g for Th-230; and 0.75 to 24.7 pCi/g for U-238. Inorganic constituents detected consisted mostly of metals in concentrations close to background concentrations. There were also some organic constituents reported. Most of these constituents are common laboratory contaminants and do not demonstrate any direct linkage to the silo contents.

5.3.2 Subsurface Soils

As part of the RI for Operable Unit 4, samples were collected from the subsurface soils located under and adjacent to the K-65 silos. Analytical results reveal elevated concentrations of radionuclides from the uranium decay series in the soils at the interface between the berm and the original ground level. Elevated concentrations (up to 53 pCi/g for U-238, about 40 times background) were also noted in slant boreholes, which passed in close proximity to the silo underdrains. The occurrence of these above background concentrations in soils near the silo underdrains are attributed to vertical migration of leakage from the silo underdrains or decanting system. Elevated readings at the interface between the silo berms and the native soils may be attributed to historical air deposition or past spillage from the silos during filling operations in the 1950s, prior to installation of the berms.

5.3.3 Surface Water and Sediment

Extensive sampling was conducted on the sediment and surface water present in Paddys Run and on key drainage swales leading to Paddys Run, as part of the RI for Operable Unit 4 and other site programs. Results of the surface water sampling indicate the occurrence of above background concentrations of U-238, up to 1500 times background, in the drainage swales in the vicinity of the Silos 1 through 4. The highest readings were recorded in a drainage ditch, which flows from east to west, located approximately 76 m (250 ft) south of Silo 1. The most probable source of the contamination in Paddys Run and the drainage swales is the resuspension of contaminated particles from surface soils within the Operable Unit 4 and Operable Unit 1 Study Areas into storm water.

5.3.4 Groundwater

Groundwater samples were collected from wells within the Operable Unit 4 Study Area during the RI for Operable Unit 4. Groundwater occurs not only in the Great Miami Aquifer underlying the FEMP site, but also in discrete zones of fine-grained sands located in the glacial overburden. The water contained in these sand pockets in the clay-rich glacial soils are termed perched water zones. Samples were collected from slant borings placed adjacent to and under Silos 1 and 2; 1000-series wells screened in the glacial overburden; 2000-series wells screened at the water table in the Great Miami Aquifer; and 3000-series wells screened at approximately the central part of the Great Miami Aquifer, just above the clay interbed.

Background concentrations of naturally occurring inorganics and radionuclides in groundwater in the vicinity of FEMP site were being established under the site-wide RI/FS during the completion of the RI for Operable Unit 4. In accordance with background data available at the time, background concentration of total uranium in groundwater of less than 3 micrograms per liter (μg/l) or 3 parts per billion (ppb) was utilized.

Perched Water

Uranium was the major radionuclide contaminant found in the perched water. Elevated concentrations of total uranium were detected in the slant boreholes under and around Silos 1 and 2. Slant Boring 1617, immediately southwest of Silo 1, contained the highest concentration of total uranium (9,240 μg/l). Uranium concentrations were also elevated in samples collected from the 1000-series wells. The highest observed total uranium concentrations obtained from 1000-series wells were in samples collected from Well No. 1032, located 46 m (150 ft) due west of Silo 2. The range of the concentrations was 196 to 276 μg/l. Considering both the slant borings and 1000-series wells, U-238 was found in the range of 1.1 to 1313 pCi/l.

The major inorganic constituents found in the perched water samples taken from 1000-series wells and the slant borings, included elevated concentrations for major cations (iron, magnesium, manganese, and sodium) and major anions (chloride, nitrate, and sulfate). In particular, the concentrations of sodium, sulfate, and nitrate were significantly above background in slant boring samples. Boring 1615, northwest of Silo 2, had the highest sodium concentration(1,040 mg/l), boring 1618, southeast of Silo 1, had the highest sulfate concentration (2,200 mg/l), and boring 1617 had the highest nitrate concentration (554 mg/l). Low levels of organic constituents, determined to be contaminants, were detected in some samples. Overall, well measurements and analytical results confirmed that the perched groundwater in the vicinity of Operable Unit 4 flows from west to east. Further, contaminants within Operable Unit 4 are contributing to contamination of perched groundwater in this region of the site.

Great Miami Aquifer

The concentration of total uranium in the upper portion of the Great Miami Aquifer, based on analysis of samples from the 2000-series wells, ranged from less than 1 μg/l to 40.3 μg/l. These data do not necessarily suggest that the silos are the source of the observed contamination because both upgradient and downgradient wells contain above background concentrations of total uranium. Well No. 2032, located 46 m (150 ft) west of Silos 1 and 2, exhibited a concentration of total uranium at 39.0 μg/l. Well No. 2033, located 46 m (150 ft) east of Silos 1 and 2, exhibited a concentration of total uranium at 40.3 μg/l. Because groundwater flow in this region of the Great Miami Aquifer is from west to east, these two wells are located upgradient and downgradient of Operable Unit 4, respectively.

The isotopic ratio of U-234 and U-238 would suggest a natural uranium ratio in these samples. Such a ratio may be expected from Operable Unit 4, but is not a "fingerprint" for this source. The presence of uranium upgradient in the aquifer from an Operable Unit 4 source could be explained by leachate travel in the perched groundwater zone of the glacial overburden with emergence to Paddys Run. Here the diluted leachate could enter the aquifer via stream bed infiltration or flow at the perched zone/stream channel interface. No evidence is available to support or preclude this potential route.

The concentration of total uranium measured at deeper levels in the Great Miami Aquifer (3000-series wells) ranged from less than 1 to 4 μg/l, with the exception of 1 sample out of 16, which contained 15 μg/l. Like the 2000-series wells, no conclusion could be drawn that linked this contamination to the silos.

5.4 POTENTIAL EXPOSURE PATHWAYS FOR CONTAMINANT MIGRATION

Contaminant transport from Operable Unit 4 may occur via the following pathways:

- Direct radiation
  - Direct exposure to gamma radiation from radioactive constituents within the silos.
  - Direct exposure to Silo 3 residues under the future source term scenario assuming structural collapse of the silo.
  - Direct exposure to gamma radiation from radioactive constituents in surface soil.
- Air emissions
  - Dispersion of radon that escapes from the silos into the atmosphere.
  - Dispersion of volatile organic compounds (VOC) or fugitive dust emissions generated from soil erosion.
  - Dispersion of Silo 3 contents under the future source term scenario assuming structural collapse of the silo.
- Surface water runoff
  - Erosion of contaminated soils into Paddys Run from the vicinity of the silos.

- Erosion of released Silo 3 contents under the future source term scenario assuming structural collapse of the silo.

- Groundwater transport
  - Leaching of contaminants from the silo contents via soils to underlying groundwater.

Each of these potential contaminant transport pathways is discussed below. The summary of the baseline risk assessment presented in Section 6 provides additional information about the impacts on environmental media or human receptors.

5.4.1 Direct Radiation

Gamma radiation from the K-65 residues and surface soils are transported as electromagnetic radiation, thus requiring no transport mechanism. As the distance from the K-65 silos and the surface soil source increases, the magnitude of the radiation's intensity decreases. The soil berms around Silos 1 and 2 provide shielding to potential receptors from the direct gamma radiation associated with the K-65 residues. The bentonite clay layer covering the silo residues decreases the diffusion of radon into the silo headspace. Radon progeny are gamma-emitters that contribute significantly to direct radiation exposure. Therefore, as long as the integrity of the berms, the bentonite clay liner, and silos is maintained, there should be no change or increase in direct radiation exposure due to this pathway.

5.4.2 Air Emissions

Rn-222 generated by the radioactive decay of Ra-226 in the K-65 and metal oxide residues accumulates in the void headspace inside the silos. At the time of their design, the four silos were not required to be airtight; therefore, air exchanges with the outside environment occur. The air exchange is a result of changes in ambient temperatures that cause expansion and contraction of the air mass inside the silos. The foam installed on top of Silos 1 and 2 in 1987 has reduced the K-65 silo breathing losses by limiting daily temperature variations inside the silo dome. In addition to direct release to the atmosphere, radon gas can also diffuse through the K-65 silo walls into the surrounding soil berms. Radon has a short half-life (3.82 days) and is expected to decay into its progeny, Pb-210 and Po-210, in the silo walls and in the soil berms surrounding Silos 1 and 2. These are nonvolatile constituents that accumulate in the soil berms. These progeny could be transported via resuspension if the berms are eroded to a point where this area is exposed.

Contaminated soil particulates can also be resuspended into the air from the surface of the K-65 berms and the surrounding Operable Unit 4 soils and transported by winds to other locations.

5.4.3 Surface Water Runoff

Contaminants in the surface soils can be transported away from Operable Unit 4 through surface soil erosion caused by surface water runoff. If the existing runoff control structures (i.e., trench drains and curb and gutters) at the perimeter of Operable Unit 4 were to fail, this would permit storm water runoff to directly enter Paddys Run. Contaminants contained in near surface soils which are subject to erosion can be transported to Paddys Run by either dissolving in the runoff surface water or attaching to entrained sediment carried by the water. A portion of these contaminants will partition (i.e., separate) into stream sediment and will not be available for immediate transport to the aquifer. Contaminants in the dissolved phase could be transported to the Great Miami Aquifer by recharge from Paddys Run throughout the length of Paddys Run from Operable Unit 4 to the Great Miami River.

5.4.4 Groundwater Transport

The final potential transport route is via groundwater. Contamination may be transported through the vadose zone into the Great Miami Aquifer in the vicinity of Operable Unit 4 by traveling through the glacial overburden present beneath the silos. A conceptual model of potential contaminant transport from the bottom of the silos to the Great Miami Aquifer has been developed. This model is based on the current understanding of the Operable Unit 4 Study Area and data from past investigations and is listed below:

- Leachate derived from Silos 1 and 2 is formed under the current storage configuration of the silos from liquids used to slurry waste materials into the silos. Additional leachate may be formed based on the assumption that precipitation infiltrates the silos through the silo top and sidewalls and interacts with the wastes within. This leachate may pass through the wastes, out the bottom of the silo, and enter the glacial overburden.

- Perched groundwater in the vicinity of Operable Unit 4 flows to the west, toward Paddys Run. Thus, once out of the silo, leachate may migrate through the glacial overburden toward the west, until it reaches Paddys Run, or in a vertical direction until it reaches the Great Miami Aquifer.

- Once in Paddys Run or the Great Miami Aquifer, the contamination can be transported through surface water or groundwater to either on-property or off-site receptors.

6.0 BASELINE RISK ASSESSMENT

Baseline risk assessments were performed to determine the potential human health effects and ecological risks which could result from exposure to contaminants currently present in Operable Unit 4.

The baseline assessment of human health risks quantified the health risks to hypothetical human receptors due to exposure from chemical sources in Operable Unit 4 under the no-action alternative. The process analyzed the human health consequences that could occur under different scenarios if no remedial actions were taken to address identified environmental concerns. This process utilized a structured, sequential analytical process that:

- Identified the specific Constituents of Concern (COCs) for Operable Unit 4.
- Assessed contaminant transport from the sources to potential exposure points.
- Quantified potential exposures to receptors under current and future land use scenarios.
- Characterized the potential baseline risks associated with Operable Unit 4 under current and potential future land use scenarios.

Appendix D and Section 6.0 of the RI Report for Operable Unit 4 provide detailed information on the baseline assessment of human health risks.

Site-wide baseline ecological risks were evaluated and included in the Site-Wide Characterization Report (DOE 1993b). An overview of that discussion is included in Section 6.2 of this ROD. The purpose was to conduct a qualitative assessment of the potential current and future risks posed by FEMP site contaminants to ecological receptors (e.g., plants and animals) if no remediation is implemented, thus, serving as a baseline for all future assessments. The Amended Consent Agreement between EPA and DOE stipulates that Operable Unit 5 is responsible for the preparation of the Site-Wide Ecological Risk Assessment as part of the RI and FS Reports for Operable Unit 5.

6.1 SUMMARY OF THE BASELINE ASSESSMENT OF RISKS TO HUMAN HEALTH

6.1.1 Constituents of Concern

The COCs for human health and their ranges of concentration in effected Operable Unit 4 media are provided in Table 6-1. COCs were detected in Silos 1, 2, and 3, the surrounding surface soil and subsurface soil, and the silo berm soils. Baseline risk assessment source term concentrations were determined for the COCs in these media. Fate and transport modeling was then conducted to estimate the exposure point concentrations of contaminants in environmental media (e.g., groundwater, air, and surface water). Contaminants with the potential of posing risk to human health include radionuclides, metals, inorganic anions, polyaromatic hydrocarbons (PAHs), and pesticides/polychlorinated biphenyls (PCBs). The selection of COCs was based on the evaluation of characterization data with respect to the distribution on contaminants in various media and the potential contribution of these contaminants to the overall human health effects. Appendix E of the RI Report for Operable Unit 4 provides full details of the process for selecting COCs.

6.1.2 Exposure Assessment

The exposure assessment and baseline risk assessment follow the methodology described in the Risk Assessment Work Plan Addendum (DOE 1992), with the exception of those items identified in Section D.1.0 of Appendix D of the RI Report for Operable Unit 4 (DOE 1993a). Baseline risks were calculated under a number of contaminant release mechanisms providing exposure to hypothetical receptors under three separate land use scenarios. Baseline risks under these land use scenarios were calculated for a current source term and a future source term. The concentrations of contaminants found in the contents of Silos 1, 2, and 3, the surrounding surface soil, the silo berm soil, and subsurface soil within the Operable Unit 4 Study Area were used to determine the source term concentrations used in each exposure scenario.

Land use scenarios include: (1) current land use without access controls, (2) current land use with access controls, and (3) future land use without access controls. Under the first scenario, the FEMP site is assumed to be managed by an industrial concern other than DOE. Access restrictions currently provided by DOE are assumed to be discontinued. In addition, no remedial actions are assumed to have been taken, and no members of the public establish residence within the boundaries of Operable Unit 4. Thus, potential receptors include an off-property resident farmer, a trespassing child, an on-property worker (groundskeeper), and an off-property user of surface water from the Great Miami River.

TABLE 6-1

CONSTITUENTS OF CONCERN FOR OPERABLE UNIT 4

	Silo 1 & 2	Silo 3	Surface Soil	Berm Soil
Range of Detection for Chemicals (mg/kg)				
2-Butanone	0.002-0.022		0.002-0.008	0.011[a]
2-Hexanone	0.002-0.017			
2-Nitrophenol		.052[a]		
4,4'-DDE	0.029-0.120			
4,4'-DDT	0.014-0.068			
4-Methyl-2-pentanone	0.002-0.003			
4-Nitrophenol		.045[a]		
Acenaphthylene			1.30[a]	
Acetone	0.033-0.150		0.004-0.079	0.064[a]
Aldrin	0.056[a]			
Ammonia	1.100-8.90			
Anthracene			0.780[a]	
Antimony	13.300-77.4		22.60-32.30	19.100-24.900
Aroclor-1248	1.700-10.0			
Aroclor-1254	0.420-20.0			
Aroclor-1260	0.340-3.50			
Arsenic	3.100-1960	532-6380	2.70-9.50	5.000-8.000
Barium	89.20-22100	118.000-332.000	44.7-113.0	47.100-89.400
Benzo(a)anthracene			0.062-4.70	
Benzo(a)pyrene			5.20[a]	
Benzo(b)fluoranthene			0.150-9.70	
Benzo(g,h,i)perylene			5.30[a]	
Benzoic Acid	0.075-0.390		0.059[a]	
Beryllium	0.590-6.00	10.000-39.900	0.670-1.00	0.670-0.850
Bis(2-ethylhexyl)phthalate	0.070-6.00		0.075-1.60	
Boron	18.400-81.20			
Cadmium	0.560-19.1	21.500-204.000	4.70-6.20	2.600-4.200
Carbon tetrachloride	0.170[a]			
Chromium	0.207-165	139-560	10.20-22.60	16.400-28.400
Chrysene			0.062-3.50	
Cobalt	6.20-2430	1100-3520		
Copper	122-1790	1610-7060	16.200-23.50	19.300-23.800
Cyanide	0.520-7.10		0.120[a]	0.120[a]
Di-n-butyl phthalate	0.046-0.057		0.190[a]	0.048[a]
Di-n-octyl phthalate	0.045-0.970			
Dieldrin	0.093[a]			
Diethyl phthalate	0.410[a]			
Dimethyl phthalate	0.068-0.160			
Endosulfan-II	0.082-0.260			
Endosulfan-I	0.011-0.092			

Table 6-1

(continued)

	Silo 1 & 2	Silo 3	Surface Soil	Berm Soil
Range of Detection for Chemicals (mg/kg)				
Endrin	0.089[a]			
Fluoranthene	0.064[a]		0.040-6.70	
Fluoride	15.0-394			
Heptachlor epoxide	0.022-0.20			
Indeno(1,2,3-cd)pyrene			4.20[a]	
Lead	153-299000	646-4430		
Manganese		2420-6500		
Mercury	0.150-2.80	0.300-0.690		
Methylene chloride	0.015-0.190		0.025[a]	
Molybdenum	148-8600		3.60-4.90	2.400-13.300
N-nitroso-di-n-propylamine	0.059-0.260			
Nickel	14.60-3380	1760-6170	22.8-38.9	21.700-32.400
Nitrate	2216-8900			
Phenanthrene			2.60[a]	
Phenol	0.40[a]		0.230[a]	0.110[a]
Phosphorus	0.40-3290			
Pyrene	0.047[a]		0.045-8.20	
Selenium	49.60-2810	101.000-349.000		
Silver	5.0-34.9	9.200-23.800	6.60-9.70	5.800-14.400
Tetrachlorethene	0.140[a]			
Thallium	0.090-5.700	4.000-73.900	0.510[a]	0.710[a]
Toluene	0.002-0.190		0.001[a]	0.002-0.200
Total xylenes	0.003[a]			0.069[a]
Tributyl Phosphate	0.200-73.00			
Uranium	137.0-8394.0	738.0-4554.0	4.0-64.0	10.50-12.40
Vanadium	21.90-535.00	418-4550	15.9-27.7	24.600-28.400
Zinc	7.70-212.00	301-672	32.9-65.2	44.200-59.600

Table 6-1

(continued)

	Silo 1 & 2	Silo 3	Surface Soil	Berm Soil
Range of Detection for Radionuclides (pCi/g)				
Actinium-227	2905.0-17390	234.0-1363		
Cesium-137				0.23[a]
Lead-210	48980.0-399200	454.0-6427		0.98-4.45
Polonium-210	55300-43400			1.68-4.70
Protactinium-231	4041[a]	266.0-931		
Radium-224		64.00-453.00		1.020[a]
Radium-226	657.0-890700	467.0-6435	0.6-2.3	1.04-6.68
Radium-228		82.0-559	0.5-1.7	0.8-0.98
Strontium-90			0.8-1.8	
Technetium-99			1.2-3.6	
Thorium-228	411.0-7360	459.0-996	0.9-1.4	1.12-1.52
Thorium-230	8365.0-132800	21010.0-71650	1.4-4.8	1.69-4.78
Thorium-232	661.0-1106	411.0-1451	0.9-1.7	0.86-1.45
Uranium-234	89.0-1548	348.0-1935	2.4-6.9	1.26-3.62
Uranium-235/236	19.1-172	42.0-158		
Uranium-238	46.0-1925	320.0-2043	2.4-20.8	1.13-4.19

[a]-only one sample was found to be above the detection limit.

Under the second scenario, the site access restrictions historically provided by DOE are assumed to be maintained, and no remedial actions are assumed to have been taken. The scenario further assumes that no members of the public have established residence in the Operable Unit 4 Study Area, and that DOE maintains a site-specific health and safety program to ensure that non-remediation workers and visitors are properly protected. Therefore, the risk assessment addresses workers subjected to short exposure durations under controlled conditions. These controls include engineered emission control equipment, personnel protective equipment, and administrative health and safety practices. Potential receptors under this scenario include an off-property resident farmer, a trespassing child, and an off-property user of surface water from the Great Miami River.

The third land-use scenario, future land use without access controls, includes exposure routes that require development time, such as establishing a home and farm within Operable Unit 4. Access controls are assumed to be absent and no remedial actions are assumed to have been taken. In addition, members of the public are assumed to have established a residence within the Operable Unit 4 boundaries. Hypothetical receptors under this scenario are a reasonable maximum exposure (RME) on-property resident farmer, a central tendency (CT) on-property resident farmer, an on-property resident child, an off-property resident farmer, and an off-property user of surface water from the Great Miami River.

In addition to the three land use scenarios, there are two source term scenarios: the current source-term scenario and the future source term scenario. The current source term scenario considers the silos as they exist today. The future source term scenario considers complete structural failure of Silo 3, resulting in the spread of its contents to Operable Unit 4 surface soil, and dome collapse for Silos 1 and 2, consequently exposing their contents to the elements and increasing leaching of the contents through the interception of rainwater.

Under the current land use scenario without access control and the future land use scenario, risks are calculated using both the current source term and the future source term. Under the current land use with access control scenario, the future source term does not apply; if the site remains under the institutional control of DOE, the assumption is made that measures would be undertaken to maintain the current configuration of the silos and implement mitigative action in the event of silo failure. Thus, under the current land use with access control scenario, risk was calculated only for the current source term.

The on-property resident farmer receptor was also evaluated using exposure and intake parameters such as exposure duration, which represents the CT of risk. This was performed in response to new guidance from EPA, which suggests that all risk assessments provide an evaluation of the CT of the risk range, using the best information available to describe the average situation (EPA 1992a). This scenario is used to provide an estimate of risk closer to average for the resident adult scenario. This receptor scenario is currently being developed by EPA and will require additional review as guidance becomes available. The CT receptor for this scenario is located at the same location as the RME on-property resident farmer receptor. Table 6-2 provides a summary of the land use/source term/receptor scenarios used for the Baseline Risk Assessment.

Exposure pathways quantified in the risk assessment for each scenario are shown in Figures 6-1 and 6-2 and are discussed in greater detail in Appendix D of the RI Report for Operable Unit 4. A summary of exposure pathways that have the most impact to site risks is presented in Section 6.1.4. The conceptual model depicted in Figures 6-1 and 6-2 indicates which exposure routes are quantitatively evaluated in the risk assessment for each receptor and land use scenario, and the basis for excluding other exposure routes. Exposures to the RME resident farmer due to the ingestion of groundwater consider two scenarios, which include water obtained from the Great Miami Aquifer and water obtained from perched water beneath and west of Silos 1 and 2.

Section 5.0 and Appendix E of the RI Report for Operable Unit 4 address in detail all fate and transport modeling efforts employed in the determination of exposure point concentrations of the COCs. Appendix D of the RI Report for Operable Unit 4 discusses the assumptions regarding source term and potential release mechanisms upon which the fate and transport modeling is based.

6.1.3 Toxicity Assessment

The human health hazards identified in the toxicity assessment are cancer induction and chemical toxicity. Chemical toxicity includes numerous health effects such as kidney damage, liver disease, or eye irritation. For both types of health hazards, dose-response data from human and animal studies are used to determine the potency of the individual radionuclides and chemicals.

Intakes calculated in the exposure assessment are used in conjunction with the cancer slope factor from the dose-response data to determine the incremental lifetime cancer risk (ILCR). Toxicity data for the Operable Unit 4 risk assessment were taken from the Integrated Risk Information System

TABLE 6-2

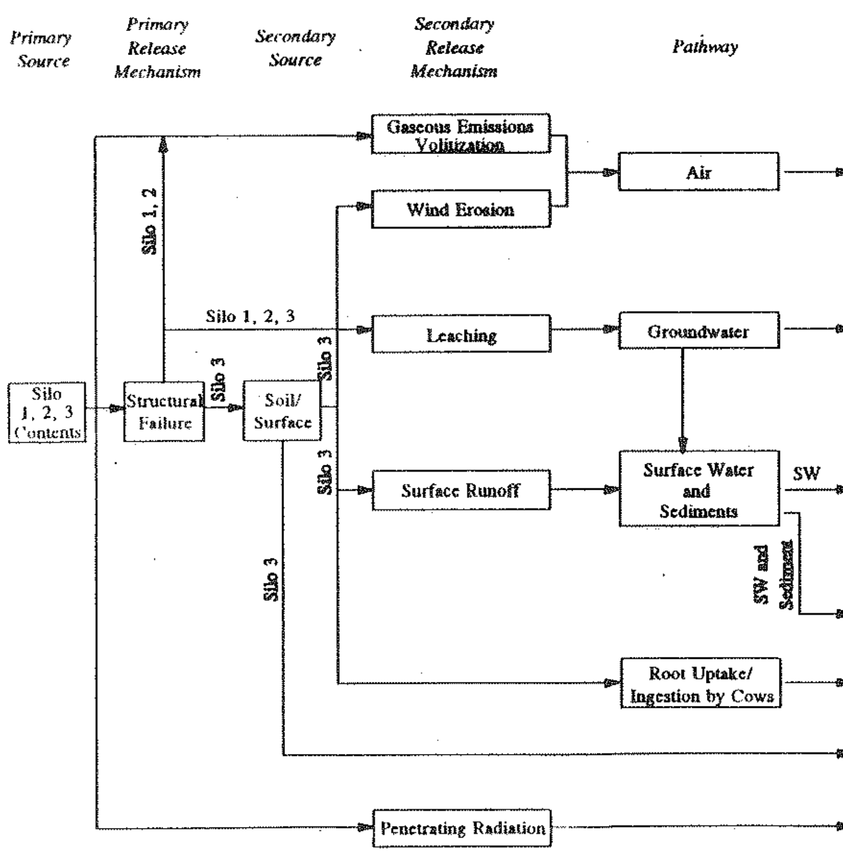
SUMMARY OF LAND-USE/RECEPTOR/SOURCE TERM SCENARIOS

	RECEPTORS	
LAND USE	**CURRENT SOURCE TERM**	**FUTURE SOURCE**
Current Land Use Without Access Control	Off-Property Farmer, Trespassing Child, Groundskeeper Worker, Off-Property User of Surface Water from the Great Miami River	Off-Property Farmer, Trespassing Child, Groundskeeper Worker, Off-Property User of Surface Water from the Great Miami River
Current Land Use With Access Control	Off-Property Farmer, Trespassing Child, Off-Property User of Surface Water	N/A
Future Land Use	RME On-Property Resident Farmer, CT On-Property Resident Farmer, On Property Resident Child, Off-Property Farmer, Off-Property User of Surface Water from the Great Miami River	RME On-Property Resident Farmer, CT On-Property Resident Farmer, On Property Resident Child, Off-Property Farmer, Off-Property User of Surface Water from the Great Miami River

Notes: N/A Not Applicable
RME Reasonable Maximum Exposure
CT Central Tendency

Cross-hatched boxes indicate receptor exposure routes that are included in the quantiatove risk assessment

CT = Central Tendency
RME = Reasonable Maximum Exposure



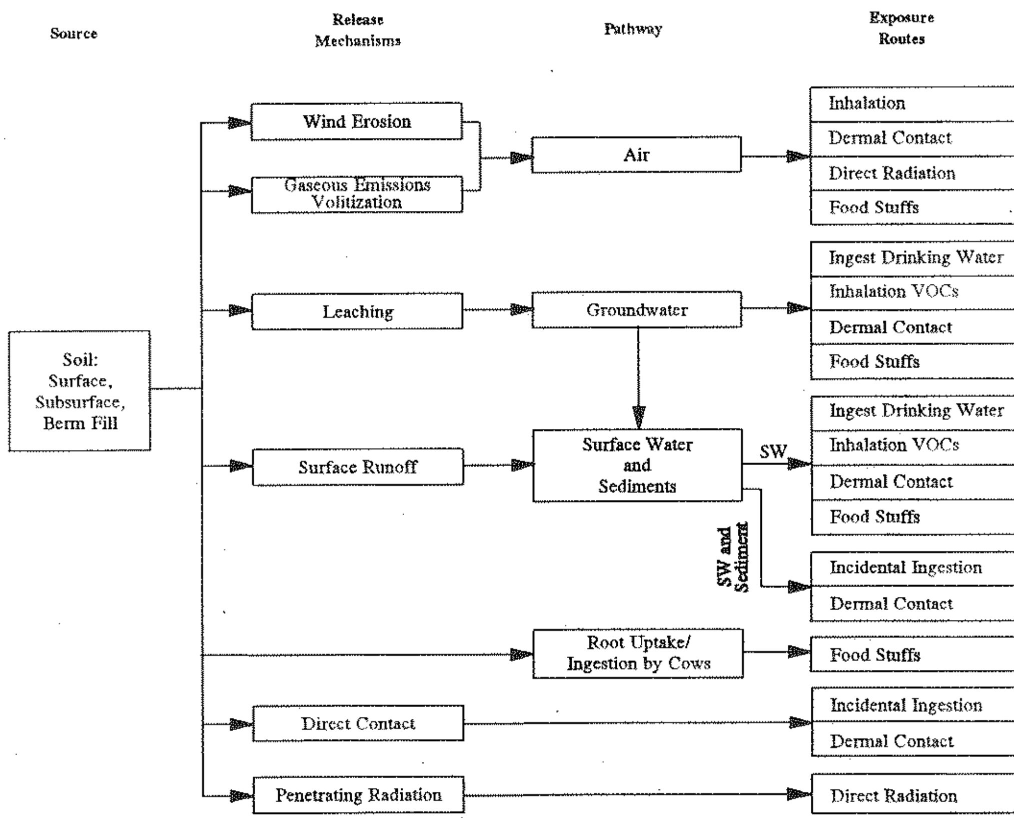
Pathway	Exposure Routes	Current Land Use without Access Controls: Trespassing Child	Current Land Use without Access Controls: Groundskeeper Worker	Current Land Use without Access Controls: Off-Property Farmer	Current Land Use without Access Controls: Off-Property User of Surface Water	Current Land Use with Access Controls: Trespassing Child	Current Land Use with Access Controls: Off-Property Farmer	Current Land Use with Access Controls: Off-Property User of Surface Water	Future Land Use: Typical On-Property Farmer	Future Land Use: RME On-Property Farmer	Future Land Use: On-Property Resident Child	Future Land Use: Off-Property Farmer	Future Land Use: Off-Property User of Surface Water
Air	Inhalation				1			1					1
Air	Dermal Contact	2	2	2	1	2	2	1	2	2	2	2	1
Air	Direct Radiation	2,3	2,3	2,3	1	2,3	2,3	1	2,3	2,3	2,3	2,3	1
Air	Food Stuffs	4	4		1	4		1					1
Groundwater	Ingest Drinking Water	4	4		1	4		1					1
Groundwater	Inhalation VOCs	4	4		1	4		1		8			1
Groundwater	Dermal Contact	4	4		1	4		1					1
Groundwater	Food Stuffs	4	4		1	4		1					1
Surface Water (SW)	Ingest Drinking Water	4	4	7		4	7		7	7	7	7	
Surface Water (SW)	Inhalation VOCs	4	4	7		4	7		7	7	7	7	
Surface Water (SW)	Dermal Contact	4	4	7		4	7		7	7	7	7	
Surface Water (SW)	Food Stuffs	4	4	7		4	7		7	7	7	7	
SW and Sediment	Incidental Ingestion	9	8	2	2	9	2	2	2	2	9	2	2
SW and Sediment	Dermal Contact	9	8	2	2	9	2	2	2	2	9	2	2
Root Uptake/Ingestion by Cows	Food Stuffs	4	4	6	1	4	6	1				6	1
Soil/Surface (Silo 3)	Incidental Ingestion			6	1		6	1				6	1
Soil/Surface (Silo 3)	Dermal Contact			6	1		6	1				6	1
Penetrating Radiation	Direct Radiation			2	1		2	1				2	1

1) The objective of quantifying exposure routes to the off-property user of surface water is to isolate and evaluate the impact of contamination from the Great Miami River through water pathways.
2) Potential impact of exposure route is minor compared to other exposure routes .
3) EPA Risk assessment methodology for radionuclides dos not address this exposure route.
4) Exposure route is not applicable to a transient, non-resident receptor.
5) Evaluated using two different exposure point concentrations: modeled aquifer concentration and modeled sand lens concentration.
6) Off-property soils is within the scope of OU5. Impact on food stuff exposure routes from air deposition is included in the air exposure routes.
7) Receptor is assumed to obtain water for all needs from groundwater.
8) Receptor is assumed to restrict activities to work at OU4 and not contact surface water via these exposure routes.
9) Evaluated for sediment ingestion and dermal contact with sediment using modeled concentration impacted by sand lens.

FIGURE 6-1. OU4 CONCEPTUAL MODEL - SILO CONTENTS

Cross-hatched boxes indicate receptor exposure routes that are included in the quantitative risk assessment

CT = Central Tendency
RME = Reasonable Maximum Exposure



Pathway	Exposure Routes	Current Land Use without Access Controls: Trespassing Child	Groundskeeper Worker	Off-Property Farmer	Off-Property User of Surface Water	Current Land Use with Access Controls: Trespassing Child	Off-Property Farmer	Off-Property User of Surface Water	Future Land Use: Typical On-Property Farmer	RME On-Property Farmer	On-Property Resident Child	Off-Property Farmer	Off-Property User of Surface Water
Air	Inhalation	X	X	X	1	X	X	1	X	X	X	X	1
Air	Dermal Contact	2	2	2	1	2	2	1	2	2	2	2	1
Air	Direct Radiation	2,3	2,3	2,3	1	2,3	2,3	1	2,3	2,3	2,3	2,3	1
Air	Food Stuffs	4	4	X	1	4	X	1	X	X	X	X	1
Groundwater	Ingest Drinking Water	4	4	5	1	4	5	1	5	5	5	5	1
Groundwater	Inhalation VOCs	4	4	5	1	4	5	1	5	5	5	5	1
Groundwater	Dermal Contact	4	4	5	1	4	5	1	5	5	5	5	1
Groundwater	Food Stuffs	4	4	5	1	4	5	1	5	5	5	5	1
SW	Ingest Drinking Water	4	4	7	X	4	7	X	7	7	7	7	X
SW	Inhalation VOCs	4	4	7	X	4	7	X	7	7	7	7	X
SW	Dermal Contact	4	4	7	X	4	7	X	7	7	7	7	X
SW	Food Stuffs	4	4	7	X	4	7	X	7	7	7	7	X
SW and Sediment	Incidental Ingestion	X	8	2	2	X	2	2	2	2	X	2	2
SW and Sediment	Dermal Contact	X	8	2	2	X	2	2	2	2	X	2	2
Root Uptake/ Ingestion by Cows	Food Stuffs	4	4	6	1	4	6	1	X	X	X	6	1
Direct Contact	Incidental Ingestion	X	X	6	1	X	6	1	X	X	X	6	1
Direct Contact	Dermal Contact	X	X	6	1	X	6	1	X	X	X	6	1
Penetrating Radiation	Direct Radiation	X	X	2	1	X	2	1	X	X	X	2	1

1) The objective of quantifying exposure routes to the off-property user of surface water is to isolate and evaluate the impact of contamination from the Great Miami River through water pathways.
2) Potential impact of exposure route is minor compared to other exposure routes.
3) EPA Risk assessment methodology for radionuclides does not address this exposure route.
4) Exposure route is not applicable to a transient, non-resident receptor.
5) Soil in Operable Unit 4 is not included as a source term to groundwater modeling.
6) Off-property soils is within the scope of OU5. Impact on food stuff exposure routes from air deposition is included in the air exposure routes.
7) Receptor is assumed to obtain water for all needs from groundwater.
8) Receptor is assumed to restrict activities to work at OU4 and not contact surface water via these exposure routes.

FIGURE 6-2. OU4 CONCEPTUAL MODEL - SOIL AND BERM FILL MATERIAL

(IRIS, EPA 1992a) and the updated Health Effects Assessment Summary Table (HEAST, EPA 1992b). Cancer slope factors have been developed by the EPA for estimating ILCRs associated with exposure to carcinogenic chemicals. The slope factors, which are expressed in units of milligrams per kilograms-day $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a carcinogen, in mg/kg-day, to provide an upper-bound estimate of the ILCR associated with exposure at that intake level. The term "upper-bound" reflects the conservative estimate of the risks calculated from the slope factor. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer slope factors are derived from the results of human epidemiological studies, or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied. Tables 6-3 and 6-4 provide the cancer slope factors for Operable Unit 4 chemical COCs and radiological COCs respectively.

For cancer induction, it is assumed that no dose threshold exists. Therefore, for any dose of a carcinogen, there exists a possibility, however small, of contracting cancer. Incremental lifetime cancer risks are expressed in terms of the probability that a given receptor (person) will contract cancer due to the calculated exposures. For example, if the receptor has an additional 1 chance in 10,000 of contracting cancer due to the calculated exposures, the probability of developing cancer is expressed as a 10^{-4} (1 in 10,000) risk. However, these risk factors should only be used to make a qualitative estimate of individual receptor impact, because the risk coefficients are intended for predicting cancer in a large population.

For chemical toxicants, the data suggests a dose threshold or reference dose (RfD) exists below which no toxic effect is observed. RfDs have been developed by the EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting non-carcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse non-carcinogenic effects to occur. Table 6-5 provides the RfDs for Operable Unit 4 COCs.

To determine if the exposure levels of Operable Unit 4 constituents may cause adverse health effects, the estimated intake of a particular constituent (calculated from the exposure assessment) is compared

TABLE 6-3

CANCER SLOPE FACTORS FOR CARCINOGENIC EFFECTS OF CONSTITUENTS OF CONCERN FOR OPERABLE UNIT 4

Chemical	Oral Cancer Slope Factor (mg/kg/day)$^{-1}$	Inhalation Cancer Slope Factor (mg/kg/day)$^{-1}$ [a]	Tumor Site: Oral	Tumor Site: Inhalation	Cancer Classification[a,b]	Reference
Inorganics						
Ammonia	ND[c]	ND	ND	ND	ND	ND
Antimony	ND	ND	ND	ND	D	d
Arsenic	1.75	15	skin	respiratory tract	A	e
Barium	ND	ND	ND	ND	D	d
Beryllium	4.3	8.4	gross tumors	lung	B2	e
Boron	ND	ND	ND	ND	ND	ND
Cadmium (food)	ND	6.3	ND	respiratory tract	B1	e
Cadmium (water)	ND	6.3	ND	respiratory tract	B1	e
Chromium (VI)	ND	42	ND	lung	A	e
Cobalt	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	D	e
Cyanide	ND	ND	ND	ND	D	e
Fluoride	ND	ND	ND	ND	ND	ND
Lead	ND	ND	kidney	ND	B2	e
Manganese	ND	ND	ND	ND	D	e
Mercury	ND	ND	ND	ND	D	e
Molybdenum	ND	ND	ND	ND	D	d
Nickel	ND	0.84	ND	respiratory tract	A	e
Nitrate	ND	ND	ND	ND	ND	ND
Phosphorus	ND	ND	ND	ND	D	e
Selenium	ND	ND	ND	ND	D	e
Silver	ND	ND	ND	ND	D	e
Thallium compounds	ND	ND	ND	ND	ND	e

TABLE 6-3
(Continued)

Chemical	Oral Cancer Slope Factor (mg/kg/day)$^{-1}$	Inhalation Cancer Slope Factor (mg/kg/day)$^{-1}$[a]	Tumor Site: Oral	Tumor Site: Inhalation	Cancer Classification[a,b]	Reference
Uranium	ND	ND	ND	ND	ND	f
Vanadium	ND	ND	ND	ND	ND	d
Zinc	ND	ND	ND	ND	D	e
Volatiles						
2-Butanone	ND	ND	ND	ND	D	e
2-Hexanone	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	ND
Acetone	ND	ND	ND	ND	D	e
Carbon tetrachloride	0.13	0.053	liver	ND	B2	e
Methylene chloride	0.0075	0.0016	liver	lung, liver	B2	e
Tetrachloroethene	0.052	0.002	lung	lung	B2-C	g
Toluene	ND	ND	ND	ND	D	e
Total xylenes	ND	ND	ND	ND	D	e
Semivolatiles						
Acenaphthylene	ND	ND	ND	ND	D	e
Aldrin	17	17	liver	ND	B2	e
Anthracene	ND	ND	ND	ND	D	e
Benzo(a)anthracene	7.3	6.1	ND	ND	B2	h
Benzo(a)pyrene	7.3	6.1	stomach	respiratory tract	B2	e, g
Benzo(b)fluoranthene	7.3	6.1	ND	ND	B2	h
Benzo(g,h,i)perylene	ND	ND	ND	ND	D	e
Benzoic acid	ND	ND	ND	ND	D	e
bis(2-Ethylhexyl)phthalate	0.014	ND	liver	ND	B2	e
Chrysene	7.3	6.1	lymphoma, skin	ND	B2	h
Di-n-butylphthalate	ND	ND	ND	ND	D	e

TABLE 6-3
(Continued)

Chemical	Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg/day)^{-1}$[a]	Tumor Site: Oral	Tumor Site: Inhalation	Cancer Classification[a,b]	Reference
Di-n-octylphthalate	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	7.3	6.1	ND	ND	B2	h
Diethyl phthalate	ND	ND	ND	ND	D	e
Dimethyl phthalate	ND	ND	ND	ND	D	e
Fluoranthene	ND	ND	ND	ND	D	e
Indeno(1,2,3-cd)pyrene	7.3	6.1	ND	ND	B2	h
2-Nitrophenol	ND	ND	ND	ND	ND	ND
4-Nitrophenol	ND	ND	ND	ND	ND	ND
N-Nitroso-di-n-propylamine	7	ND	multiple	ND	B2	e
Phenanthrene	ND	ND	ND	ND	D	e
Phenol	ND	ND	ND	ND	D	e
Pyrene	ND	ND	ND	ND	D	e
Tributyl phosphate	ND	ND	ND	ND	D	i
Pesticides/PCBs						
Aroclor-1248	7.7	ND	liver	ND	B2	i
Aroclor-1254	7.7	ND	liver	ND	B2	i
Aroclor-1260	7.7	ND	liver	ND	B2	e
4,4'-DDE	0.34	ND	liver	ND	B2	e
4,4'-DDT	0.34	0.34	liver	ND	B2	e
Dieldrin	16	16	liver	ND	B2	e
Endosulfan I	ND	ND	ND	ND	ND	ND
Endosulfan II	ND	ND	ND	ND	ND	ND
Endrin	ND	ND	ND	ND	D	d
Heptachlor epoxide	9.1	9.1	liver	ND	B2	e

TABLE 6-3
(Continued)

			Tumor Site			
Chemical	Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg/day)^{-1}$[a]	Oral	Inhalation	Cancer Classification[a,b]	Reference

[a]Derived from inhalations unit risk.
[b]Cancer weight-of-evidence Group A = human carcinogen; Group B1 and B2 = probable human carcinogen; Group C = possible human carcinogen; Group D - not classifiable as to carcinogenicity to humans; Group E = evidence of noncarcinogenicity to humans
[c]ND - no data
[d]EPA 1993b, "Drinking Water Regulations and Health Advisories"
[e]Integrated Risk Information System (IRIS), 1993 (EPA 1993a) current as of April 1993
[f]The carcinogenicity of uranium is attributed to its radioactivity; see Appendix D of the Operable Unit 4 Remedial Investigation.
[g]EPA, Health Effects Assessment Summary Table (HEAST)(EPA 1992a).
[h]The oral and inhalation cancer slope factors for benzo(a)pyrene are used for the other polyaromatic hydrocarbons assigned to cancer classification B2 (see the toxicological profile for polyaromatic hydrocarbons of Appendix D from the Operable Unit 4 Remedial Investigsation for additional information).
[i]EPA, 1993d, Memorandum from J. Dollarhide ECAO to P. VanLeeuwen Region V, 7/21/93, including Attachments 1-6.

TABLE 6-4

CANCER SLOPE FACTORS FOR OPERABLE UNIT 4 RADIONUCLIDES OF CONCERN[a]

Radionuclide	ICRP Lung Class[b]	Inhalation $(pCi)^{-1}$	GI Absorption Factor (f_1)	Ingestion $(pCi)^{-1}$	Penetrating External Exposure $(pCi \cdot yr/g)^{-1}$
Uranium - 238 Series					
U-238 + 2 dtrs	Y	5.2×10^{-8}	5.0×10^{-2}	2.8×10^{-11}	3.6×10^{-8}
U-234	Y	2.6×10^{-8}	5.0×10^{-2}	1.6×10^{-11}	3.0×10^{-11}
Th-230	Y	2.9×10^{-8}	2.0×10^{-4}	1.3×10^{-11}	5.4×10^{-11}
Ra-226 + 5 dtrs	W	3.0×10^{-9}	2.0×10^{-1}	1.2×10^{-10}	6.0×10^{-6}
Rn-222 + 4 dtrs	Gas	7.7×10^{-12}	1.0×10^{0}	1.7×10^{-12}	5.9×10^{-6}
Pb-210 + 2 dtrs	D	4.0×10^{-9}	2.0×10^{-1}	6.6×10^{-10}	1.6×10^{-10}
Uranium - 235 Series					
U-235 + 1 dtr	Y	2.5×10^{-8}	5.0×10^{-2}	1.6×10^{-11}	2.4×10^{-7}
Pa-231	Y	3.6×10^{-8}	1.0×10^{-3}	9.2×10^{-11}	2.6×10^{-8}
Ac-227 + 7 dtrs	Y	8.8×10^{-8}	1.0×10^{-3}	3.5×10^{-10}	8.5×10^{-7}
Thorium - 232 Series					
Th-232	Y	2.8×10^{-8}	2.0×10^{-4}	1.2×10^{-11}	2.6×10^{-11}
Ra-228 + 1 dtr	W	6.9×10^{-10}	2.0×10^{-1}	1.0×10^{-10}	2.9×10^{-6}
Th-228 + 7 dtrs	Y	7.8×10^{-8}	2.0×10^{-4}	5.5×10^{-11}	5.6×10^{-6}
Fission Products					
Tc-99	W	8.3×10^{-12}	8.0×10^{-1}	1.3×10^{-12}	6.0×10^{-13}
Sr-90 + 1 dtr	D	6.2×10^{-11}	3.0×10^{-1}	3.6×10^{-11}	0.0×10^{0}

[a]EPA, Health Effects Assessment Summary Tables, Annual FY 1992 including the July 1992 and November 1992 supplements (EPA 1992a)
[b]Classification recommended by the ICRP for half-time for clearance from the lung. "Y" = years, "W" = weeks, "D" = days.

TABLE 6-5

REFERENCE DOSES FOR NONCARCINOGENIC EFFECTS OF CONSTITUENTS OF CONCERN FOR OPERABLE UNIT 4

Chemical	Oral Reference Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)[a]	Target Organ		Uncertainty Factor	
			Oral	Inhalation	Oral	Inhalation
Inorganics						
Ammonia	ND	0.029[b]	ND	Respiratory system	ND	30
Antimony	0.0004[b]	ND[c]	Liver	ND	1000	ND
Arsenic	0.0003[b]	ND	Skin	ND	3	ND
Barium	0.07[b]	0.00014[d]	Cardiovascular system	Fetus	3	1000
Beryllium	0.005[b]	ND	ND	ND	100	ND
Boron	0.09[b]	0.0057[d]	Testis	Respiratory system	100	100
Cadmium (food)	0.001[b]	ND	Kidney	Cancer (see Table 6-3)	10	ND
Cadmium (water)	0.0005[b]	ND	Kidney	Cancer (see Table 6-3)	10	ND
Chromium (VI)	0.005[b]	ND	ND	ND	500	ND
Cobalt	0.06[e]	0.0000003[f]	Cardiovascular system	Respiratory system	ND	1000
Copper	ND	ND	ND	ND	ND	ND
Cyanide	0.02[b]	ND	Central nervous system	ND	500	ND
Fluoride	0.06[b]	ND	Teeth	ND	1	ND
Lead	ND	ND	Central nervous system	Central nervous system	ND	ND
Manganese	0.14 (food)[b]	0.00011[b]	Central nervous system	Respiratory system	1	300
Manganese	0.005 (water)[b]	0.00011[b]	Central nervous system	Respiratory system	1	300
Mercury	0.0003[d]	0.000086[d]	Kidney	Central nervous system	1000	30
Molybdenum	0.005[b]	ND	Liver	ND	30	ND
Nickel	0.02[b]	ND	ND	Cancer (see Table 6-3)	300	ND
Nitrate	1.6[b]	ND	Blood	ND	1	ND

TABLE 6-5
(Continued)

Chemical	Oral Reference Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)[a]	Target Organ: Oral	Target Organ: Inhalation	Uncertainty Factor: Oral	Uncertainty Factor: Inhalation
Inorganics						
Phosphorus	0.00002[b]	ND	Reproductive system	ND	1000	ND
Selenium	0.005[b]	ND	Skin	ND	3	ND
Silver	0.005[b]	ND	ND	ND	3	ND
Thallium	0.00006[b,g]	ND	Central nervous system	ND	3000	ND
Uranium	0.003[b]	ND	Kidney	ND	1000	ND
Vanadium	0.007[d]	ND	ND	ND	100	ND
Zinc	0.3[b]	ND	Blood	ND	3	ND
Volatiles						
2 Butanone	0.05[d]	0.3[b]	ND	Fetus	1000	1000
2 Hexanone	0.04[k]	ND	ND	ND	ND	ND
4 Methyl 2-pentanone	0.05[d]	0.023[d]	Liver	Liver	1000	1000
Acetone	0.1[b]	ND	Liver	ND	1000	ND
Carbon tetrachloride	0.0007[b]	0.00057[h]	Liver	ND	1000	ND
Methylene chloride	0.06[b]	0.86[d]	Liver	Liver	100	100
Tetrachloroethene	0.01[b]	ND	Liver	ND	1000	ND
Toluene	0.2[b]	0.11[d]	Liver	Central nervous system	1000	300
Total xylenes	2[b]	ND	Central nervous system	ND	100	ND
Semivolatiles						
Acenaphthylene	ND	ND	ND	ND	ND	ND
Aldrin	0.00003[b]	ND	Liver	ND	1000	ND
Anthracene	0.3[b]	ND	ND	ND	3000	ND

TABLE 6-5
(Continued)

Chemical	Oral Reference Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)[a]	Target Organ		Uncertainty Factor	
			Oral	Inhalation	Oral	Inhalation
Semivolatiles						
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND
Benzoic acid	4[b]	ND	ND	ND	1	ND
bis(2-Ethylhexyl)phthalate	0.02[b]	ND	Liver	ND	1000	ND
Chrysene	ND	ND	ND	ND	ND	ND
Di-n-butylphthalate	0.1[b]	ND	ND	ND	1000	ND
Di-n-octylphthalate	0.02[d]	ND	Liver	ND	1000	ND
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND
Diethyl phthalate	0.8[b]	ND	ND	ND	1000	ND
Dimethyl phthalate	10[d]	ND	Kidney	ND	10	ND
Fluoranthene	0.04[b]	ND	Kidney	ND	3000	ND
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND
2-Nitrophenol	ND	ND	ND	ND	ND	ND
4-Nitrophenol	0.008[h]	ND	ND	ND	ND	ND
N-Nitroso-di-n-propylamine	ND	ND	ND	ND	ND	ND
Phenanthrene	ND	ND	ND	ND	ND	ND
Phenol	0.6[b]	ND	Fetus	ND	100	ND
Pyrene	0.03[b]	ND	Kidney	ND	3000	ND
Tributyl phosphate	0.005[k]	ND	ND	ND	ND	ND

TABLE 6-5
(Continued)

Chemical	Oral Reference Dose (mg/kg/day)	Inhalation Reference Dose (mg/kg/day)[a]	Target Organ		Uncertainty Factor	
			Oral	Inhalation	Oral	Inhalation
Pesticides/PCBs						
Aroclor-1248	0.00007[b,i]	ND	Fetus	ND	100	ND
Aroclor-1254	0.00007[b,i]	ND	Fetus	ND	100	ND
Aroclor-1260	0.00007[b,i]	ND	Fetus	ND	100	ND
4,4'-DDE	ND	ND	ND	ND	ND	ND
4,4'-DDT	0.0005[b]	ND	Liver	ND	100	ND
Dieldrin	0.00005[b]	ND	Liver	ND	100	ND
Endosulfan I	0.00005[j]	ND	Kidney	ND	3000	ND
Endosulfan II	0.00005[j]	ND	Kidney	ND	3000	ND
Endrin	0.0003[b]	ND	Liver	ND	100	ND
Heptachlor epoxide	0.000013[b]	ND	Liver	ND	1000	ND

[a]Derived from inhalation RfC.
[b]Integrated Risk Information System (IRIS) (EPA 1993[a]) current as of April 1993.
[c]ND - no data.
[d]EPA, Health Effects Assessment Summary Tables, (HEAST) Annual FY 92 including July and November Supplements (EPA 1992a).
[e]EPA 1992[e], Memorandum from D. L. Forman, U. S. EPA Region VII, Philadelphia, Pennsylvania, "Subject: Cobalt Toxicity," dated March 12, 1992.
[f]EPA 1990c, Memorandum from Pei-Fung Hurst, ECAO, Cincinnati, Ohio, to R. Riccio, U.S. EPA Region III, Philadelphia, Pennsylvania, "Subject: Toxicity of Cobalt (Halby Chemical/Wilmington, Delaware)," dated October 9, 1990.
[g]Derived by analogy to thallium sulfate, adjusting for differences in molecular weight.
[h]EPA 1993c
[i]Based on anology to Aroclor - 1016.
[j]EPA, 1993e, Health Effects Assessment Summary Tables, (HEAST), March, 1993.
[k]EPA, 1993d, Memorandum from J. Dollarhide, ECAO to P. VanLeeuwen, Region V, 7/21/93.

to the RfD, which defines the acceptable intake. If the ratio of estimated intake to the acceptable intake is greater than one, the site-related intake may cause toxic effects. This ratio is called the Hazard Quotient (HQ). When HQs for multiple COCs are summed, the resultant value is the Hazard Index (HI).

6.1.4 Risk Characterization Results

Excess lifetime cancer risks are determined by multiplying the intake level with the cancer potency factor. These risks are probabilities that are generally expressed in scientific notation (e.g. 1×10^{-6} or 1E-6). An excess lifetime cancer risk of 1×10^{-6} indicates that, as a plausible upper bound, an individual had a one in one million chance of developing cancer as result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site.

Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the HQ (or the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's reference dose). By adding the HQs for all contaminants within a medium or across all media to which a given population may reasonably be exposed, the HI can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

Tables 6-6 and 6-7 shows the baseline risks and HIs for each hypothetical receptor by land use and source term scenario. Risk values in Table 6-6 are reported in units of ILCR for radiological, chemical, and total risk. The chemical HI, which has no units, is presented in Table 6-7.

6.1.4.1 Current Land Use Without Access Control/Current Source-Term Scenario

The receptor with the greatest total radiological risk is the trespassing child (Table 6-6). The greatest contributor under this scenario is from exposure to external radiation while the receptor is on top of the Silo 1 or 2 dome (5×10^{-3}). In addition, the receptor is exposed to air, soil, and surface water pathways resulting in radiological risk of 3×10^{-5}. The total radiological risk to the trespassing child is 5×10^{-3} (external radiation) plus 3×10^{-5} (nuclide-specific radiation) totalling 5×10^{-3}. The receptor with the greatest total chemical risk (1×10^{-4}) is the off-property resident farmer (Table 6-6). The greatest contribution under this scenario is from exposure to air pathways (1×10^{-4}). The receptor with the greatest total radiological plus chemical risk under this scenario (5×10^{-3}, Table 6-6) is the trespassing child. The greatest HI is 0.3 to the trespassing child (Table 6-7). The greatest contribution, under this scenario is from soil exposure pathways (0.2).

TABLE 6-6

INCREMENTAL LIFETIME CANCER RISK SUMMARY ALL SOURCES/ALL PATHWAYS

Land Use/ Source Term Scenario	Type of Risk	Trespassing Child	Grounds Keeper	Off-Property Resident Farmer	Off-Property User of Surface Water	CT On-Property Resident Farmer	RME On-Property Resident Farmer[a]	On-Property Resident Child
Current Land Use without Access Control/Current Source Term Scenario	Radiological-Nuclide Specific[b]	3.0×10^{-5}	8.0×10^{-5}	1.0×10^{-5}	1.0×10^{-7}	NA[c]	NA	NA
	Radiological-External[d]	5×10^{-3}	1×10^{-4}	NA	NA	NA	NA	NA
	Chemical Risk	1.0×10^{-3}	2.0×10^{-5}	1.0×10^{-4}	1.0×10^{-7}	NA	NA	NA
	Total Risk	5.0×10^{-3}	2.0×10^{-4}	1.0×10^{-4}	2.0×10^{-7}	NA	NA	NA
Current Land Use without Access Control/Future Source Term Scenario	Radiological-Nuclide Specific	1.0×10^{-2}	3.0×10^{-2}	2.0×10^{-3}	1.0×10^{-6}	NA	NA	NA
	Chemical Risk	4.0×10^{-4}	6.0×10^{-4}	2.0×10^{-4}	7.0×10^{-7}	NA	NA	NA
	Total Risk	1.0×10^{-2}	3.0×10^{-2}	2.0×10^{-3}	2.0×10^{-6}	NA	NA	NA
Current Land Use with Access Control/Current Source Term Scenario	Radiological-Nuclide Specific	3.0×10^{-5}	NA	1.0×10^{-5}	1.0×10^{-7}	NA	NA	NA
	Radiological-External	5.0×10^{-3}	NA	NA	NA	NA	NA	NA
	Chemical Risk	1.0×10^{-5}	NA	1.0×10^{-4}	1.0×10^{-7}	NA	NA	NA
	Total Risk	5.0×10^{-3}	NA	1.0×10^{-4}	2.0×10^{-7}	NA	NA	NA
Future Land Use/Current Source Term Scenario	Radiological-Nuclide Specific	NA	NA	1.0×10^{-5}	1.0×10^{-7}	2.0×10^{-4}	3.0×10^{-3}	3.0×10^{-4}
	Radiological-External	NA	NA	NA	NA	2.0×10^{-4}	2.0×10^{-3}	9.0×10^{-3}
	Chemical Risk	NA	NA	1.0×10^{-4}	1.0×10^{-7}	5.0×10^{-3}	8.0×10^{-2}	5.0×10^{-2}
	Total Risk	NA	NA	1.0×10^{-4}	2.0×10^{-7}	5.0×10^{-3}	9.0×10^{-2}	6.0×10^{-2}
Future Land Use/ Future Source Term Scenario	Radiological-Nuclide Specific	NA	NA	2.0×10^{-5}	1.0×10^{-6}	1.0×10^{-1}	1.0×10^{0}	1.0×10^{-1}
	Chemical Risk	NA	NA	2.0×10^{-4}	7.0×10^{-7}	1.0×10^{-2}	2.0×10^{-1}	9.0×10^{-2}
	Total Risk	NA	NA	2.0×10^{-3}	2.0×10^{-6}	1.0×10^{-1}	>1.0	2.0×10^{-1}

[a]The ILCR values were identical for the future land use/future source term scenario evaluated for either the Great Miami Aquifer or for perched water.
[b]The ILCR result from exposure to radionuclides from air, water, (ground and surface), soil and sediment as detailed in Attachment II of Appendix D and summarized in tables within Section D.5.
[c]NA signifies not applicable.
[d]This risk results from exposure to direct external radiation from large sources (Silos 1, 2, and 3) and are presented in Table D.5-2. It does not include exposure to external radiation emanating from radionuclides in surface soils. These later risk are accounted for in the nuclide-specific ILCR.

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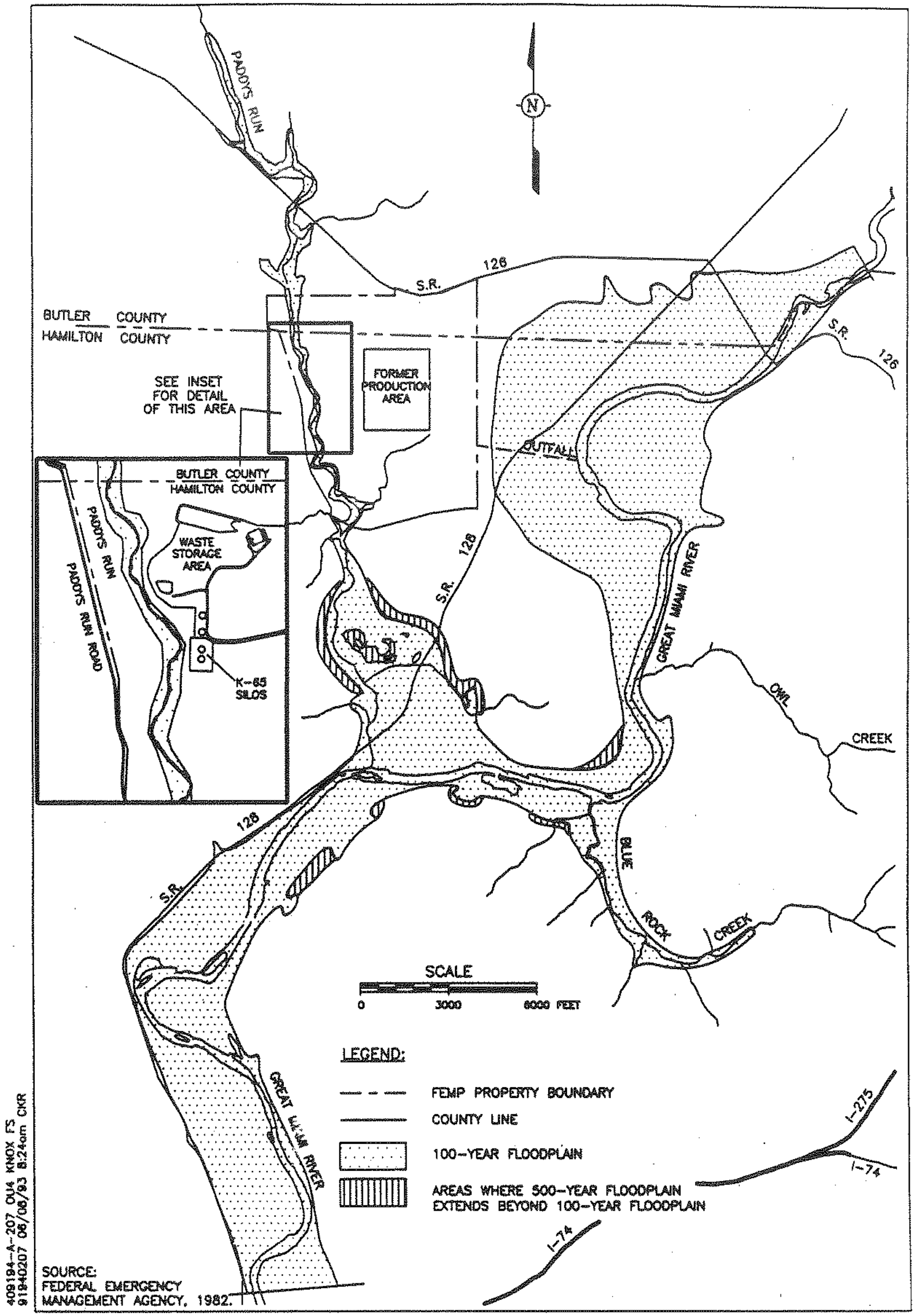

FIGURE 1-6. GREAT MIAMI RIVER AND PADDYS RUN 100-YEAR AND 500-YEAR FLOODPLAIN

TABLE 6-7

HAZARD INDEX SUMMARY ALL SOURCES/ALL PATHWAYS

Land Use/ Source Term Scenario	Type of Risk	Trespassing Child	Grounds Keeper	Off-Property Resident Farmer	Off-Property User of Surface Water	CT On-Property Resident Farmer	RME On-Property Resident Farmer[a]	On-Property Resident Child
Current Land Use without Access Control/Current Source Term Scenario	Chemical Hazard Index	0.3	0.1	0.05	0.0004	NA[b]	NA	NA
Current Land Use without Access Control/Future Source Term Scenario	Chemical Hazard Index	20	20	5	0.002	NA	NA	NA
Current Land Use with Access Control/Current Source Term Scenario	Chemical Hazard Index	0.3	NA	0.05	0.0004	NA	NA	NA
Future Land Use/Current Source Term Scenario	Chemical Hazard Index	NA	NA	0.05	0.0004	8	20	100
Future Land Use/Future Source Term Scenario	Chemical Hazard Index	NA	NA	5	0.002	300	500	2000

[a]The HI (500) was identical for the future land use/future source-term scenario.
[b]NA signifies not applicable.

6.1.4.2 Current Land Use Without Access Control/Future Source-Term Scenario

The receptor with the greatest total radiological risk is the groundskeeper (Table 6-6). The greatest contribution under this scenario is from exposure to soil pathways (2 x 10^{-2}). The total radiological risk to the groundskeeper under this scenario is 3 x 10^{-2} (Table 6-6). The receptor with the greatest total chemical risk is also the groundskeeper (Table 6-6). The greatest contribution is from exposure to soil pathways (5 x 10^{-4}). The total chemical risk to the groundskeeper under this scenario is 6 x 10^{-4}. The total radiological plus chemical risk to the groundskeeper under this scenario is 3 x 10^{-2} (Table 6-6). The greatest HI is 20 to the groundskeeper (Table 6-7) and to the trespassing child (Table 6-6). The greatest contribution to both receptors under this scenario is from exposure to air pathways.

6.1.4.3 Current Land Use With Access Control/Current Source-Term Scenario

This scenario most closely approximates current conditions at the FEMP site. However, the risk and HI results for this scenario are numerically the same as the results for the current land-use scenario without access controls assuming the current source term (Section 6.1.4.1). This is because the presence or absence of access controls does not change the numerical values of exposure parameter values for receptors. The trespassing child's exposure parameter values reflect the standard scenario specified by the EPA. Also, the off-property resident farmer, and surface water user exposures are not impacted by the status of access controls.

6.1.4.4 Future Land Use/Current Source-Term Scenario

The receptor with the greatest total radiological risk is the on-property resident child (Table 6-6). The greatest contribution under this scenario is from exposure to external radiation while the receptor is on top of the Silo 1 or 2 dome (9 x 10^{-3}). In addition, the receptor is exposed to air, soil, and surface water pathways resulting in a radiological risk of 3 x 10^{-4}, primarily from the soil pathway (2 x 10^{-4}). The total radiological risk to the on-property resident child is 9 x 10^{-3} plus 3 x 10^{-4} totalling 9 x 10^{-3}. The receptor with the greatest total chemical risk (8 x 10^{-2}) is the RME on-property resident farmer (Table 6-6). The greatest contribution under this scenario is from exposure to soil pathways (8 x 10^{-2}). The receptor with the greatest total radiological plus chemical risk under this scenario (9 x 10^{-2}, Table 6-6) is the RME on-property resident farmer. The greatest HI is 100 to the on-property resident child (Table 6-7). The greatest contribution to chemical hazard under this scenario is from soil exposure pathways (100).

6.1.4.5 Future Land Use/Future Source-Term Scenario

This represents the most conservative scenario considered under the baseline risk assessment. Within this scenario, a family is assumed to have established a residence within the Operable Unit 4 boundaries. Additionally, the domes of Silos 1 and 2 are assumed to have failed and Silo 3 is assumed to have suffered total structural failure, spreading its contents to the surface of Operable Unit 4. As described in Section D.3 of the RI Report for Operable Unit 4, the failure of Silo 3 and the assumed distribution of its contents on the surrounding surface makes it more appropriate to evaluate direct external exposure in a nuclide- specific manner rather than as a large source. With the failure of the domes of Silos 1 and 2 it is no longer appropriate to evaluate direct external radiation exposure at these locations. Therefore, the separate entry in Table 6-6 for external radiation does not appear for the future source-term scenario.

The receptor with the greatest total radiological risk is the RME on-property resident farmer (Table 6-6). The greatest contribution under this scenario is from exposure to soil pathways (approaching unity risk). The total radiological risk to the RME on-property resident farmer under this scenario also approaches unity (1) risk. The receptor with the greatest total chemical risk is also the RME on-property resident farmer (Table 6-6). The greatest contribution is from exposure to soil pathways (2×10^{-1}). The total chemical risk to the RME on-property resident farmer under this scenario is 2×10^{-1}. The total radiological plus chemical risk to the RME on-property resident farmer under this scenario exceeds unity (Table 6-6). The greatest HI is 2000 to the on-property resident child (Table 6-7). The greatest contribution to this receptor under this scenario is from exposure to soil pathways.

6.1.5 Risk Assessment Uncertainties

The uncertainties inherent in the risk assessment process are presented in detail in Section D.6.0 of Appendix D of the RI Report for Operable Unit 4. These uncertainties are summarized below to enable a better understanding of their impacts on the foregoing risk assessment.

Uncertainty is a factor in each step of the exposure and toxicity assessment process. Such uncertainty can involve variations in sample analytical results, the values of variables used as input to a given model, the accuracy with which the model itself represents actual environmental or biological processes, the manner in which the exposure scenario is developed, and the high-to-low dose and interspecies extrapolations for dose-response relationships.

Generally, risk assessments carry two types of uncertainty. First, measurement uncertainty refers to the usual variance that accompanies scientific measurements (such as the range of an exposure estimate) and reflects the accumulated variances of the individual measured values used to develop the estimate. The second form of uncertainty is due to the absence of information needed to complete the database for the assessment. In some instances, the impact is significant, such as the absence of information on the adverse effects or the biological mechanism of action of a chemical agent.

6.1.5.1 Sources of Uncertainty

As noted previously, uncertainties are associated with the information and data used in each phase of the Operable Unit 4 baseline risk assessment. The first source of uncertainty arises from data gaps or limitations in the data. For example, the data set for soil is limited, and virtually nothing is known regarding contaminants in the area of the former Drum-Handling Building. These limitations could result in failure to identify some COCs which may result in underestimating risk. (This data limitation and its expected impact on the baseline risk assessment is further discussed in greater detail in Section 7.5 of the RI Report for Operable Unit 4).

Other sources of uncertainty include the conservative bias of parameters, parameter variability (random errors or natural variations), and the necessity of using computer models to predict complex environmental interactions. Uncertainties also arise from the use of animal data to predict the toxic effects and the toxic potency in humans. Uncertainties associated with information and data are evaluated below to provide the spectrum of information in regard to the overall quality of the risk assessment results. The uncertainties are associated with exposure route selection, selection of COCs, exposure point concentrations, and exposure factors.

6.1.5.2 Toxicity Assessment

Considerable uncertainty is associated with the qualitative (hazard assessment) and quantitative (dose-response) evaluations of a Superfund risk assessment. A hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will induce adverse effects in humans. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using either the International Agency for Research on Cancer (IARC) (1987) or EPA (1986) schemes. Positive cancer test data in experimental animals suggest that a human exposed to the same agent may suffer adverse effects. However, animal data, may not accurately predict the same response or the same target organ tissue for cancer in humans. Also, biochemical repair mechanisms present in humans may inhibit or preclude an identical response. Accordingly the uncertainty of possible effects is significant. In assessing noncancer effects, however, positive experimental animal data from well designed studies in appropriate models suggest both the target tissues and type of effects that may be anticipated in humans (EPA 1989a).

6.2 OVERVIEW OF THE BASELINE ECOLOGICAL RISK ASSESSMENT

The purpose of the ecological risk assessment, which was completed as a companion to the preliminary site-wide baseline risk assessment in the Site-Wide Characterization Report (SWCR), was to estimate the potential and future baseline risks of FEMP contaminants to ecological receptors.

The EPA and DOE have agreed in the Amended Consent Agreement (September 1991) that the Site-Wide Ecological Risk Assessment will be performed as part of the RI for Operable Unit 5. The Site-Wide Ecological Risk Assessment in the RI for Operable Unit 5 will quantify and assess the possible risks from current concentrations of site contaminants to ecological receptors inhabiting on-property and off-site areas not presently targeted for remediation based on human-health concerns. More discussion on the Risk Assessment and Ecological Risk issues specific to Operable Unit 4 can be found in the Operable Unit 4 Proposed Plan.

The ecological receptors potentially exposed to FEMP contaminants include all organisms, exclusive of humans and domestic animals. The ecological risk assessment focused on a group of indicator species selected to represent a variety of exposure pathways and trophic positions. Terrestrial vegetation was represented by a generic plant species. Terrestrial wildlife species to be evaluated were selected based on species abundance on the FEMP site, trophic level position, and habitat requirements. The species evaluated were the white-tailed deer (*Odocoileus virginianus*), white-footed mouse (*Peromyscus leucopus*), raccoon (*Procyon lotor*), red fox (*Vulpes fulva*), muskrat (*Ondatra zibethica*), American robin (*Turdus migratorius*), and red-tailed hawk (*Buesto jamaicensis*).

The assessment examined risks to terrestrial organisms associated with contaminants in two environmental media -- surface soils, summarized for the entire site, and surface water in Paddys Run from the northern boundary of the FEMP site to the confluence with the storm sewer outfall ditch. Risks to aquatic organisms were evaluated for exposure to contaminants in Paddys Run, the Great Miami River, and in runoff into the storm sewer outfall ditch. All nonradioactive and radioactive constituents of greatest human health risk were considered to be of concern for the ecological risk assessment. Estimated ecological risks associated with exposure to FEMP site COCs are primarily due to nonradioactive inorganic chemicals in soils, rather than to organic chemicals or radionuclides. This is true for both terrestrial and aquatic organisms and for plants as well as wildlife. In particular, estimated intakes of arsenic, cobalt, lead, and silver from FEMP soils were all higher than the estimated No Observed Effect Levels (NOELs) for at least six of the seven indicator species selected for this assessment. The relative hazards to individual species varied, but the white-footed mouse consistently had the highest indices of these chemicals. This can be attributed to the assumed intake by the mouse of insects (using earthworms as surrogates), which in turn were assumed to assimilate chemicals from soil with a transfer coefficient of 1.0.

Estimated hazards to terrestrial organisms of exposure to COCs in FEMP surface waters were relatively low, with HIs greater than one only for arsenic, lead, molybdenum, and silver. These chemicals presented hazards of two, five, four and three to species, respectively, and the highest HI estimated was for lead intake by the mouse.

Estimated doses to terrestrial organisms at the FEMP site, originating from soil uptake by plants and earthworms, were below levels expected to cause detectable effects. However, as with inorganic chemicals, this conclusion is sensitive to assumptions about muscle-to-muscle transfer of radionuclides. If perfect transfer or biomagnification of uranium occurs (i.e., transfer factor equals 1.0), it could expose terrestrial wildlife at the FEMP to potentially harmful radiation levels. However, if more realistic muscle-to-muscle transfer coefficient were assumed (i.e., 0.1), the estimated radiation doses would fall below the range likely to result in harmful effects. Radiation doses due to water intake were insignificant.

Exposure to radiological contaminants does not appear to pose a significant risk to aquatic organisms at the measured concentrations in the surface waters and sediments impacted by the FEMP site. However, modeled concentrations of radionuclides in runoff from the FEMP site into surface water would cause estimated exposures to exceed the upper limit of 1 rad/day. A chronic dose rate of 1 rad/day or 3.65 x 10^{-5} mrad/year or less to the maximally exposed member of a population of aquatic organisms would ensure that there were no deleterious effects from radiation on the population. The most affected organisms would be aquatic plants, receiving a total dose from internal and external exposure of about 140 rad/day. The total dose to fish is minimally over the limit, at 1.6 rad/day, and the total dose to benthic macroinvertebrates is about 14 rad/day. The maximum concentrations calculated in the storm sewer outfall ditch were used in source runoff calculations. Doses to aquatic organisms in the storm sewer outfall ditch may exceed the limit of 1 rad/day. Doses in Paddys Run and the Great Miami River would be lower than that indicated in the storm sewer outfall ditch and would be well below 1 rad/day. The measured concentrations of cadmium in Paddys Run and the Great Miami River, copper in the Great Miami River, mercury in Paddys Run, the Great Miami River, and the storm sewer outfall ditch, and silver in Paddys Run water exceeded chronic toxicity criteria for the protection of freshwater organisms.

Field studies on the impact of the FEMP site on terrestrial and aquatic communities do not indicate any effects consistent with contaminant impacts except for above-background levels of arsenic and mercury recorded in RI/FS plant samples. In addition, although potential impacts at the individual level were predicted for wildlife species, detrimental or adverse impacts have not been observed in the field. This suggests that the potential exposures predicted by modeling may not occur in the field or that the resulting potential effects as a result of exposures may not occur. A comparison of the concentrations of inorganic chemical concentrations in FEMP soils to regional background values indicate the mean FEMP concentrations may be similar to the upper 95 percent confidence levels of background values. This indication suggests that ecological risks estimated using background values of inorganics would be comparable to those estimated for the FEMP site, and emphasizes the conservative nature of the method used.

In summary, although radionuclides are the most ubiquitous contaminants at the FEMP, estimated ecological risks to both terrestrial and aquatic organisms are primarily associated with nonradioactive inorganic chemicals. Although estimated risks are substantial in some instances, they are based on soil inorganic chemical concentrations comparable to background levels, and deleterious effects have not been observed in the field. This suggests that current FEMP site-specific ecological risks are low. However, remedial actions are appropriate to address contaminants which have potential to cause harm in the future.

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7.0 DESCRIPTION OF REMEDIAL ALTERNATIVES

As previously discussed in Section 5.0, the waste materials within Operable Unit 4 exhibit a wide range of properties. Most notable would be the elevated direct radiation associated with the moist to wet Silos 1 and 2 residues versus the much lower direct radiation associated with the dry, powdery cold metal oxides in Silo 3. Even more significant would be the much lower levels of contamination associated with the soils and building materials, like concrete, within the Operable Unit 4 Study Area. To account for these differences and for the varied cleanup alternatives applying to each type of waste, Operable Unit 4 was segmented into three subunits. These subunits, which are listed below, were used through the detailed evaluation of alternatives and the identification of the preferred alternative.

Subunit A: Silos 1 and 2 (K-65 residues and bentonite clay) and the sludge in the decant sump tank

Subunit B: Silo 3 (cold metal oxides)

Subunit C: Silos 1, 2, 3, and 4 structures; contaminated soils within the Operable Unit 4 boundary including surface and subsurface soils and the earthen berm around Silos 1 and 2; the decant sump tank; the radon treatment system; the concrete pipe trench and the miscellaneous concrete structures within Operable Unit 4, any debris (i.e., concrete, piping, etc.,) generated through implementing cleanup for Subunits A and B, and any perched groundwater encountered during remedial activities.

With the exception of Alternatives 2A/Vit and 2A/Cem (see Section 11 for details) the remedial alternatives, which went through detailed analysis during the FS for Operable Unit 4, are summarized below. The discussions presented here are based on the information used for detailed analysis of alternatives during the FS. Actual methods used during the implementation of the selected alternative(s) will be determined during detail engineering design described in the remedial design and may differ from the descriptions provided below.

Section 121 of CERCLA requires that remedial actions be protective of human health and the environment, and a level or standard of control that is consistent with federal or state environmental laws or state facility siting regulations, which are termed applicable or relevant and appropriate requirements (ARARs). ARARs pertain to all aspects of a remedial action, including the establishment of cleanup levels, the operation and performance of treatment systems, and the design of disposal facilities.

The baseline risk assessment performed as part of the RI Report for Operable Unit 4, quantified the health risks to hypothetical human receptors due to exposure from chemical and radiological sources in Operable Unit 4 under the no-action alternative. A summary of the risk assessment and results is presented in Section 6.0. Essentially, the results emphasize the need to effectively complete the selected remedial actions at Operable Unit 4 in order to ensure overall protection of human health and the environment.

Potential remedial alternatives were developed and evaluated in the FS Report for Operable Unit 4 as to how these risks would be eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. Both long-term and short-term risks associated with implementing an alternative were considered in determining whether a given alternative was protective. Each alternative evaluated provides a description of its overall effectiveness in reducing risks to human health and the environment.

ARARs consist of two sets of requirements, those that are applicable and those that are relevant and appropriate. Applicable requirements are those substantive standards that specifically address a situation at a CERCLA site. Relevant and appropriate requirements are standards that address problems sufficiently similar to the situation at a CERCLA site that their use is well suited to the site. In certain cases, standards may not exist in the promulgated regulation that address the proposed action or the constituents of concern. In these cases, non-promulgated advisories, criteria, or guidance that were developed by the EPA, other federal agencies, or states are to be considered (TBC) in establishing remedial action objectives that are protective of human health and the environment.

A detailed discussion of all ARARs and TBC criteria associated with the remedial alternatives being evaluated for Operable Unit 4 is presented in Appendix F of the FS Report for Operable Unit 4. From these detailed lists, certain major ARARs and TBCs were selected based on their importance in protecting human health and the environment. These include those associated with the protection of drinking water sources, the control of radionuclide emissions, the design and siting of a solid waste disposal facility, the management of RCRA hazardous waste, and compliance with NEPA.
The major ARARs associated with the remedial alternatives evaluated in this section, with the exception of the no action alternatives, are presented in Appendix A of this ROD. These major ARARs are segregated into three types:

(a) Chemical-specific ARARs are usually health- or risk-derived numerical values or methodologies that establish an acceptable level or concentration of chemical or radionuclide that may remain in specific environmental media after remediation is complete. These levels are deemed to be protective of human health and are used to help establish remedial cleanup goals.

(b) Location-specific ARARs generally restrict certain activities or dictate where certain activities may be conducted, solely because of geographical, hydrologic, hydrogeologic, or land use concerns.

(c) Action-specific ARARs are usually technology or activity based requirements or restrictions on the conduct of certain activities or the operation of certain technologies at the site.

Appendix A identifies all remedial alternatives evaluated along with their major regulatory requirements, the rationale for designation of each regulatory requirement as an ARAR/TBC, and the mechanism by which the remedial alternative will comply with the requirement.

7.1 NO-ACTION ALTERNATIVE FOR ALL SUBUNITS

The No-Action Alternative for Subunits A, B, and C is presented to provide a baseline for comparison with the other alternatives per the President's Council on Environmental Quality and 40 CFR Part 300, the National Oil and Hazardous Substances Pollution Contingency Plan regulations. Under the No-Action Alternatives, designated as 0A, 0B, and 0C for each of the three subunits, the contaminated and/or uncontaminated materials within each subunit would remain unchanged without any further waste removal, treatment, or containment activities.

Alternatives 0A, 0B, and 0C do not provide for the monitoring of soil, groundwater, or radon emissions from the Operable Unit 4 facilities or soils, and do not provide for access controls (e.g., physical barriers and deed restrictions) to reduce the potential for exposure to any human or ecological receptors. The No-Action Alternatives would not decrease the toxicity, mobility, or volume of contaminants or reduce public health or environmental risks. Also, goals for protecting the underlying groundwater aquifer would not be met. No costs are associated with the No-Action Alternative.

ARAR Compliance for No-Action Alternatives

Alternatives 0A, 0B, and 0C would not comply with a number of chemical-specific, location-specific, or action-specific ARARs. Under the no-action alternatives, Silos 1, 2, and 3 would eventually fail, resulting in the release of silo contents to the air, soil, groundwater, and surface water. Fate and transport modeling indicates that uranium and gross alpha and beta radiation would exceed safe drinking water limits under 40 CFR §141. In addition, localized "hot spots" could exceed the limits established in 40 CFR §192.12.

7.2 SUBUNIT A - CONTENTS OF SILOS 1 AND 2 AND THE DECANT SUMP TANK

With the exception of Alternatives 2A/Vit and 2A/Cem (see Section 11 for details) this section presents the alternatives which were evaluated for Subunit A during the detailed analysis of alternatives phase of the FS for Operable Unit 4. These alternatives focus on the remediation of the K-65 residues contained in Silos 1 and 2 and the sludges in the decant sump tank.

All of the alternatives would provide overall protection of human health (assuming continued federal government control) and the environment by eliminating, reducing, or controlling risk through treatment, engineering controls, or institutional controls. The selected remedy (3A.1/Vit) would provide greater certainty for overall protection than other alternatives because the Subunit A residues would be vitrified and removed to the NTS to reduce the potential for contaminant migration to human and ecological receptors. The source of unacceptable risks to the Operable Unit 4 expanded trespasser and off-site farmer would be eliminated, and in the event that the government lost control of the FEMP site, there would be no risk from Subunit A residues to an on-property farmer.

Overall protection at the NTS would be maintained because the vitrified residues resist leaching and the NTS is located in a climatic, demographic, and hydrogeologic setting which favors minimization of contaminant migration to both human and environmental receptors.

7.2.1 Alternative 3A.1/Vit - Removal, Vitrification, and Off-Site Disposal - Nevada Test Site

Capital Cost:	$38.3 Million (M)
O&M Costs:	
During Remediation:	$11.7 M
Post-Remediation:	$0
Present Worth:	$43.7 M
Years to Implement:	6

This alternative involves the removal, vitrification, and off-site disposal of the treated Silos 1 and 2 contents and decant sump tank sludge. Treated material would be transported by rail, then truck, to the NTS, a DOE-owned facility that currently accepts low-level radioactive material from DOE facilities for disposal. Under Alternative 3A.1/Vit, approximately 6,796 m^3 (8,890 yd^3) of untreated residues would be removed from Silos 1 and 2 and combined with approximately 3,785 Liters (L) (1,000 gallons) of sludge from the decant sump tank and treated. Approximately 2,770 m^3 (3,623 yd^3) of vitrified material would be packaged in containers and transported to the NTS for disposal. Disposal of contaminated materials from the berms, Silos 1 and 2 structures, the material removal equipment, and the vitrification system would be managed under the selected alternative for Subunit C. No five-year CERCLA reviews would be required under this alternative since no Subunit A residue material would remain at the FEMP. The components of this alternative not previously described are as follows.

Material Removal

Silos 1 and 2 residues and decant sump tank sludge would be slurried and pumped to the vitrification plant for processing. During the material removal phase, Silos 1 and 2 and the decant sump tank would be equipped with an off-gas handling system to treat radon and other potential airborne contaminants. This off-gas handling system would be operational during material removal and before personnel enter the area above the silo domes to reposition material removal equipment and conduct repairs or maintenance. The off-gas handling system and operating procedures would be designed as necessary to minimize exposure to personnel located over the work areas and to prevent the escape of radon and radioactive particulates from the silos and the decant sump tank to the atmosphere.

Material Stabilization

Silos 1 and 2 residues and decant sump tank sludge would be combined with glass forming agents, processed in a high temperature furnace, and converted into a stable vitrified glass form exhibiting excellent durability and constituent leaching characteristics. It should be noted that current planning focuses upon pouring the molten glass directly into containers capable of withstanding the high temperature of the vitrified waste form. The final waste form would continue to be optimized in pilot plant treatability studies and final decision regarding the final waste form would be reached during the pilot plant treatability studies. Process tanks/vessels and piping containing slurried K-65 residues would be designed to minimize potential radon and particulate emissions to the atmosphere during treatment. The direct radiation associated with the treated residues would remain relatively unchanged from the untreated form of the K-65 residues.

Interim Storage

The containerized vitrified product will require interim storage at the FEMP prior to its transportation to the NTS for disposal. The purpose of this interim storage is two-fold; first, the vitrified product will require verification sampling in order to certify that each production lot has met specific performance and waste disposal criteria; and second, to provide the Fernald waste shipping program a buffer staging area where the material can be safely managed prior to its shipment to NTS in accordance with DOE ALARA principles, ARARs identified and included in the Operable Unit 4 ROD, as well as in a manner protective of human health and the environment. It has been anticipated that the interim storage area will be needed to accommodate the interim handling of approximately 90 days of vitrification production.

Disposal of Treated Material

Off-site disposal for this alternative involves the packaging, loading, and shipping of the treated material, in accordance with all required United States Department of Transportation (DOT) specification regulations, to the low-level radioactive waste disposal site at the NTS, a DOE-owned facility that currently accepts low level radioactive material from DOE facilities for disposal. Shipment of the treated material to the NTS would be performed by rail and/or truck transportation from the FEMP site. Currently, there are no direct rail lines into the NTS. The treated material would be transported by rail to either a point near Las Vegas, Nevada, or one of the areas north of Las Vegas. From either location, the containers carrying the treated material would be transferred to trucks for transportation over roads to the NTS.

The NTS is located approximately 3,219 kilometers (km) [2,000 miles (mi)] from the FEMP site. Because the vitrified residues resist leaching and the NTS is located in a sparsely populated, arid region, where depths to groundwater are at least 235 m (771 ft) below the surface, disposal at the NTS would be very effective at precluding human contact with and contaminant migration from the treated residues from Subunit A. The FEMP site has an approved NTS waste shipment and certification program that is periodically audited by the NTS. Efforts have been initiated to amend the current program to include Operable Unit 4 treated material. All the NTS waste acceptance requirements would need to be satisfied prior to any shipment of the Operable Unit 4 treated material to the NTS.

Implementation Time and Costs

Remedial action activities under Alternative 3A.1/Vit could be completed in approximately six years. Approximately three years is projected for completion of site preparation, facilities construction, and equipment installation. Material removal and treatment activities would require about three years. Transportation and off-site disposal would conclude shortly after the completion of material processing. Capital costs for Alternative 3A.1/Vit are estimated to be 38.3 million dollars. O&M costs during remediation are estimated at 11.7 million dollars over three years. Due to the off-site disposal option, there are no post-remediation O&M costs associated with this alternative. The total present worth cost for this alternative is estimated at 43.7 million dollars.

7.2.2 Alternative 3A.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal - NTS

Capital Cost:	$71.8 M
O&M Costs:	
During Remediation:	$11.7 M
Post-Remediation	$0
Present Worth:	$73.1 M
Years to Implement:	6

This alternative is identical to Alternative 3A.1/Vit except that the vitrification of the Silos 1 and 2 contents and decant sump tank sludge have been replaced by cement stabilization. Treated material and debris would be transported by rail, then truck to the NTS. Under Alternative 3A.1/Cem, approximately 6,796 m^3 (8,890 yd^3) of untreated materials would be removed from Silos 1 and 2, combined with approximately 3,785 L (1,000 gallons) of sludge from the decant sump tank, and treated. Approximately 18,166 m^3 (23,760 yd^3) of cement stabilized product would be packaged in containers and transported to NTS for disposal. Disposal of contaminated materials from the berms, Silos 1 and 2 structures, the material removal equipment, and the cement stabilization system would be managed under the selected alternative for Subunit C. No five-year CERCLA reviews would be required since all Subunit A materials would be removed from the site. The components of this alternative not previously described under alternative 3A.1/Vit are as follows.

Material Stabilization

Silos 1 and 2 residues and the decant sump tank sludge would be combined with cement and other additives necessary for stabilizing the materials into a cement form. Similar to Alternative 3A.1/Vit, process tanks/vessels and piping containing slurried K-65 residues would be designed to minimize potential radon and radionuclide particulate emissions to the atmosphere during treatment. Studies conducted on a small scale in a laboratory, as part of the Operable Unit 4 RI/FS, indicate that an estimated 150 percent increase can be expected in the volume of waste requiring disposal following stabilization. This increase is a result of the large volume of additives needed to effectively stabilize the silo residues and decant sump tank sludge in cement. These studies have also concluded that the cement stabilization of the wastes does not effectively reduce the radon emission rate from the waste and the tendency of the waste to leach contaminants into groundwater. The direct radiation associated with the untreated residues would be slightly reduced due to the effects of mixing the additives with the residues. The solidified materials would be packaged in containers for disposal.

Implementation Time and Costs

Remedial action activities under Alternative 3A.1/Cem could be completed in about six years. Approximately three years are projected for completion of site preparation, facilities construction, and equipment installation. Material removal and treatment activities would require about three years. Transportation and off-site disposal would conclude shortly after the completion of material processing. Capital costs for Alternative 3A.1/Cem are estimated to be 71.8 million dollars. O&M costs during remediation are estimated at 11.7 million dollars over three years. Due to the off-site disposal option, there are no post-remediation O&M costs associated with this alternative. The total present worth cost of this alternative is estimated at 73.1 million dollars.

7.3 SUBUNIT B - CONTENTS OF SILO 3

This section presents the alternatives which were evaluated for Subunit B during the detailed analysis of alternatives phase of the Operable Unit 4 FS. These alternatives focus on the remediation of the cold metal oxides contained in Silo 3.

As discussed in Section 6, this evaluation assumes that the federal government would continue to own the FEMP site. For a cleanup remedy to be considered protective, it should not result in any unacceptable risks to an Operable Unit 4 expanded trespasser or an off-site farmer.

All alternatives would provide overall protection of human health and the environment. These alternatives will eliminate, reduce, or control the health or environmental risks resulting from constituents in Subunit B materials. All of the action alternatives, except Alternative 4B, would limit exposure to contaminants by removing the material, treating the material by either vitrification or cement stabilization, and then disposing the treated material in an on-property above-grade disposal vault (Alternative 2B) or off site at NTS (Alternative 3B.1). Alternative 4B's protection is based on removal and disposal in an on-property above-grade vault, and by retaining institutional controls. Long-term effectiveness would be attained for each of these alternatives.

In summary, the preferred alternative (3B.1/Vit) would provide for overall protection because the Subunit B residues would be vitrified and removed to the NTS to reduce the potential for contaminant migration to human and ecological receptors.

7.3.1 Alternative 2B/Vit - Removal, Vitrification, and On-Property Disposal

Capital Cost:	$25.2 M
O&M Costs:	
During Remediation:	$4.9 M
Post-Remediation:	$3.2 M
Present Worth:	$28.0 M
Years to Implement:	4

This alternative requires the removal, vitrification, and on-property disposal of the Silo 3 contents. Under Alternative 2B/Vit, approximately 3,890 m^3 (5,088 yd^3) of untreated materials would be removed from Silo 3 and stabilized in a vitrified glass form. Following treatment, approximately 1,471 m^3 (1,924 yd^3) of vitrified material would be packaged in containers and placed in an on-property above-grade reinforced concrete disposal vault. The Silo 3 structural materials, associated soils, the material removal system and the vitrification system would be managed under the selected alternative for Subunit C. In accordance with CERCLA 121(c) requirements, after commencement of remedial activities, a review would be performed every five years by the EPA to ensure the continued protection of human health and the environment.

Material Removal

Due to the powder-like characteristics of Silo 3 cold metal oxide residues, Alternative 2B/Vit would utilize a pneumatic removal process to transport Silo 3 contents to the material processing facility. The pneumatic removal system consists of a compressed air-driven pump that displaces and removes the dry wastes. Air entrained in the cold metal oxides, suctioned from Silo 3, would be separated using filter/receiver systems allowing the cold metal oxides to be pneumatically "pushed" to the vitrification facility. A glove box system will be used at the interface of the pneumatic removal system and the silo dome to function as secondary containment. This arrangement, along with appropriate operations procedures, would be designed to prevent releases to the atmosphere during operations.

Material Stabilization

The vitrification process is identical to that described in Section 7.2.1 for Alternative 3A.1/Vit. Bench-scale studies conducted in a laboratory as part of the RI/FS for Operable Unit 4 indicate that vitrification can effectively reduce the tendency of the Silo 3 residues to leach inorganics and radionuclides to groundwater. This testing also demonstrated that over a 50 percent reduction in the volume of material requiring disposal could be achieved through the application of vitrification technology to the Silo 3 residues. The vitrified residues would be packaged in containers for disposal.

Disposal of Treated Material

Studies completed on a bench-scale as part of the RI/FS project that the volume of material requiring disposal can be reduced by over 50 percent as a result of applying the vitrification process. The vitrified material would be containerized and disposed in an above-grade reinforced concrete disposal vault located on property. The vault would be constructed on a reinforced concrete mat and equipped with a leachate collection/detection system to facilitate the collection of any contaminated leachate after final closure. The capping system would be composed of alternating composite soil liners and drainage layers to minimize the potential release of contaminated leachate to the underlying Great Miami Aquifer. The proposed disposal facility would be located at a suitable location of the FEMP site.

Final closure would be completed by the construction of a multimedia cap over the vault. This cap would include a clay cover to eliminate radon emanation from the disposed materials to the atmosphere and a barrier to preclude intrusion by burrowing animals and hypothetical future residents of the area. Upon completion of the multimedia cap, security controls such as fencing would be installed. Monitoring wells would be appropriately located to evaluate the effectiveness of the above-grade disposal vault in ensuring long-term protection of human health and the environment.

To provide added assurance against any future activities by humans to intrude into the disposal vault, permanent markers would be installed to identify the vault, and restrictions would be placed on the site. Additionally, in order to ensure long-term protectiveness for this alternative, it is assumed that the effected disposal areas at the FEMP would require the continued ownership by the federal government. While the disposal vault would be designed to not require any continued active operations or maintenance, long-term ownership would permit the government to continue to exercise the right to preclude any development or drilling in areas where contaminated materials are disposed.

All facilities and equipment installed and used by this alternative would be disassembled and decontaminated during the post-remediation phase. Contaminated materials would be disposed in accordance with the selected remedy for Subunit C.

Implementation Time and Costs

Remedial action activities under Alternative 2B/Vit could be completed in about four years. Site preparation and construction activities would take approximately three years. Removal and material processing activities would require about one year. Capital costs for Alternative 2B/Vit are estimated to be 25.2 million dollars. O&M costs during remediation are estimated at 4.9 million dollars over one year, while post-remediation O&M costs are estimated at 3.2 million dollars over a thirty year period. The total present worth cost for this alternative is estimated at 28.0 million dollars.

7.3.2 Alternative 2B/Cem - Removal, Cement Stabilization, and On-Property Disposal

Capital Cost:	$35.9 M
O&M Costs:	
During Remediation:	$4.9 M
Post-Remediation:	$3.2 M
Present Worth:	$37.4 M
Years to Implement:	4

This alternative uses the material removal methodology presented in Alternative 2B/Vit, followed by treatment of the Silo 3 contents by cement stabilization and on-property disposal of the stabilized material. Under Alternative 2B/Cem, approximately 3,890 m^3 (5,088 yd^3) of untreated materials would be removed from Silo 3 and stabilized in a cement form. Approximately 5,999 m^3 (7,846 yd^3) of stabilized material would be packaged in containers and placed in an on-property above-grade reinforced concrete disposal vault. The Silo 3 structural materials, the material removal system, and the cement stabilization system and associated soils would be remediated with the selected alternative for Subunit C. In accordance with CERCLA 121(c) requirements, after commencement of remedial activities, a review would be performed every five years by the EPA to ensure the continued protection of human health and the environment. The components of this alternative not previously discussed are as follows.

Material Stabilization

The cement stabilization process is identical to that described in Section 7.2.2 for Alternative 3A.1/Cem with the exception of differences in the cement formulations required to accommodate physical and chemical differences between K-65 residues and Silo 3 cold metal oxides. The FS Report for Operable Unit 4, Appendix C, discusses the results of bench-scale treatability studies which indicate that cementation of the Silo 3 metal oxides would result in an approximately 50 percent increase in the volume of treated material requiring disposal.

Implementation Time and Costs

Remedial action activities under Alternative 2B/Cem could be completed in about four years. Site preparation and construction activities would take approximately three years. Removal and material processing activities would require about one year. Capital costs for Alternative 2B/Cem are estimated to be 35.9 million dollars. O&M costs during remediation are estimated at 4.9 million dollars over one year, while post-remediation O&M costs are estimated at 3.2 million dollars over a thirty year period. The total present worth cost for this alternative is estimated at 37.4 million dollars.

7.3.3 Alternative 3B.1/Vit - Removal, Vitrification, and Off-Site Disposal - NTS

Capital Cost:	$26.8 M
O&M Costs:	
During Remediation:	$4.9 M
Post-Remediation:	$0
Present Worth:	$28 M
Years to Implement:	4

This alternative involves the removal, stabilization, and off-site disposal of the Silo 3 contents. This alternative is identical to Alternative 2B/Vit, except the on-property disposal, monitoring, and institutional controls have been replaced by the transportation of the treated material by rail and/or truck to the NTS for disposal. Under Alternative 3B.1/Vit, approximately 3,890 m^3 (5,088 yd^3) of untreated materials would be removed from the silo. Approximately 1,471 m^3 (1,923 yd^3) of vitrified material would be packaged in containers and transported to NTS for disposal. Alternative 3B.1/Vit would have to meet applicable off-site requirements, which include the NTS material acceptance criteria and DOT regulations pertaining to the transport of hazardous and radioactive materials. No five-year reviews would be required since all Subunit B wastes would be removed from the site under this alternative.

Implementation Time and Costs

Remedial action activities under Alternative 3B.1/Vit could to be completed in about four years. Site preparation and construction activities would take approximately three years. Removal activities would require about one year. Transportation and off-site disposal would conclude shortly after the completion of material processing. Capital costs for Alternative 3B.1/Vit are estimated to be 26.8 million dollars. O&M costs during remediation are estimated at 4.9 million dollars over one year. Due to the off-site disposal option, there are no post-remediation O&M costs associated with this alternative. The total present worth cost of this alternative is estimated at 28 million dollars.

7.3.4 Alternative 3B.1/Cem - Removal, Cement Stabilization, and Off-Site Disposal - NTS

Capital Cost:	$36.8 M
O&M Costs:	
During Remediation:	$4.1 M
Post-Remediation:	$0
Present Worth:	$36 M
Years to Implement:	4

This alternative is identical to Alternative 3B.1/Vit (Section 7.3.3), except that Silo 3 contents would be stabilized in cement prior to off-site disposal at NTS as described for Alternative 2B/Cem (Section 7.3.2). Under Alternative 3B.1/Cem, approximately 3,890 m^3 (5,088 yd^3) of contaminated materials would be removed from Silo 3. Approximately 5,999 m^3 (7,846 yd^3) of stabilized material would be transported to NTS for disposal. No five-year reviews would be required since all Subunit B wastes would be removed from the site under this alternative.

Implementation Time and Costs

Remedial action activities under Alternative 3B.1/Cem could be completed in about four years. Site preparation and construction activities would take approximately three years. Removal activities would require about one year. Transportation and off-site disposal would conclude shortly after the completion of material processing. Capital costs for Alternative 3B.1/Cem are estimated to be 36.8 million dollars. O&M costs during remediation are estimated at 4.1 million dollars over one year.

Due to the off-site disposal option, there are no post-remediation O&M costs associated with this alternative. The total present worth cost of this alternative is estimated at 36 million dollars.

7.3.5 Alternative 4B - Removal and On-Property Disposal

Capital Cost:	$21.8 M
O&M Costs:	
During Remediation:	$1.1 M
Post-Remediation:	$3.2 M
Present Worth:	$22.0 M
Years to Implement:	2

This alternative requires removal of the Silo 3 contents, packaging, and on-property disposal of the untreated material. This alternative is identical to Alternative 2B, with the exception that it does not include treatment. Under Alternative 4B, approximately 3,890 m^3 (5,088 yd^3) of contaminated materials would be removed from Silo 3 and packaged in containers for disposal in an on-property above-grade reinforced concrete disposal vault. The Silo 3 structural materials, associated soils, and removal system would be managed under the Subunit C alternative. In accordance with CERCLA 121(c) requirements, after commencement of remedial activities, a review would be performed every five years by the EPA to ensure the continued protection of human health and the environment.

Implementation Time and Costs

Remedial action activities under Alternative 4B could be completed in about two years. Site preparation and construction activities would take approximately one year. Removal and packaging activities would require about one year. Capital costs for Alternative 4B are estimated to be 21.8 million dollars. O&M costs during remediation are estimated at 1.1 million dollars over one year. Post-remediation O&M costs are estimated to be 3.2 million dollars. The total present worth cost of this alternative is estimated at 22 million dollars.

7.4 SUBUNIT C - SILOS 1, 2, 3, AND 4 STRUCTURES, SOILS, AND DEBRIS

This section presents the alternatives which were evaluated for Subunit C during the detailed analysis of alternatives phase of the FS for Operable Unit 4. These alternatives focus on the remediation of Silos 1, 2, 3, and 4 structures, contaminated soils within the Operable Unit 4 boundary including surface and subsurface soils and the earthen berms around Silos 1 and 2, the existing Radon Treatment System (RTS), the K-65 Drum Handling Building pad, standing water within Silo 4 (if any), the decant sump tank, the process piping and trenches, and any rubble or debris [i.e., decontamination and decommissioning (D&D) of the treatment facility] generated consequential to the implementation of remedial actions for all Operable Unit 4 subunits. The volumes of soil, rubble, and debris to be generated under Subunit C are small in comparison to the volume of similar materials that will be generated by other FEMP operable units. All the Subunit C alternatives evaluated through detailed analysis consider integration of disposal activities with Operable Unit 3 and Operable Unit 5. These integration efforts allow waste minimization initiatives developed for Operable Units 3 and 5 to be integrated into the final remedy chosen for Subunit C materials.

As discussed in Section 6, evaluations were conducted for future land uses with and without continued federal ownership. For a cleanup remedy to be considered protective, it would not result in any unacceptable risks to an Operable Unit 4 expanded trespasser or an off-site farmer under the future land use with continued federal ownership scenario.

All of the evaluated alternatives would limit exposure to constituents by decontaminating, demolishing, and removing the material to either an on-property above-grade disposal facility or off-site disposal facility, and then excavating contaminated soils and placing clean fill over residual contaminated subsurface soils. The placement of the clean fill was not used as a measure to limit exposures but rather to restore the natural drainage patters and promote revegetation. Table 9-2 summarizes the proposed remedial levels for soils, all of which would be protective to the Operable Unit 4 expanded trespasser, trespassing child and off-site resident over the long-term. Short-term risks would be higher for off-site disposal due to the increased risk of transportation accidents. These action alternatives would be protective of all anticipated receptors assuming continued federal government ownership and control of the area; this includes the off-site farmer and the Operable Unit 4 expanded trespasser receptors.

The basic difference among the action alternatives is the disposal option. On-property disposal (Alternative 2C) would be in an above-grade disposal facility. Off-site disposal options include NTS (Alternative 3C.1) and a permitted commercial disposal site (Alternative 3C.2).

The on-property, above-grade disposal facility would be designed for a 1,000 year life with no active maintenance. Fate and transport modeling using conservative assumptions concludes that protectiveness would be maintained over the long-term.

NTS and the permitted commercial disposal facility would incorporate engineering controls to ensure protectiveness. Both are located in a climatic, demographic, and hydrogeologic setting which favors minimization of constituent migration to human or environmental receptors. Short-term risks to the public and workers are slightly greater for the off-site disposal options due to the increased risks of transportation accidents resulting in injuries or radiation exposure.

For all of the Subunit C alternatives, hazardous substances (i.e., contaminated soil or debris) will remain on site at levels which preclude unlimited use or unrestricted exposure. Therefore, in accordance with the requirements of CERCLA 121(c), all the Subunit C alternatives would require that a review be conducted every five years, after commencement of remediation to ensure that the alternative continues to provide adequate protection of human health and the environment.

7.4.1 Alternative 2C - Demolition, Removal, and On-Property Disposal

Capital Cost:	$36.3
O&M Costs:	
During Remediation:	$0
Post-Remediation:	$3.6 M
Present Worth:	$34.3 M
Years to Implement:	2

Alternative 2C involves the demolition of the Silos 1, 2, 3, and 4 structures and disposal of the materials from the removal of the earthen berm, decant sump tank, process piping, and trenches. Alternative 2C further addresses the excavation of contaminated subsurface soils within the operable unit boundary and disposal of the debris generated as a result of implementing remedial actions for Subunits A and B. Contaminated material would be placed in an above-grade disposal vault at the FEMP site. Under Alternative 2C, approximately 34,956 m^3 (45,748 yd^3) of material would be placed in an on-property above-grade disposal vault.

Demolition and Decontamination of the Silo Structures

Before Silos 1, 2, 3, and 4 are demolished, loose interior materials and concrete would be removed from the silo surfaces. Concrete exhibiting highly elevated direct radiation levels would be segregated from other Subunit C waste and dispositioned as part of the selected remedy for Subunit A. Silo demolition would consist of the systematic decontamination, removal, dismantling, and disposal of the Silos 1, 2, 3, and 4 domes, walls, floor slabs and footers. Removal would involve cutting each of the silo structures into manageable pieces after appropriate bracing has been installed. The demolition would begin with the dismantling of Silo 4, since this silo has never been used, making it an ideal full-scale model to test and confirm demolition methodologies with minimal risk of radiological release to the environment. Based on experience obtained through the dismantling of Silo 4, demolition of Silos 1, 2, and 3 would proceed according to the sequencing and procedures established during the remedial design and remedial action phases.

Demolition and Decontamination of Other Operable Unit 4 Structures

The existing RTS, Drum Handling Building pad, sump lift station foundation, concrete pipe trench, and the decant sump tank would also be removed and decontaminated. It is estimated that approximately 790 m (2,600 ft) of process piping in the process piping trenches would be cut into manageable sections and disposed. It is estimated that 280 m^3 (365 yd^3) of concrete from the trench, decant sump tank process piping, and existing RTS would be disposed. Additionally, all facilities constructed and equipment installed and used to implement the selected alternatives for Subunits A and B would be disassembled, decontaminated (if necessary), and either recycled, reused, or disposed.

Non-porous materials, such as steel fencing and structural steel, attaining the unrestricted use, free release criteria defined in DOE Order 5400.5 would be released from the site as uncontaminated. Materials not attaining these levels would be retained for disposal as contaminated waste consistent with the approved Operable Unit 3 Record of Decision.

Remediation of Soil

After the silos are demolished, the contaminated surface soils within the boundary of Operable Unit 4 would be excavated to attain proposed remediation levels for each of the constituents of concern. After the silos are demolished, the contaminated surface soils within the boundary of Operable Unit 4 would be excavated to attain proposed remediation levels, as described in Section 9.2.2 of this ROD, for each of the contaminants of concern. Attainment of these levels would be demonstrated applying regulatory guidance available at the time. The cleanup levels are considered protective of the hypothetical expanded trespasser receptor. To attain these goals, a minimum of 15 centimeters (cm) [6 inches (in)] of soils across the entire operable unit area would be excavated. Additional soils beneath the silos, decant sump tank, concrete pipe trench, or other locations below this depth would be removed as necessary to attain these cleanup goals.

Soils exhibiting highly elevated direct radiation levels (i.e., potentially contaminated soils beneath Silos 1 and 2) would be segregated from other Subunit C wastes and dispositioned as part of the selected remedy for Subunit A. Following excavation, the affected areas would be returned to original grade with the placement of clean backfill and seeded. The area would then be fenced and appropriate signs placed indicating no trespassing and no hunting. Continued federal ownership with appropriate deed restrictions would be implemented to ensure that any future transfer of property would be consistent with CERCLA 120(h).

Water Treatment

Wastewater generated as a result of this remedial action, along with water removed from the decant sump tank, Silo 4 (if any), and any perched groundwater encountered during remedial activities would be collected, pretreated if necessary, and sent to the FEMP Advanced Wastewater Treatment facility for treatment prior to discharge to the Great Miami River. In accordance with the Amended Consent Agreement, groundwater remediation will be handled by Operable Unit 5. Operable Unit 4 would only handle the cleanup of perched water encountered during remedial action activities.

Disposal of Soil, Debris, and Rubble

The volume of contaminated soil, rubble, and debris to be addressed under Operable Unit 4 represents a small fraction (less than one percent) of the total volume of similar wastes to be addressed under Operable Units 5 and 3. Operable Unit 3 is currently in the process of conducting a RI/FS which will include gaining additional insight into the effectiveness of various decontamination technologies on building materials. Additionally, the Operable Unit 3 RI/FS is evaluating the appropriate type and location of disposal for contaminated rubble and debris. The decision on the Operable Unit 3 RI/FS is presently scheduled at a time which coincides with the implementation of remedial actions for Operable Unit 4.

Contaminated soil and debris generated from the selected remedy for Operable Unit 4 will be placed into interim storage, if necessary, and final disposition of that material will be determined as part of the Record of Decision for Operable Units 5 and 3. Placing the Operable Unit 4 on-property disposal decision in abeyance permits an integrated site-wide (FEMP) disposal approach for soil and debris. In addition, Operable Unit 4 would be able to take advantage of any applicable waste minimization initiatives developed for soil and debris by Operable Units 5 and 3 respectively.

Implementation Time and Costs

Approximately three months would be required for site preparation; 15 months would be required to demolish and decontaminate the silo structures as well as the surface soil, berm soils, subsurface soils, process piping, and decant sump tank. Demobilization activities would extend the duration of the alternative to two years. During this time frame, the above-grade disposal facility would also be constructed and capped. Capital costs for Alternative 2C are estimated to be 36.3 million dollars. Post-remediation O&M costs are estimated to be 3.6 million dollars. The total present worth cost of this alternative is estimated at 34.3 million dollars.

7.4.2 Alternative 3C.1 - Demolition, Removal, and Off-Site Disposal - NTS

Capital Cost:	$83.6 M
O&M Costs:	$0
Present Worth:	$75.5 M
Years to Implement:	2

This alternative is identical to Alternative 2C, except that the on-property disposal, monitoring, and institutional controls have been replaced by packaging and off-site transportation of the material by rail or truck to the NTS for disposal. The off-site disposal option for Alternative 3C.1 involves the packaging, loading, and shipping of the material generated by this alternative to the NTS.

Implementation Time and Costs

Remedial actions for Alternative 3C.1 could require about two years to complete, including the transportation of the packaged materials to the NTS. Capital costs for Alternative 3C.1 are estimated to be 83.6 million dollars. Due to the off-site disposal aspect of this alternative, there are no O&M costs anticipated. The total present worth cost of this alternative is estimated at 75.5 million dollars.

7.4.3 Alternative 3C.2 - Demolition, Removal, and Off-Site Disposal (Permitted Commercial Disposal Site)

Capital Cost:	$48.6 M
O&M Costs:	$0
Present Worth:	$44.0 M
Years to Implement:	2

This alternative is identical to Alternative 3C.1, except that the off-site disposal at the NTS has been replaced by the off-site disposal at a permitted commercial disposal site and the waste will not be packaged, but rather it would be shipped in bulk. One such site is located near Clive, Utah, approximately 3,058 km (1,900 mi) from the FEMP site. The facility has been permitted by the State of Utah to accept mixed hazardous waste and naturally occurring by-product materials such as those in Subunit C.

Disposal

Due to its relatively long distance from the FEMP site, coordination with several states for transportation of Subunit C wastes would be required. Additionally, an exemption from DOE Order 5280.2A prohibiting disposal of DOE wastes at a commercial facility would be needed for the Operable Unit 4 waste before it could be transported to the disposal site.

Implementation Time and Costs

Remedial actions for Alternative 3C.2 would require about two years to complete, including the transportation of the materials to a permitted commercial disposal site. Capital costs are estimated to be 48.6 million dollars. Due to the off-site disposal option, no operation and maintenance (O&M) costs are anticipated for Alternative 3C.2. The total present worth cost of this alternative is estimated at 44.0 million dollars.

8.0 SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES

8.1 EVALUATION CRITERIA

Specific legal requirements for remedial actions are specified under CERCLA Section 121. These requirements include protection of human health and the environment, compliance with ARARs (unless a waiver is obtained), a preference for permanent solutions which use treatment as a principal element (to the maximum extent possible), and cost-effectiveness. To determine whether alternatives meet the requirements, EPA has identified nine criteria in the National Oil and Hazardous Substances Pollution Contingency Plan that must be evaluated for each alternative selected for detailed analysis. These criteria are as follows:

1. **Overall protection of human health and the environment:** Examines whether a remedy would provide adequate overall protection to human health and the environment in the short- and long-term . Evaluates how risks would be eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls included in the alternative.

2. **Compliance with ARARs:** Addresses whether the alternative attains compliance with federal and state environmental laws and requirements, unless a waiver of an ARAR applies.

3. **Long-term effectiveness and permanence:** Evaluates the permanence of the remedy, long term effectiveness and likelihood that the remedy will be successful.

4. **Reduction of toxicity, mobility, or volume through treatment:** Reviews the anticipated treatment technologies to reduce the hazards of, prevent the movement of, or reduce the quantity of waste materials.

5. **Short-term effectiveness:** Evaluates the ability of a remedy to achieve protection of workers, the public, and the environment during construction and implementation of the remedial action.

6. **Implementability:** Examines the practicality of carrying out a remedy, including the availability of materials and services needed during implementation of the remedial action.

7. **Cost:** Reviews both estimated capital and operation and maintenance costs of the remedy. Costs are presented as present worth costs. "Present worth" is defined as the amount of money that, if invested in the first year of implementing a remedy and paid out as needed, would be sufficient to cover all costs associated with the remedy over its planned life. Present worth costs allow remedies that would occur over different time periods to be compared on an even basis.

8. **State Acceptance:** Evaluates the technical and administrative issues and concerns that the State of Ohio may have regarding each of the alternatives; and the State comments on ARARs or proposed use of waivers.

9. **Community Acceptance:** Evaluates the issues and concerns the public may have regarding each of the alternatives, including which parts of the alternatives are supported or opposed.

The first two criteria are considered threshold criteria and must be met by the final remedial action alternatives for Operable Unit 4 (unless a specific ARAR is waived). The next five criteria are considered primary balancing criteria and are considered together to identify significant tradeoffs that must be addressed. The last two are considered modifying criteria which are considered in final remedy selection. The alternatives comparison for each subunit is summarized in Table 8-1.

8.2 COMPARATIVE ANALYSIS OF ALTERNATIVES

The following sections summarize the information presented in Section 5.0 of the FS Report for Operable Unit 4 and rely upon the detailed analysis of alternatives presented in Section 4.0 of the same report.

8.2.1 Analysis for Subunit A

8.2.1.1 Threshold Criteria

The analysis of the Subunit A alternatives against the threshold criteria of overall protection of human health and the environment and compliance with ARARs is summarized below.

Overall Protection of Human Health and the Environment. As part of the FS, two potential future land uses of the FEMP were evaluated to assess the ability of the individual alternative to adequately protect human health and the environment. These land uses consider potential exposures to contaminants released during or following the implementation of the alternatives and were evaluated for a range of viable receptors. These scenarios included future land use with and without the assumption of continued federal ownership. With continued government ownership, the FEMP land would not be available for residential or farming use. Access to the site would be limited by fencing and physical markers, it would be reasonable to assume that an Operable Unit 4 expanded trespasser would visit the site occasionally.

It is also assumed that the land surrounding the FEMP site would continue to be used for family farms. For a cleanup remedy to be considered protective, it should not result in any unacceptable risks to an expanded trespasser or an off-site farmer. The evaluation also considers the future possibility that the federal government might not have control of the FEMP site. In that case, a farm

TABLE 8-1

COMPARISON OF REMEDIAL ALTERNATIVES

SUBUNIT A - SILOS 1 AND 2 CONTENTS

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through treatment	Short-Term Effectiveness	Implementability	Total Present Worth Cost
0A - No Action	Not protective	**Does not comply with all ARARs**	**Not effective or permanent**	No treatment; therefore, no reduction	High	Easy	-0-
3A.1/Vit - **Removal, Vitrification,** Off-Site Disposal - **Nevada Test** Site	**Protective**	**Complies with all ARARs**	**Effective and most reliable**	**Reduces toxicity, mobility, and volume**	**Medium**	**Innovative technology, Difficult**	**$43.7M**
3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - Nevada Test Site	Protective	Complies with all ARARs	Effective and most reliable	Reduces mobility	Medium	Reliable technology, Difficult	$73.1M

[1] Assessment of protectiveness adopts the use of continued federal goverment ownership and evaluates risk to expanded trespassers and the off-property farmer.
[2] Assumes substantive technical requirements for Ohio disposal facility siting are met.
Bold -- Preferred Remedial Action Alternative.
Shaded areas -- Did not meet threshold criteria (Overall Protection or Compliance with ARARs), therefore, not compared.
Protective -- Risk is within the one in ten thousand to one in a million (10^{4} to 10^{6}) EPA target risk range.

TABLE 8-1
(Continued)

SUBUNIT B - SILO 3 CONTENTS

Alternative	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through treatment	Short-Term Effectiveness	Implementability	Total Present Worth Cost
0B - No-Action	Not protective	Does not comply with all ARARs	Not effective or permanent	No treatment; therefore, no reduction	High	Easy	-0-
2B/Vit - Removal, Vitrification, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces mobility and volume	Medium	Innovative technology, Moderately Difficult	$28M
2B/Cem - Removal, Cement Stabilization, On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	Reduces mobility	Medium	Reliable technology, Easy	$37.4M
3B.1/Vit - Removal, Vitrification, Off-Site Disposal - NTS	**Protective**	**Complies with all ARARs**	**Effective and most reliable**	**Reduces mobility and volume**	**Medium**	**Innovative technology, Difficult**	**$28M**
3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - NTS	Protective	Complies with all ARARs	Effective and most reliable	Reduces mobility	Medium	Reliable technology, Difficult	$36M
4B - Removal and On-Property Disposal	Protective[1]	Complies with all ARARs[2]	Effective and reliable	No treatment; therefore, no reduction	High	Reliable technology, Easy	$22M

[1] -- Assessment of protectiveness adopts the use of continued federal goverment ownership and evaluates risk to expanded trespassers and the off-property farmer.
[2] -- Assumes substantive technical requirements for Ohio disposal facility siting are met.
Bold -- Preferred Remedial Action Alternative
Shaded areas -- Did not meet threshold criteria (Overall Protection or Compliance with ARARs), therefore, not compared.
Protective -- Risk is within the one in ten thousand to one in a million USEPA target risk range

TABLE 8-1
(Continued)

SUBUNIT C - SILOS 1, 2, 3, AND 4 STRUCTURES, SOILS, AND DEBRIS

Alternative	Overall Protection of Human Health and Environment	Compliance	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through treatment	Short-Term Effectiveness	Implementability	Total Present Worth Cost
0C - No-Action	Not protective	**Does not comply with all ARARs**	**Not effective or permanent**	No treatment; therefore, no reduction	High	Easy	-0-
2C - Demolition, Removal, On-Property Disposal	**Protective**[1]	**Complies with all ARARs**[2]	**Effective and reliable**	**No treatment; therefore, no reduction**	Medium	**Reliable technology, Easy**	$34.3M
3C.1 - Demolition, Removal, Off-Site Disposal - Nevada Test Site	Protective	**Complies with all ARARs**	**Effective and most reliable**	No treatment; therefore, no reduction	Medium	Reliable technology, Moderately difficult	$75.5M
3C.2 - Demolition, Removal, Off-Site Disposal - Permitted Commercial Facility	Protective	**Complies with all ARARs**	**Effective and most reliable**	No treatment; therefore, no reduction	Medium	Reliable technology, Moderately difficult	$44M

[1] -- Assessment of protectiveness adopts the use of continued federal goverment ownership and evaluates risk to expanded trespassers and the off-property farmer.
[2] -- Assumes substantive technical requirements for Ohio disposal facility siting are met.
Bold -- Preferred Remedial Action Alternative
Shaded areas -- Did not meet threshold criteria (Overall Protection or Compliance with ARARs), therefore, not compared.
Protective -- Risk is within the one in ten thousand to one in a million USEPA target risk range

might be established on the FEMP property. The remedial alternatives were evaluated as to what risks might exist for a hypothetical on-property farmer if government control is no longer present. The basis for and detailed results of these evaluations are in Appendix D of the FS Report for Operable Unit 4.

All of the alternatives would provide protection of human health and the environment by eliminating, reducing, or controlling risk through treatment, engineering controls, or institutional controls. The preferred alternative (3A.1/Vit) would provide for overall protection, because the Subunit A residues would be treated and removed to the NTS. The source of risks to the Operable Unit 4 expanded trespasser and off-site farmer would be eliminated, and in the event that the government lost control of the FEMP site, there would be no risk from Subunit A residues to an on-property farmer. Overall protection at the NTS would be maintained because the vitrified residues resist leaching and the NTS is located in a sparsely populated, arid region, where depths to groundwater are at least 235 m (771 ft) below the surface.

Compliance with ARARs. CERCLA requires that remedial actions achieve a standard or level of control that is consistent with federal and state environmental laws or state siting regulations, which are termed applicable or relevant and appropriate requirements (ARARs). ARARs apply to all aspects of remedial action, including the establishment of cleanup levels, the operation and performance of treatment systems, and the design of disposal facilities. In addition to meeting ARARs, operations at DOE-owned facilities must be conducted according to DOE Orders. Although DOE Orders are not promulgated standards, the technical requirements may be adapted if they cover areas not addressed by other laws, or if they improve protection of human health and the environment because they are more stringent than existing laws. Detailed discussion of compliance with ARARs is provided in Appendix F of the FS Report for Operable Unit 4.

With the exception of Alternatives 2A/Vit, 2A/Cem (see Section 11 for details) and the no action alternative, all of the Subunit A alternatives would meet ARARs. Since the preferred alternative, Alternative 3A.1/Vit, includes off-site disposal at NTS, there would be no long-term compliance issues associated with the FEMP site. For example, off-site disposal would eliminate the need to demonstrate that drinking water MCLs are attained for Subunit A residues. In the short-term, the on-property remediation activities during removal and treatment would address the operational requirements for airborne emissions, soil pathways, and penetrating radiation by engineered controls.

For Alternative 3A.1/Vit, the packaging and transportation of the treated waste would comply with the requirements for the protection of worker and public safety from the radiological hazards (49 CFR §171-177). This alternative would also comply with other off-site requirements, such as the waste acceptance criteria specified by NTS, to meet their disposal requirements. The probability of an inadvertent intruder coming in contact with the Subunit A residues at NTS is less than that for the FEMP site, based on the demographic characteristics of both locations.

8.2.1.2 Primary Balancing Criteria

Those alternatives which satisfy the threshold criteria comparative analysis were carried forward to the primary balancing criteria for further comparative analysis. Because Alternative 0A (No Action) did not satisfy either of the threshold criteria, and Alternatives 2A/Vit and 2A/Cem (see Section 11 for details) do not satisfy compliance with specific ARARs, these alternatives were not considered further in this analysis.

Long-Term Effectiveness and Permanence. Alternatives 3A.1/Vit and 3A.1/Cem would ensure long-term protectiveness to human health and the environment because residual risks to viable receptors (off-site farmer and expanded trespasser) would be less than a 10^{-6} incremental lifetime cancer risk, and no non-carcinogenic effects (hazard index less than 0.2) would be indicated for either receptor.

All alternatives involve the removal and treatment of Subunit A residues by either vitrification or cement stabilization. The preferred alternative would be most effective based on the results of bench-scale treatability studies conducted during the RI/FS (Feasibility Study Report for Operable Unit 4, Appendix C) on the Subunit A materials which demonstrated that vitrification would be effective in reducing radon emanation and in minimizing the leaching of constituents. Tests using cement stabilization demonstrated that this process would be effective in preventing the movement of constituents from the stabilized form; however, there was little or no reduction in radon emanation rates. The vitrified material is expected to have greater durability over the long term.

The characteristics (i.e., demographics, climate, geology, groundwater level) of the NTS would provide for greater certainty than FEMP on-property disposal over the long term, that the treated residues would not affect human health and the environment.

Reduction of Toxicity, Mobility, or Volume through Treatment. Alternative 3A.1/Vit would use the vitrification process to treat the Subunit A material. This technology would physically bind the contaminants in a glass-like matrix which would significantly reduce contaminant mobility and material volume. Mobility would be reduced because the contaminants would be bound in the matrix and the volume of the treated material would be less than 50 percent of the untreated material volume. Vitrification would also destroy organic contaminants in the treated material. Although most contaminants in the treated material would be incorporated into the vitrified product to reduce mobility over the long term, some contaminants would be released during the vitrification process and must be treated through an off-gas treatment system. The material generated through the off-gas treatment system may require stabilization to limit subsequent contaminant mobility.

Alternative 3A.1/Cem would use the cement stabilization process to treat contaminated material. This technology will physically and chemically bind the constituents in a cement-like matrix, so the mobility of constituents via leaching from this treated material would be greatly reduced. However, organic constituents would not be destroyed. The total volume of material would increase by approximately 150 percent as a result of adding the cement stabilizing and setting agents.

Alternative 3A.1/Vit is favored over Alternative 3A.1/Cem because they would: reduce the toxicity of organic contaminants; more effectively reduce the radon emanation from the treated material; generate a treated form which has very good resistance to leaching; and significantly reduce the volume of Subunit A materials.

Short-Term Effectiveness. Alternatives 3A.1/Vit and 3A.1/Cem, the various removal, treatment, and disposal activities will result in increased short-term risks for exposures (compared to no action). The short-term effectiveness of the material removal operations is expected to be the same among all alternatives for Subunit A. There is some uncertainty associated with controlling and treating the off-gases generated by the vitrification process. The on-property risks for 3A.1/Cem from transportation would be higher than 3A.1/Vit, because the increased volume of the treated material would increase the number of potential transportation accidents. Short-term impacts at the NTS associated with the transportation and off-loading of the treated residues would be indistinguishable from normal operations.

In summary, Alternative 3A.1/Cem is favored over Alternative 3A.1/Vit because of the uncertainty associated with off-gas control and treatment for the vitrification process.

Implementability. The removal and treatment activities in Alternative 3A.1/Cem could be implemented using standard equipment, procedures, and readily available resources. Hydraulic removal is a standard mining technology that is normally reliable and uses readily available equipment. The cement stabilization technology has been applied successfully at a number of remedial sites. EPA considers cement stabilization a demonstrated treatment technology and has approved its use in the final remedy for many NPL sites. This technology has also been applied at other sites that have radioactively contaminated waste. The cement stabilization process would require large quantities of cement, flyash, and blast furnace slag, which are available.

Although removal and disposal are the same for Alternative 3A.1/Vit as for Alternative 3A.1/Cem, the vitrification process is more difficult to implement than the cement stabilization process. The vitrification process would require fewer chemical reagents than the cement stabilization process, but larger amounts of energy (electricity). Vitrification would allow the re-processing of off-specification treated materials compared to cement stabilization. However, the vitrification process equipment would be more complex to construct and operate than that of the cement stabilization process. There is limited experience available for the types and quantities of the material from the silos and decant sump tank on which to base an assessment of the likely performance of the vitrification technology. The vitrification technology is not as widely available as the cement stabilization technology. Off-gas treatment is also an additional complexity with vitrification where delays could occur. However, operational experience is being gained as part of the structured RI/FS treatability studies and planned vitrification pilot studies currently in progress.

Alternatives 3A.1/Vit and 3A.1/Cem involve off-site transportation and disposal at the NTS. While technically straightforward, off-site transportation would require coordination efforts with a number of states located along the transportation route, as well as the State of Nevada. Demonstrated compliance with the NTS waste acceptance criteria would be required prior to shipping the Subunit A materials. The transportation of this material would also comply with the off-site acceptability amendment to CERCLA's implementing regulations, the National Contingency Plan [58 FR 49200 (September 22, 1993)].

In summary, Alternative 3A.1/Cem would be favored over Alternative 3A.1/Vit, based on relative overall implementation.

Cost. The estimated total present worth costs for the Subunit A alternatives are provided on Table 8-2, and include a breakdown of capital and operating and maintenance costs. The present worth cost of Alternative 3A.1/Cem is approximately 67 percent more expensive than Alternative 3A.1/Vit, primarily due to the additional packaging, transportation, and disposal for the larger volume of cement-stabilized material.

8.2.1.3 Modifying Criteria

State Acceptance
The State of Ohio reviewed the preferred remedial alternative for Subunit A that was provided in the PP, and concurs with the selection of Alternative 3A.1/Vit. A letter from the OEPA conditionally approving the FS and PP for Operable Unit 4 can be found in Appendix E of this ROD.

Community Acceptance
DOE solicited input from the community on the preferred remedial alternative for Subunit A that was provided in the PP. Verbal comments received during the public meeting indicated support of the chosen remedial alternative. Written comments received during the public comment period are addressed in the responsiveness summary (see Appendix C).

8.2.1.4 Subunit A Comparative Analysis Summary

Alternative 3A.1/Vit is identified as the preferred alternative because it would result in the permanent treatment and volume reduction of Subunit A materials and it is cost-effective. It would provide overall protection of human health and the environment with fewer uncertainties over the long-term.

8.2.2 SUBUNIT B

8.2.2.1 Threshold Criteria

Subunit B alternatives would employ the same removal, treatment, and disposal options as those for Subunit A materials. Many of the factors considered and discussed under the Subunit A analysis are identical for Subunit B. Therefore, frequent references will be made to the information presented previously in Section 8.2.1. Only those factors unique to remediation of the Subunit B materials will be emphasized. This approach will be applied to the discussions under the primary balancing criteria as well.

TABLE 8-2

OPERABLE UNIT 4 REMEDIAL ALTERNATIVE COST SUMMARY (MILLION $)

ALTERNATIVE	CAPITAL	OPERATING & MAINTENANCE		TOTAL PRESENT WORTH COST
		SHORT-TERM (During Remediation)	LONG-TERM (Post Remediation)	
Subunit A - Silos 1 and 2 Contents				
OA - No Action	0	0	0	0
3A.1/Vit - Removal, Vitrification, Off-Site Disposal - Nevada Test Site	38.3	11.7	0	43.7
3A.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - Nevada Test Site	71.8	11.7	0	73.1
Subunit B - Silo 3 Contents				
OB - No Action	0	0	0	0
2B/Vit - Removal, Vitrification, On-Property Disposal	25.2	4.9	3.2	28
2B/Cem - Removal, Cement Stabilization, On-Property Disposal	35.9	4.9	3.2	37.4
3B.1/Vit - Removal, Vitrification, Off-Site Disposal - Nevada Test Site	26.8	4.9	0	28
3B.1/Cem - Removal, Cement Stabilization, Off-Site Disposal - Nevada Test Site	36.8	4.1	0	36
4B - Removal, On-Property Disposal	21.8	1.1	3.2	22
Subunit C - Silos 1, 2, 3, and 4 Structures, Soils, and Debris				
0C - No Action	0	0	0	0
2C - Demolition, Removal, On-Property Disposal	36.3	0	3.6	34.3
3C.1 - Demolition, Removal, Off-Site Disposal - Nevada Test Site	83.6	0	0	75.5
3C.2 - Demolition, Removal, Off-Site Disposal - Permitted Commercial Facility	48.7	0	0	44

NOTES:
The accuracy of the cost estimates are between +50% and -30%.
Estimates of capital and operations and maintenance costs are expressed in terms of total costs. The total present worth costs are calculated from the total cost figures applying a discount rate of 7 percent and an operating and maintenance period of 30 years.

The comparison of the Subunit B alternatives against the threshold criteria of overall protection of human health and the environment and compliance with ARARs is summarized below.

Overall Protection of Human Health and the Environment. As discussed in Section 8.2.1.1, this evaluation assumes that the federal government would continue to own the FEMP site. For a cleanup remedy to be considered protective, it should not result in any unacceptable risks to an expanded trespasser or an off-site farmer.

All alternatives, with the exception of the no-action alternative (0B), would provide overall protection of human health and the environment. These alternatives will eliminate, reduce, or control the health or environmental risks resulting from constituents in Subunit B materials. Except for Alternative 4B, the alternatives would limit exposure to contaminants by removing the material, treating the material by either vitrification or cement stabilization. The treated material is disposed in an on-property above-grade disposal vault for Alternative 2B or off-site at NTS for Alternative 3B.1. Alternative 4B's protection is based on removal and disposal in an on-property above-grade vault and institutional controls. All alternatives would attain long-term effectiveness.

In summary, Alternatives 3B.1/Vit and 3B.1/Cem would provide overall protection to the expanded trespasser and off-site farmer because they would remove the Subunit B residues from the FEMP site.

Compliance with ARARs. With the exception of the no-action alternative, Subunit B alternatives would comply with all pertinent ARARs. Under the no-action alternative, Silo 3 would eventually fail, resulting in the release of cold metal oxides to the environment. This scenario would likely result in radiological releases to the air, soil, groundwater, and surface water (via storm water runoff). For example, fate and transport modeling for this scenario indicates that the safe drinking water limits (MCLs in 40 CFR §141) would be exceeded for uranium, and gross alpha and beta radiation.

For those alternatives that include on-property disposal, an Alternative 4B is the least favorable on-property alternative because the material is not treated.

In summary, Alternatives 2B/Vit, 2B/Cem, 3B.1/Vit, 3B.1/Cem, and 4B, would meet all pertinent ARARs. Because the uncertainty associated with demonstrating that the FEMP on-property disposal vault would provide for the long-term protection of inadvertent intruders, Alternatives 3B.1/Vit and 3B.1/Cem are favored over 2B/Vit, 2B/Cem, and 4B.

8.2.2.2 Primary Balancing Criteria

Those alternatives that satisfy the threshold criteria comparative analysis were carried forward to the primary balancing criteria comparative analysis. Because Alternative 0B (No Action) did not satisfy either of the threshold criteria, it is not considered further in this analysis.

Long-Term Effectiveness and Permanence. All Subunit B alternatives would ensure long-term protectiveness to human health and the environment. For all alternatives, projected FEMP site residual risks to viable receptors (off-site farmer and expanded trespasser) would be less than 10^{-6} incremental lifetime cancer risk, and no non-carcinogenic effects (hazard index less than 0.2) would be indicated for either receptor.

The characteristics of the treated residue form (vitrification or cement stabilization) and the disposal options (on-property or off-site at NTS) are similar to those discussed under long-term effectiveness for Subunit A materials. Long-term environmental impacts are also the same as those considered for Subunit A.

In summary, Alternatives 3B.1/Vit and 3B.1/Cem provide a greater degree of long-term effectiveness than Alternatives 2B/Vit, 2B/Cem, and 4B.

Reduction of Toxicity, Mobility, or Volume through Treatment. Alternatives 2B/Vit and 3B.1/Vit would use the vitrification process to treat the Subunit B material. This technology would physically bind the contaminants in a glass-like matrix, which would significantly reduce contaminant mobility and material volume. Mobility would be reduced since the contaminants would be bound in the matrix and the volume of the treated material would be approximately 62 percent of the untreated material volume.

Alternatives 2B/Cem and 3B.1/Cem would use the cement stabilization process to treat the Subunit B material. This technology will physically and chemically bind the constituents in a cement-like matrix, so the mobility of constituents (via leaching from) in this treated material would be greatly reduced. However, the total volume of material will increase by 55 percent as a result of adding the cement stabilizing and setting agents.

Alternative 4B does not reduce toxicity, mobility, or volume because it does not include the treatment. In summary, Alternatives 2B/Vit and 3B.1/Vit are favored over Alternatives 2B/Cem, 3B.1/Cem, and 4B because they would generate a treated form which has very good resistance to leaching and would significantly reduce the volume of the Subunit B materials.

Short-Term Effectiveness. For the Subunit B action alternatives, the various removal, treatment, and disposal activities would result in increased short-term risks (compared to no action). The short-term effectiveness of removal operations is expected to be the same among all alternatives for Subunit B. There is some degree of uncertainty associated with controlling and treating the off-gases generated by the vitrification process.

The increased risks due to off-site transportation of the treated residues to NTS and the short-term environmental impacts associated with removal, treatment, and disposal are similar to those described in Section 8.2.1.2. Alternative 4B provides the highest short-term effectiveness because no treatment is provided.

In summary, Alternative 4B is the favored alternative, and Alternatives 2B/Cem and 3B.1/Cem are favored over Alternatives 2B/Vit and 3B.1/Vit because of the uncertainty associated with off-gas control and treatment for the vitrification process.

Implementability. The removal and treatment activities for all Subunit B action alternatives could be implemented with standard equipment, procedures, and readily available resources. Pneumatic removal would be employed for the Subunit B materials and it is a standard technology that is typically reliable and uses readily available equipment. All other aspects of implementing the action alternatives for Subunit B are identical to those discussed for Subunit A under the implementability criterion in Section 8.2.1.2.

In summary, Alternative 4B would be favored and Alternatives 2B/Vit and 3B.1/Vit would be the least favored, based on relative overall implementability.

Cost. The estimated total present worth costs for Subunit B Alternatives are provided in Table 8-2 and include a breakdown of capital and operating and maintenance costs.

Alternative 4B is the least expensive action alternative. The present worth costs of Alternatives 2B/Vit and 3B.1/Vit are approximately the same, and are about 6 million dollars higher than that of Alternative 4B. This is due to the treatment component of those alternatives not included in Alternative 4B. Alternatives 3B.1/Cem and 2B/Cem are approximately 30 percent and 34 percent more expensive, respectively, than Alternatives 3B.1/Vit and 2B/Vit, respectively. Alternative 3B.1/Cem is more expensive than Alternative 3B.1/Vit primarily due to the additional packaging, transportation, and disposal of the larger volume of cement-stabilized material.

8.2.2.3 Modifying Criteria

State Acceptance

The State of Ohio reviewed the preferred remedial alternative for Subunit B that was provided in the Proposed Plan, and concurs with the selection of alternative 3B.1/Vit. A letter from the OEPA conditionally approving the FS and PP for Operable Unit 4 can be found in Appendix E of this ROD.

Community Acceptance

DOE solicited input from the community on the preferred remedial alternative for Subunit B that was provided in the Proposed Plan. Verbal comments received during the public meeting indicated support of the chosen remedial alternative. Written comments received during the public comment period are addressed in the responsiveness summary (see Appendix C).

8.2.2.4 Subunit B Comparative Analysis Summary

Alternative 3B.1/Vit is the preferred alternative because it is cost-effective and would result in the permanent treatment and volume reduction of Subunit B materials. Alternative 3B.1/Vit would provide overall protection of human health and the environment with fewer uncertainties over the long-term.

8.2.3 Subunit C

8.2.3.1 Threshold Criteria

The analysis of the Subunit C alternatives against the threshold criteria of overall protection of human health and the environment, and compliance with ARARs is summarized below.

Overall Protection of Human Health and the Environment. Alternative 0C would not provide adequate protection of human health and the environment. As discussed in Section 8.2.1.1, evaluations were conducted for future land uses with and without continued federal ownership. For a cleanup remedy to be considered protective, it would not result in any unacceptable risks to an expanded trespasser or an off-site farmer under the future land use with continued federal ownership scenario, or an on-property farmer under the future land use without continued federal ownership.

All of the action alternatives (Alternatives 2C, 3C.1, and 3C.2) would limit exposure to constituents by decontaminating, demolishing, and removing the material to either an on-property above-grade disposal facility or off-site disposal facility, and then excavating contaminated soils and placing clean fill over residual contaminated subsurface soils. Section 9.2 presents and discusses the soil cleanup levels, all of which would be protective to the expanded trespasser and off-site resident over the long term. Short-term risks would be higher for off-site disposal due to the increased risk of transportation accidents.

The basic difference among the action alternatives is the disposal option. On-property disposal (Alternative 2C) would be in an above-grade disposal facility. Off-site disposal options include NTS (Alternative 3C.1) and a permitted commercial disposal site (Alternative 3C.2).

The on-property, above-grade disposal facility would be designed for a 1,000 year life with no active maintenance. Fate and transport modeling using conservative assumptions concludes that protectiveness would be maintained over the long term.

NTS and the permitted commercial disposal facility would incorporate engineering controls to ensure protectiveness. Both are located in a climatic, demographic, and hydrogeologic setting which favors minimization of constituent migration to human or environmental receptors.

In summary, Alternatives 3C.1 and 3C.2 would provide overall protectiveness because they would remove the Subunit C excavated soils and debris from the FEMP site.

Compliance with ARARs. All alternatives, other than Alternative 0C (No Action) would meet all pertinent ARARs. Under the no-action alternative, it would be likely that constituents would continue to be released to the air, groundwater, and surface water. There would also be a risk for direct contact with contaminated soil and exposure to direct radiation.

For Alternative 2C, an exemption to Ohio Administrative Code (OAC) rule 3745-27-07(B)(5) may be granted on the basis of meeting certain technical requirements. Supporting technical data for the proposed location of the disposal facility on the FEMP site must be developed to satisfy the requirements of OAC rule 3745-27-07(B)(5).

In summary, Alternatives 3C.1, and 3C.2 would meet all pertinent ARARs. Alternative 2C would require a waiver of OAC rule 3745-27-07(B)(5) based on demonstration that it would meet certain technical requirements.

8.2.3.2 Primary Balancing Criteria

Those alternatives that satisfy the threshold criteria of compliance with ARARs and overall protection of human health and environment were carried forward to the primary balancing criteria comparative analysis. Because Alternative 0C (No Action) did not satisfy either of the threshold criteria, it is the only alternative not considered further in this analysis.

Long-Term Effectiveness and Permanence. All Subunit C alternatives would ensure long-term protectiveness to human health and the environment. For all alternatives, projected FEMP site residual risks to viable receptors (off-site farmer and expanded trespasser) would be less than 10^{-6} incremental lifetime cancer risk and no non-carcinogenic effects (hazard index less than 0.2) would be indicated for either receptor. Although residual contamination would remain in the Operable Unit 4 Study Area, the level of risk from the contaminated soil would be controlled by excavating soil that exceeds proposed cleanup levels, by placing clean soil over the excavated areas, and by providing appropriate access controls and deed restrictions.

Alternative 2C would employ an on-property disposal facility designed to minimize leachate generation from water infiltration and contact with contaminated soil and debris. Fate and transport modeling using conservative assumptions demonstrates that both risk- and ARAR-based protective levels would be maintained for the Great Miami Aquifer over the long term.

Alternatives 3C.1 (NTS) and 3C.2 (permitted commercial disposal facility) would provide long-term protectiveness because the residual soils and debris would be removed from the FEMP site.

Following completion of remedial operations, impacted areas would be restored; long-term environmental impacts are expected to be minor. Alternative 2C would result in permanent commitment of approximately 4.7 hectares (11.6 acres) of land for the disposal facility.

In summary, Alternatives 3C.1 and 3C.2 would provide a greater degree of long-term effectiveness than Alternative 2C.

Reduction of Toxicity, Mobility, or Volume through Treatment. Alternatives 2C, 3C.1, and 3C.2 will isolate the material from the environment by containment. Treatment of the contaminated silo structures, berm material, or soils is not included in any of the alternatives, so no reduction in toxicity, mobility, or volume would be achieved.

Short-Term Effectiveness. For all alternatives, the various demolition and removal activities would result in increased short-term exposures compared to no action. Alternatives 3C.1 and 3C.2 would pose additional risks to the public and workers associated with off-site shipment to the NTS or the permitted commercial disposal facility.

During the implementation of any of the action alternatives, the general public is not likely to be exposed to contaminants because of the distance from the work area, the very low levels of contamination, and the methods proposed to control emission dust during demolition and excavation. Potential short-term environmental impacts resulting from the implementation of Alternatives 2C, 3C.1, and 3C.2 include generation of fugitive dust, increased sediment in surface runoff, and disturbance and/or displacement of wildlife as a result of noise, dust, and human activity. Engineering controls would be used to minimize these potential short-term impacts.

In summary, Alternative 2C is favored over Alternatives 3C.1 and 3C.2. The short-term risks to the public and workers for constructing the on-property disposal facility would offset the increased risks to the public and workers associated with off-site transportation of the contaminated soils and debris.

Implementability. Alternatives 2C, 3C.1, and 3C.2 would all employ the same decontamination, demolition, and excavation operations. With the exception of the remotely controlled operations proposed for decontaminating Silos 1, 2, and 3, all operations are standard construction activities which would be easily implemented. The remote silo decontamination operations would be used on the uncontaminated Silo 4 first to attain improved worker familiarity with the operation processes and identify any potential operational difficulties.

Alternative 2C involves on-property disposal facility construction, which would employ standard construction services and materials. The off-site disposal alternatives (3C.1 and 3C.2) would involve standard transportation practices for radioactive materials. Alternatives 3C.1 and 3C.2 would be more administratively difficult to implement than Alternative 2C due to the coordination required with those states through which shipment would pass to the off-site locations. Additional efforts would be required to ensure that the Subunit C materials complied with criteria established by either the NTS or the permitted commercial disposal facility. Alternative 2C would require coordination with the State of Ohio to ensure that all technical requirements for the on-property disposal facility were met.

In summary, Alternative 2C is favored over Alternatives 3C.1 and 3C.2 based on relative overall implementability.

Cost. The estimated total present worth costs for Subunit C alternatives are provided in Table 8-2, and include a breakdown of capital and operating and maintenance cost.

Alternative 2C, which includes an on-property disposal, is the least expensive action alternative. Transportation to the NTS (Alternative 3C.1) or to a permitted commercial disposal facility (Alternative 3C.2) are both more expensive than constructing an on-property vault. However, the overall cost of disposal at a permitted commercial disposal facility is anticipated to be approximately 60 percent lower than the cost of disposal at a DOE-owned facility. This is primarily due to the packaging requirements of the DOE-owned facility. The commercial disposal facility accepts bulk shipment of material.

8.2.3.3 Modifying Criteria

State Acceptance

The State of Ohio reviewed the preferred remedial alternative for Subunit C that was provided in the Proposed Plan, and concurs with the decision that the final disposition of the Subunit C contaminated soil and debris would be placed in abeyance to take full advantage of planned and in progress waste minimization treatment processes. The contaminated soil and debris would either be processed through the selected Operable Unit 5 and Operable Unit 3 remedy identified by the respective Operable Unit 5 and Operable Unit 3 ROD or placed in interim storage to await the finalization of the disposal decisions for soils and debris under Operable Unit 5 and Operable Unit 3. For the sole purpose of evaluating the performance of an overall preferred remedial alternative for Operable Unit 4, the State of Ohio concurs with the identification of Alternative 2C as the preferred alternative for Subunit C.

Community Acceptance

DOE solicited input from the community on the preferred remedial alternative for Subunit C that was provided in the Proposed Plan. Verbal comments received during the public meeting indicated support of the chosen remedial alternative. Written comments received during the public comment period are addressed in the responsiveness summary (see Appendix C).

8.2.3.4 Subunit C Comparative Analysis Summary

Alternatives 2C and 3C.2 are relatively equal, as both would be cost-effective, and would provide overall protection of human health and the environment both in the short-term and the long-term. For evaluation purposes only, Alternative 2C has been identified as the preferred alternative for Subunit C. The decision regarding the final disposition of the Operable Unit 4 Subunit C contaminated soil and debris would be placed in abeyance to take full advantage of planned and in progress waste minimization treatment processes. The contaminated soil and debris would either be processed through the selected Operable Unit 5 and Operable Unit 3 remedy identified by the respective Operable Unit 5 and Operable Unit 3 ROD or placed in interim storage to await the finalization of the disposal decisions for soils and debris under Operable Unit 5 and Operable Unit 3.

9.0 SELECTED REMEDY

On the basis of the evaluation of final alternatives, the selected remedy to be used at Operable Unit 4 at the FEMP is a compilation of the selected alternatives from each subunit; i.e., Alternatives 3A.1/Vit - Removal, Vitrification, and Off-site Disposal - NTS; 3B.1/Vit - Removal, Vitrification, and Off-site Disposal - NTS; and 2C - Demolition, Removal and On-Property Disposal. The selected remedy will satisfy the requirements of both CERCLA and NEPA for the protection of human health and the environment; will comply with all regulatory requirements; will be cost-effective; will utilize permanent solutions to the maximum extent practicable; and will utilize treatment as a principal element of the response. The discussions presented here are based on the information used for detailed analysis of alternatives during the FS for Operable Unit 4. Actual methods used during the implementation of the remedy will be determined during detailed engineering design described in the remedial design and may differ from the descriptions provided below.

9.1 KEY COMPONENTS

The major components of the selected remedy consist of the following:

- Removal of the contents of Silos 1, 2, and 3 (K-65 residues and cold metal oxides) and the decant sump tank sludge.
- Vitrification (glassification) to stabilize the residues and sludges removed from the silos and decant sump tank.
- Off-site shipment for disposal at the NTS of the vitrified contents of Silos 1, 2, 3, and the decant sump tank.
- Demolition of Silos 1-4 and decontamination of the gross and loose contamination, to the extent practicable, of the concrete rubble, piping, and other generated construction debris.
- Removal of the earthen berms and excavation of contaminated soils within the boundary of Operable Unit 4, to achieve proposed remediation levels. Placement of clean backfill following excavation (i.e. structure, foundations or large excavations which affect local topography).
- Segregation of non-contaminated soils, demolition of the vitrification treatment unit and associated facilities after use. Decontamination or recycling of debris prior to disposition.
- On-property interim storage of excavated contaminated soils and remaining contaminated debris in a manner consistent with the approved Work Plan for Removal Action 17 (improved storage of soil and debris).
- Continued access controls and maintenance, and monitoring of the stored wastes inventories.

- Institutional controls of the Operable Unit 4 area such as deed and land use restrictions.
- Potential additional treatment of stored Operable Unit 4 soil and debris using Operable Unit 3 and 5 waste treatment systems.
- Pumping and treatment of any contaminated perched groundwater encountered during remedial activities.
- Disposal of remaining Operable Unit 4 contaminated soils and debris consistent with the selected remedies for Operable Units 5 and 3, respectively.

9.1.1 Removal of Silo 1, 2 and 3, and Decant Sump Tank Contents

The K-65 residues in Silos 1 and 2, the cold metal oxides in Silo 3, and the sludge in the decant sump tank will be removed. Approximately 6,796 m^3 (8,890 yd^3) of K-65 residues from Silos 1 and 2, 3,785 L (1,000 gallons) of sludge from the decant sump, and 3,890 m^3 (5,088 yd^3) of cold metal oxides from Silo 3 will be removed. The silos and the decant sump will be equipped with an off-gas treatment system(s) designed to handle radon emissions generated during removal.

9.1.2 Vitrification of Silo 1, 2 and 3, and Decant Sump Tank Contents

The major treatment component of the selected remedy consists of a vitrification system to stabilize the wastes from Silos 1, 2, and 3 and the decant sump tank. The wastes removed from the silos and the decant sump will be transferred to a vitrification processing facility which will be constructed on site. The wastes will be thickened as necessary for vitrification and then mixed with glass forming agents and placed into a vitrification melter. The vitrification process will convert the contents of the silos and the decant sump into a very durable glass form which is extremely resistant to the effects of time and weather. The process will destroy organic contaminants and the vitrified waste form will significantly reduce both the tendency of the waste to leach contaminants into the environment and the emission rate of radon gas. The direct radiation associated with the treated residues will remain relatively unchanged from the untreated form of the wastes. Off gases produced as a result of the high operating temperatures of the vitrification melter will be routed through an off-gas treatment system designed to remove solid particles and treat gaseous emissions such as radon.

Treatability studies, conducted on a small scale as part of the RI/FS, indicate that the volume of vitrified material requiring disposal can be reduced by as much as 50 percent of the volume of untreated material removed from the silos and the decant sump.

9.1.3 Off-Site Shipment and Disposal of Treated Material

Approximately 2,770 m^3 (3,623 yd^3) of vitrified material from Silo 1 and 2 and the decant sump, along with approximately 1,471 m^3 (1,923 yd^3) of vitrified material from Silo 3, will be packaged and transported to the NTS for disposal.

The NTS is a DOE owned and operated disposal site located near Las Vegas, Nevada. The treated material will either be transported by rail to a destination near to or north of Las Vegas, Nevada or directly to the NTS by truck. If by rail, the waste containers carrying the treated material will be required to be transferred to trucks for transportation over roads to the NTS.

The NTS is located approximately 3,219 kilometers (km) [2,000 miles (mi)] from the FEMP. The FEMP has an approved NTS waste shipment and certification program, for low-level radioactive wastes, that is periodically audited by the NTS. Technical oversight of the waste management activities at the NTS is provided by the State of Nevada. This existing waste shipment disposal program will be modified and amended to include the shipment and disposal of treated Operable Unit 4 wastes.

All off-site shipments will comply with the DOT regulations found in 49 CFR Parts 171 - 178 pertaining to transportation of hazardous and radioactive materials. Additionally, all the NTS waste acceptance requirements will be satisfied. The off-site transport of materials would also comply with the off-site acceptability requirements under CERCLA.

The remedy specifies off-site disposal of vitrified contents of Silos 1, 2 and 3 at the NTS. At the time of the signing of this ROD, the Department of Energy - Nevada Operations Office (DOE-NV) is in the process of preparing a Sitewide Environmental Impact Statement (EIS) under NEPA for the NTS. Shipments of waste generated from the cleanup of Operable Unit 4 are not proposed to begin until after the expected completion of the NTS site-wide EIS.

9.1.4 Demolition and Decontamination of Structures

Demolition of the silo structures will proceed with the systematic removal and dismantling of the Silos 1, 2, 3, and 4 domes, walls, floor slabs and footers. After removal of the silo contents and before Silos 1, 2, 3, and 4 are demolished, loose interior residues and loose concrete will be removed from the surfaces of the silos and transferred to the vitrification facility to be vitrified. Also, contaminated concrete from Silos 1 and 2, which exhibit highly elevated direct radiation fields, will be separated from the other Operable Unit 4 concrete and construction debris and prepared for processing in the vitrification facility. Contaminated piping, steel fencing, and other non-porous materials will be decontaminated to facilitate segregation for possible unrestricted release or disposal in a permitted commercial landfill. Only non-porous materials attaining the unrestricted use, free release criteria defined in DOE Order 5400.5 or any subsequent DOE order or amendment or final promulgated regulation addressing free release, will be released from the site as uncontaminated.

9.1.5 Demolition and Decontamination of Other Operable Unit 4 Structures

The existing RTS, Drum Handling Building pad, sump lift station foundation, concrete pipe trench, and decant sump tank will be removed and decontaminated. Additionally, all vitrification facilities constructed and equipment installed and used for the implementation of this remedy will be disassembled, decontaminated (if necessary), and dispositioned. Conventional decontamination and decommission techniques and equipment would be employed for these facilities. Uncontaminated materials attaining the unrestricted use, free release criteria defined in DOE Order 5400.5 will be released from the site for unrestricted use or for disposal in a commercial landfill.

9.1.6 Disposition of Demolished Structures and Debris

The selected remedy as defined under Alternative 2C specifies on-property disposal for Operable Unit 4 contaminated rubble and debris. However, this final action will be held in abeyance until a decision is reached in the Operable Unit 3 ROD for the final treatment and disposal of rubble and debris. The final decision on disposal of rubble and debris, generated from the demolition of the Operable Unit 4 silos and other facilities, will be determined as part of the ROD for Operable Unit 3. The Operable Unit 4 waste will be managed consistent with the disposal remedy put forth in the Operable Unit 3 ROD for contaminated rubble and debris. In the unlikely event unforeseen circumstances preclude the integration of Operable Unit 4 rubble and debris into the Operable Unit 3 treatment and disposal decision, the disposal decision for Operable Unit 4 rubble and debris will be documented in a ROD amendment for Operable Unit 4 in accordance with Section 117(c) of CERCLA and EPA guidance. The ROD amendment will provide the public and the EPA further opportunity to review and comment on the on-property disposal option for Operable Unit 4 rubble and debris. A ROD amendment to the Operable Unit 4 ROD will not be necessary in the event the Operable Unit 3 remedy for rubble and debris can be feasibly implemented by Operable Unit 4.

Holding action on the Operable Unit 4 on-property disposal decision in abeyance fosters an integrated site-wide disposal program for rubble and debris. The volume of rubble and debris to be generated from Operable Unit 4 is anticipated to be less than 1 percent of the volume expected to be generated site wide. The largest volume of rubble and debris from the site will be generated from Operable Unit 3, making it more appropriate to fully develop the on-property disposal option for rubble and debris through the Operable Unit 3 ROD. Additionally, Operable Unit 4 will be able to take advantage of any available waste minimization initiatives developed for rubble and debris which are identified in the Operable Unit 3 ROD.

Demolition and removal of Operable Unit 4 structures and facilities will proceed as described above. Operable Unit 4 rubble and debris will be dispositioned according to the selected remedy identified in the Operable Unit 3 ROD. Rubble and debris generated prior to finalization of the Operable Unit 3 ROD will be placed in interim storage to await finalization of the disposal decision for rubble and debris under Operable Unit 3. The design and management of interim storage facilities will be consistent with the approved Work Plan for FEMP Removal Action No. 17 - Improved Storage of Soil and Debris.

9.1.7 Soil Removal

After the silos are demolished, the surface and subsurface soils within the boundary of Operable Unit 4 will be excavated to attain required remediation levels for each of the constituents of concern. These soil remediation levels are considered preliminary until final soil remediation levels can be established through the Operable Unit 5 ROD. As indicated earlier, Operable Unit 5 has site-wide responsibility for soil cleanup. Also, the anticipated volume of soil to be removed from Operable Unit 4 will be less than 1 percent of the anticipated volume of soil to be remediated for the entire site. The surface and subsurface soils within Operable Unit 4 will be excavated to achieve the preliminary remediation levels presented and discussed in Section 9.2. These Operable Unit 4 soil remedial levels are based upon information available at the time of preparation of this ROD, from the Operable Unit 5 RI/FS. In the event that the Operable Unit 5 ROD determines that lower soil remediation levels are required, further remedial action will be conducted on the Operable Unit 4 residual soils to achieve the lower remediation levels for those COCs which are affected.

Soils exhibiting elevated direct radiation levels (i.e., potentially contaminated soils beneath Silos 1 and 2) will be segregated from other soils and transported to the vitrification facility for processing. Following excavation, the affected areas will be returned to original grade with the placement of clean backfill and revegetated to control erosion.

9.1.8 Soil Disposition

The selected remedy as defined under Alternative 2C specifies on-property disposal for Operable Unit 4 contaminated soils. However, this final action will be held in abeyance until a site-wide decision is reached in the Operable Unit 5 ROD for the final disposal of contaminated soils. The final decision on disposal of contaminated soils generated from Operable Unit 4 will be determined as part of the Record of Decision for Operable Unit 5. The Operable Unit 4 soils will be managed consistent with the disposal remedy put forth in the Operable Unit 5 ROD for contaminated soils. In the event unforeseen circumstances preclude the integration of Operable Unit 4 contaminated soils into the Operable Unit 5 disposal decision, the final disposal decision for Operable Unit 4 contaminated soils will be documented in a ROD amendment for Operable Unit 4 in accordance with Section 117(c) of CERCLA and EPA guidance. The ROD amendment will provide the public and the EPA further opportunity to review and comment on the final disposal option for Operable Unit 4 contaminated soils. A ROD amendment to the Operable Unit 4 ROD will not be necessary in the event the Operable Unit 5 remedy for contaminated soils can be feasibly implemented by Operable Unit 4.

Holding the Operable Unit 4 final disposal decision in abeyance fosters an integrated site-wide disposal approach for contaminated soils. The largest volume of contaminated soils from the site will be generated within Operable Unit 5, making it more appropriate to fully develop the final disposal option for contaminated soil through the Operable Unit 5 ROD. Additionally, Operable Unit 4 will be able to take advantage of any applicable waste minimization initiatives developed for contaminated soils under the Operable Unit 5 ROD.

Excavation and removal of Operable Unit 4 contaminated soils will proceed as described above. Operable Unit 4 contaminated soils will be disposed in accordance with the selected remedy identified in the Operable Unit 5 ROD for soils. Contaminated soils generated prior to finalization of the Operable Unit 5 ROD will be placed in interim storage to await finalization of the disposal decision for contaminated soils under Operable Unit 5. The design and management of interim storage facilities will be consistent with the approved Work Plan for FEMP Removal Action No. 17 -

Improved Storage of Soil and Debris. The management of Operable Unit 4 contaminated soils will include measures to ensure future identification and retrieval of these wastes for final disposition.

Water Treatment

Wastewater generated as a result of this selected remedy along with water removed from the decant sump tank, Silo 4 (if any), and any contaminated perched water encountered during remediation will be treated at the FEMP wastewater treatment facility prior to discharge. In accordance with the Amended Consent Agreement, groundwater cleanup will be handled by Operable Unit 5. Operable Unit 4 would only handle the cleanup of perched water encountered during implementation of the selected remedy.

9.1.9 Cost

The total estimated present worth cost for the selected remedy is 91.7 million dollars. Table 9-1 summarizes the capital and the operating and maintenance costs. The total estimated present worth cost is less than the sum of the total costs of the preferred alternatives for Subunit A, B, and C. This is because Subunits A and B will share common costs for site preparation, construction of the silo contents removal work platform and processing facilities, and packaging and transportation.

9.2 SOIL CLEANUP CRITERIA

After the silos are demolished, the surface and subsurface soils within the Operable Unit 4 boundary will be excavated to attain required remediation levels for each of the constituents of concern. These soil remediation levels are preliminary until final soil remediation levels can be established through the Operable Unit 5 ROD. In the event that the Operable Unit 5 ROD determines that lower soil remediation levels are required, further remedial action will be conducted on the Operable Unit 4 residual soils to achieve the lower remediation levels for those COCs that are affected.

9.2.1 Land Use and Receptor Description

Preliminary remediation levels for soil cleanup were developed for an expanded trespasser receptor under a future land use with continued federal ownership to represent post remediation conditions at Operable Unit 4 and, therefore, provide the basis for establishing cleanup levels.

The future land use with continued federal ownership scenario represents a government reserve which remains under U. S. government control with no future development intended. Active access controls currently in place at the FEMP site (i.e. fencing, security access control, signs, etc.) will be

TABLE 9–1

COMBINED COST ESTIMATE FOR SELECTED REMEDY

DESCRIPTION	DIRECT COST	INDIRECT COST	TOTAL COST
CAPITAL COSTS			
SITE PREPARATION	$768,600	$660,000	$1,428,600
WASTE PROCESSING	$1,695,800	$1,427,700	$3,123,500
VITRIFICATION EQUIPMENT	$2,935,500	$1,703,600	$4,639,100
HYDRAULIC/PNEUMATIC REMOVAL SYSTEM	$6,655,400	$14,068,800	$20,724,200
DEMOLITION & REMOVAL	$3,980,400	$5,977,000	$9,957,400
TRANSPORTATION	$1,915,000		$1,915,000
DISPOSAL	$2,360,200		$2,360,200
PACKAGING (3,694 PKGS. @ $955/PKG.)	$975,200	$2,552,600	$3,527,800
DISPOSAL VAULT	$6,410,200	$10,914,800	$17,325,000
TOTAL CAPITAL	$27,696,300	$37,304,500	$65,000,800
RISK BUDGET	$3,046,600	$4,103,500	$7,150,100
SUBTOTAL	$30,742,900	$41,408,000	$72,150,900
CONTINGENCY (20.0%)	$6,148,600	$8,281,600	$14,430,200
TOTAL ESTIMATED INSTALLED COST	$36,891,500	$49,689,600	$86,581,100
OPERATION AND MAINTENANCE (O&M) COSTS			
DURING CONSTRUCTION			$16,615,500
POST–REMEDIATION			$3,567,000
TOTAL PRESENT WORTH COST (CAPITAL AND O&M @ 7%)			$91,738,000

discontinued, but the federal government will exercise the right to preclude site development through deed restrictions. This land use scenario was not included in the Baseline Risk Assessment. It was developed in a part of the FS for Operable Unit 4 to facilitate evaluation of long-term risks with continued land use restrictions. In addition to deed and land development restrictions, fences will be erected and equipped with signs posted to prohibit trespassing.

The expanded trespasser receptor was developed to represent an adult and/or child that visits the site despite restrictions imposed under continued federal ownership. The possible activities of this receptor include hiking, roaming, bird watching, and other similar activities. An expanded trespasser may be exposed to Operable Unit 4 residual contaminants through the following pathways:

- Inhalation of fugitive dust, volatile organic compounds, and radon;
- Incidental ingestion of soil;
- Dermal contact with contaminants in soil; and
- External radiation exposure from radionuclides in soil.

9.2.2 Preliminary Remediation Levels

Tables 9-2 and 9-3 provide preliminary remediation levels for soil cleanup and the estimated risk to affected receptors from the residual contaminants left in the soils. Specific details on the development of these preliminary remediation levels are provided in the FS Report for Operable Unit 4.

As mentioned earlier, the future land use scenario for Operable Unit 4 will be as a government reserve with continued federal ownership. The on-property receptor of concern under this scenario will be an expanded trespasser. Cancer risks and chemical hazard to the expanded trespasser, from residual contaminants, are presented in Tables 9-2 and 9-3. For comparison, cancer risks and chemical hazard to an on-property farmer under a future land use scenario without federal ownership are also presented. Proposed remediation goals (PRGs), based on an ILCR of 10^{-6} and an HI of 0.2 were developed in the FS. These PRGs, presented in Tables 9-2 and 9-3 for the expanded trespasser, represent allowable incremental concentrations above background for these COCs based on targets of 10^{-6} incremental risk and hazard index of 0.2.

For radionuclide constituents of concern, the PRG was added to the background concentration to derive the preliminary remediation level. Based on the contaminant concentrations found in Operable Unit 4 soils, PRLs were not required for non-radionuclide contaminants as indicated in Table 9-3.

TABLE 9-2

PRELIMINARY REMEDIATION LEVELS IN SOILS - RADIONUCLIDES

Constituent of Concern	Expanded Trespasser 10^{-6} ILCR PRG pCi/g	Background (95th percentile) pCi/g	ARAR Target pCi/g	Max. Detected Soil Concentration, pCi/g		Proposed Remediation Level[a] pCi/g	ILCR above background to an Expanded Trespasser from Proposed Remediation Level[b]
				Surface	Subsurface		
Pb-210 +2 progeny	77	1.33	NA	4.5	101	78	1.0×10^{-6}
Ra-226 +5 progeny	0.37	1.45	5 (top 6" soil) 15 (max. below 6")	88	206	2	1.0×10^{-6}
Ra-228 +1 progeny	0.77	1.19	NA	0.48	1.24	2	1.0×10^{-6}
Sr-90 +1 progeny	1420	ND	NA	1.8	0.8	NR	$< 1 \times 10^{-6}$
Tc-99	38700	ND	NA	3.6	3.6	NR	$< 1 \times 10^{-6}$
Th-228	0.4	1.43	NA	2.9	1.3	2	1.0×10^{-6}
U-238 +2 progeny	59	1.22	NA	37	53	60	1.0×10^{-6}

Notes:
a) Sum of backround and PRG.
b) Includes the direct radiation, soil ingestion, and inhalation pathways.
NA Not Available
NR No Remediation Required

TABLE 9-3

PRELIMINARY REMEDIATION LEVELS IN SOILS - CHEMICALS

Constituent of Concern	Expanded Trespasser HI = 0.2 PRG mg/kg	Expanded Trespasser 10^{-6} ILCR PRG mg/kg	Background (95^{th} percentile) mg/kg	ARAR Target mg/kg	Max. Detected Soil Concentration, mg/kg		Proposed Remediation Levels mg/kg	HI to an Expanded Trespasser from Proposed Remediation Levels	Risk to an Expanded Trespasser from Proposed Remediation Level[a]
					Surface	Sub surface			
Antimony	31	N/A	7.7	NA	32	32	NR	0.2	N/A
Arsenic	510	23	8.45	NA	10	12	NR	N/A	$< 1x10^{-6}$
Barium	>10000	N/A	91.3	NA	112	142	NR	<.1	N/A
Cadmium	26	N/A	0.82	NA	6	7	NR	<.1	N/A
Chromium(III)	NA	N/A	15.5	NA	23	25	NR	<.1	N/A
Molybdenum	930	N/A	2.6	NA	25	30	NR	<.1	N/A
Nickel	8300	N/A	20.9	NA	39	39	NR	<.1	N/A
Silver	130	N/A	2.6	NA	10	18	NR	<.1	N/A
Thallium	31	N/A	0.58	NA	0.5	0.5	NR	<.1	N/A
Vanadium	1700	N/A	30.4	NA	28	33	NR	<.1	N/A
Zinc	>10000	N/A	62.2	NA	65	67	NR	<.1	N/A

Table 9-3
(Continued)

Constituent of Concern	Expanded Trespasser HI = 0.2 PRG mg/kg	Expanded Trespasser 10^{-6} ILCR PRG mg/kg	Background (95th percentile) mg/kg	ARAR Target mg/kg	Max. Detected Soil Concentration, mg/kg		Proposed Remediation Levels mg/kg	HI to an Expanded Trespasser from Proposed Remediation Levels	Risk to an Expanded Trespasser from Proposed Remediation Level[a]
					Surface	Sub surface			
Benzo(a)anthracene	NA	61	ND	NA	4.7	ND	NR	N/A	$<1x10^{-6}$
Benzo(a)pyrene	NA	8.8	ND	NA	5.2	ND	NR	N/A	$<1x10^{-6}$
Benzo(b)fluoranthene	NA	72	ND	NA	9.7	ND	NR	N/A	$<1x10^{-6}$
Chrysene	NA	2000	ND	NA	3.5	ND	NR	N/A	$<1x10^{-6}$
Dibenzo(a,h)anthracene	NA	7.9	ND	NA	0.9	ND	NR	N/A	$<1x10^{-6}$
Indeno(1,2,3-cd)pyrene	NA	32	ND	NA	4.2	ND	NR	N/A	$<1x10^{-6}$

[a]Includes the direct radiation, soil ingestion, and inhalation pathways.
NA = Not Available.
N/A = Not Applicable.
ND = Not Detected.
NR = No Remediation Required.

The clean-up levels presented in Tables 9-2 and 9-3 are preliminary. The development of final soil clean-up levels for Operable Unit 4 will be addressed in the Operable Unit 5 Record of Decision. These final clean-up levels will be consistent with the overall site approach for the development of soil clean-up levels as approved by the USEPA.

In those cases where a target concentration level specified by an ARAR is less than the proposed remedial level, the ARAR level was adopted as the remediation level. Remediation would be required for COCs that are present in the surface and subsurface soil at higher concentrations than the preliminary remediation level.

Based on the preliminary remediation levels, the COCs driving soil cleanup are Pb-210 and Ra-226. Soil remediation targeted at achieving the preliminary remediation levels for Pb-210 and Ra-226 will generate the largest volume of excavated soils.

9.3 MEASURES TO CONTROL ENVIRONMENTAL IMPACTS

All practical measures will be employed at the FEMP site to minimize environmental impacts during the implementation of the Operable Unit 4 Remedial Action. In accordance with DOE regulations for implementing the NEPA (10 CFR §1021), DOE has factored environmental impacts into the decision making process for the Operable Unit 4 Remedial Action.

Measures to control environmental impacts have been identified in the Operable Unit 4 FS/PP-DEIS and will be implemented during remedial design and remedial action to minimize impacts to on-property natural resources (e.g., wildlife and wildlife habitat, cultural resources, wetlands, surface water, groundwater). Operable Unit 4 remedial activities would not impact floodplain areas at the FEMP. The 100- and 500-year floodplain of Paddys Run is located near the silos and associated support facilities. Direct physical impact to the floodplain will not occur; however, the implementation of engineering controls will eliminate any indirect impact such as runoff and sediment deposition to the floodplain. Changes in flood elevation will not occur. The following provides a discussion of the measures that will be taken to minimize impacts to the environment on and adjacent to the FEMP Site.

Excavation activities and the construction and operation of the various support facilities (e.g., waste processing facility and storage facility) will result in the disturbance of 1.0 ha (2.5 acres) of terrestrial and managed field habitat and the potential for increased erosion and sediment loads to surface water i.e., Paddys Run. However, appropriate engineering controls such as silt fences, vegetative cover, and runoff control systems will be utilized to minimize runoff to Paddys Run and its associated aquatic habitat, including the state-threatened Sloan's crayfish (orconectes sloanii). In addition, appropriate High Efficiency Particulate Air (HEPA) filtration systems will be utilized during operation of the vitrification facility to minimize the potential for increased emissions to the ambient air and potential impacts to surrounding riparian habitat.

Groundwater, surface water, and air monitoring will be performed before, during, and after remedial activities. If adverse effects are detected in any of these environmental media, work will be immediately stopped until the effects are controlled and/or the appropriate response actions are executed.

The selected remedy for Operable Unit 4 includes the removal of the contaminated surface soil from the entire Operable Unit 4 Area and the replacement with clean fill material. Therefore, the primary residual contaminant would be uranium below the PRL in the subsurface soil. Because the contact of ecological receptors is limited (near background levels) to surface soil and surface waters, residual ecological risks associated with the Operable Unit 4 preferred alternative would be indistinguishable from those risks posed by background levels in the soil.

10.0 STATUTORY DETERMINATIONS

In accordance with the statutory requirements of Section 121 of CERCLA, as amended, remedial actions taken pursuant to Sections 104 and 106 must satisfy the following:

- Be protective of human health and the environment.
- Comply with all ARARs established under federal and state environmental laws (or justify a waiver).
- Be cost-effective.
- Utilize permanent solutions and alternative technologies or recovery technologies to the maximum extent practicable.
- Satisfy the statutory preference for remedies that utilize treatment and also significantly reduce the toxicity, mobility, and volume of the hazardous substances, pollutants, or contaminants.

In addition, CERCLA requires five year reviews to determine if adequate protection of human health and the environment is being maintained where remedial actions result in hazardous substances remaining on-site above health-based levels. A discussion is provided below on how the selected response actions for Operable Unit 4 satisfy these statutory requirements.

10.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy achieves the requirement of being protective of human health and the environment by: (1) removing the sources of contamination, (2) treating and stabilizing the materials giving rise to the principal threats from Operable Unit 4, (3) disposing of treated materials at an off-site location which provides the appropriate level of protectiveness, and (4) remediating contaminated soils and debris to levels which are protective. The contents of Silos 1, 2, and 3 and the Decant Sump Tank will be removed and treated through a vitrification process and disposed at the NTS. Vitrification will stabilize these materials and inhibit leaching of contaminants to the environment when they are disposed. All silo structures and other facilities will be removed from Operable Unit 4 and disposed of in a manner consistent with the forthcoming ROD for Operable Unit 3. Contaminated soil will also be removed and disposed in a manner consistent with the Operable Unit 5 ROD.

Baseline cancer risks from current conditions exceed the 10^{-4} to 10^{-6} acceptable risk range. Under current conditions, the dominant risk is 5×10^{-3} to the trespassing child. Under the future land use scenario of continued federal ownership and the expanded trespasser receptor, the residual cancer risk from Operable Unit 4 will be reduced to less than 1×10^{-6}. There are no short-term threats associated with the selected remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the remedy.

10.2 COMPLIANCE WITH LEGALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

In accordance with Section 121 of CERCLA, the selected remedy will achieve a standard or level of control consistent with all federal and State of Ohio ARARs and TBCs. The selected remedy will also be performed in accordance with all pertinent DOE Orders as well as other requirements. Appendix B provides a listing of the chemical-, action-, and location-specific ARARs and TBCs which are invoked by this remedy.

Removal, treatment by vitrification, and shipment for off-site disposal of silo material will be conducted in accordance with ARARs identified in this ROD. Disposition of rubble and debris from OU4 will be determined by the ROD for OU3, and will be conducted in accordance with the ARARs identified in that ROD; similarly, disposition of soils from OU4 will be determined by the ROD for OU5 and will be conducted in accordance with ARARs established in that ROD. Any interim storage of rubble and debris or soils, prior to final disposition under the RODs for OU3 and OU5, respectively, will be in accordance with ARARs identified in this OU4 ROD, pertinent DOE orders, and applicable site procedures.

Although RCRA is cited as an ARAR for remediation of Operable Unit 4, the silo residues destined for remediation are by-product material as defined under Section 11(e)(2) of the Atomic Energy Act of 1954, and as such, are excluded from RCRA regulation [40 CFR § 261.4(a)(4)]. By-product material, as defined by the AEA, includes tailings or wastes produced by the extraction or concentration of uranium and thorium from any ore processed primarily for its source material content (42 U.S.C. 2014).

Since the residues are excluded from regulation as solid or hazardous waste, the requirements under RCRA are not applicable to Operable Unit 4 remedial actions. However, analytical data from Silos 1, 2, and 3 material exceed toxicity characteristic levels for various toxicity characteristic metals under RCRA. Because the residues are sufficiently similar to hazardous waste regulated by RCRA and some RCRA requirements are appropriate for the circumstances of the release or potential release, certain substantive requirements of RCRA are relevant and appropriate for management of these residues, and are included in the table of ARARs.

10.3 COST EFFECTIVENESS

The selected remedial alternatives for each subunit have been determined to be protective of human health and the environment, and to be cost effective. The present worth cost for this remedy is 91.7 million dollars.

The off-site alternatives selected for the contents of Silos 1, 2, and 3 had a lower cost than the on-property disposal alternative for these materials. This is due to the fact that costs associated with construction of a facility that would provide the needed level of protection to human health and the environment from the silo contents would be greater due to the increased intruder protection requirements in the event of a trespasser. Also, the packaging and transportation costs associated with the vitrified material were lower than those for the cement stabilized material. Vitrification is more cost effective than cementation because the reduction in volume of vitrified product minimizes the amount of waste requiring handling, resulting in reduced transportation and disposal costs.

Conversely, transportation and disposal costs associated with disposing Operable Unit 4 soils and debris at NTS or a commercial facility are higher than the costs associated with construction of an engineered facility designed to manage the material on-property. Also, integration of the Operable Unit 4 disposal remedy for soils and debris with Operable Units 5 and 3 respectively, allows for economies of scale through treatment by processes developed for larger volumes of soil and debris.

10.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES OR RESOURCE RECOVERY TECHNOLOGIES TO THE MAXIMUM EXTENT PRACTICABLE

The EPA and the State of Ohio have determined that the selected remedy for Operable Unit 4 represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner. Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA, and the State of Ohio have determined that this selected remedy provides the best balance of tradeoffs among the alternatives in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, and volume through treatment, short-term effectiveness, implementability, and cost. The selected remedies also meet the statutory preference for treatment as a principal element, and meet state and community acceptance.

Vitrification and off-site disposal will provide permanent treatment and volume reduction for the silo contents. By physically binding the contaminants into a glass-like matrix, the mobility of the contaminants and the emanation of radon gas would be greatly reduced. Vitrification will also significantly reduce the leachability of metal contaminants of concern to levels that are below RCRA regulatory thresholds. Vitrification will destroy any organic contaminants in the waste material due to the operating temperature of the treatment process. In addition, the treated material would be less than 50 percent of its original volume. As a result, the selected remedy would meet the CERCLA requirement for permanent solutions that reduce the toxicity, mobility, or volume through treatment.

Part of the remedy selected for contaminated soils and debris may also involve treatment of the waste material prior to disposal. The soil and debris will be placed into interim storage pending finalization of the disposal decision for these wastes through the RODs for Operable Units 3 and 5. This allows for the implementation of any applicable resource recovery technologies for these wastes, which are developed and included in the RODs for these operable units.

10.5 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

By treating the contents of Silos 1, 2, and 3 in a vitrification process, and providing for treatment of contaminated debris and soils should treatment become the selected remedy for these wastes in the Operable Units 3 and 5 RODs, the selected remedy mitigates the principal threats posed by Operable Unit 4 through the use of treatment technologies. Therefore, the statutory preference for remedies that employ treatment as a principal element is satisfied.

10.6 UNAVOIDABLE ADVERSE IMPACTS

A number of unavoidable adverse impacts (Table 10-1) would occur when any of the action alternatives are implemented. As stated in the alternatives and in Table 10-1, many of these impacts would only be temporary. In addition, it should be noted that these impacts are presented for those remedial actions that will be implemented under the selected remedy. Those impacts associated with the final disposition of Subunit C material (soil and debris) will be identified and evaluated as part of the Records of Decision OUs 3 and 5.

TABLE 10-1

UNAVOIDABLE ADVERSE IMPACTS ON RESOURCES

Affected Resource	Impact Type
Soil and Geology	Soil at the FEMP site and the NTS would be disrupted by construction and excavation activities. Many impacts would be temporary, pending completion of remedial activities and restoration programs. The implementation of the selected remedy would temporarily disturb approximately 1.0 ha (2.5 acres) at the FEMP (e.g., excavation and construction). A permanent disruption of approximately 8 ha (20 acres) at the NTS would occur. All areas disturbed at the FEMP site would be regraded and revegetated. The regional geology of the FEMP site and surrounding area would not be affected by the selected remedy. Implementation of off-site disposal would not affect the regional geology of the NTS or surrounding areas.
Water Quality and Hydrology	Potential short-term impacts (e.g., release of sediment and fugitive dust) on water quality and hydrology would be minimal regrading and revegetation around the silos to minimize potential water quality impacts would occur. Assuming monitoring and maintenance activities continue at the NTS, no long-term impacts would be expected from waste disposal at the NTS.
Air Quality	Some temporary impacts to air quality at the FEMP site would result from fugitive dust emissions associated with construction and excavation activities (e.g., grading, compacting, loading). Lesser impacts would also be incurred from vehicle and equipment exhausts. These impacts are not expected to affect human health or the environment. No long-term impacts on air quality would be expected from activities associated with the selected remedy. Disturbed areas would be restored (e.g., regraded and revegetated) after completion of the remedial activities, thus minimizing the potential for the fugitive dust release. The off-site waste disposal facility would be designed to prohibit emission from stored waste. Only in the case of an accident during remedial actions would appreciable air quality impacts occur.
Biotic/Ecological Resources	Short-term disturbance of terrestrial, managed field, riparian and aquatic habitat would be expected. Approximately 1.0 ha (2.5 acres) of habitat at the FEMP site would be disturbed during excavation and construction activities. Habitat at the NTS is limited and it is believed little displacement of native species would occur.
Wetlands and Floodplains	Alternative 2C would not impact wetlands. Direct floodplain impacts resulting in a change of flood elevations would also not occur. Engineering controls would be implemented to minimize or eliminate indirect floodplain impacts. No wetlands or floodplains are present at the NTS.

TABLE 10-1
(Continued)

Affected Resource	Impact Type
Socioeconomics and Land Use	Minimal short-term impacts (e.g., increased traffic noise) to the socioeconomics and land use would occur. The long-term socioeconomic and land use impacts for the FEMP site would be positive because the waste would be isolated and controlled, thus no changes from current land use would be expected. Removing waste from the site would help to eliminate impacts on future populations and economic growth at the FEMP site. Disposal of this waste at the NTS would not be expected to impact socioeconomics or land use. Total present worth costs of the selected remedy is $91.7M. For this analysis, it is assumed that all resources required for remedial activities can be found within the thirteen county Consolidated Metropolitan Statistical Area (CMSA). The cumulative operating budget for the CMSA was approximately $805,000,000.00. The collectible revenue for the CMSA would increase up to approximately 11.4%.
Visual Resources	Construction and excavation activities would result in some minor incremental increases over the current visual and aesthetic impacts of the FEMP site. Short-term impacts would also be incurred at the NTS during construction, excavation, and transportation activities. The majority of impacts would be temporary and would cease following completion of remedial action activities and site restoration; however, aesthetic impacts would occur from the implementation of waste disposal facilities.
Noise	Ambient noise levels would temporarily increase as a result of construction, excavation, and transportation activities. All noise impacts would be temporary and would cease following completion of remedial activities.

10.7 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Implementing the selected remedy will result in permanent commitment of on-property land and associated natural resource services for material disposal at the FEMP site and off-site land at the NTS.

Soil at the FEMP site and the NTS will be disturbed by construction and excavation activities. Many impacts will be temporary, pending completion of remedial activities and restoration programs. The implementation of the selected remedy will temporarily disturb approximately 1.0 ha (2.5 acres) at the FEMP site. Furthermore, implementation of this remedy will permanently commit 8 ha (20 acres) at the NTS. All areas disturbed at the FEMP site will be regraded and revegetated.

Approximately 1.0 ha (2.5 acres) of habitat at the FEMP site will be disturbed during excavation and construction activities. Approximately 89 ha (220 acres) are expected to be permanently committed on a site-wide basis, with another twenty to thirty acres subject to temporary disturbances. It is assumed that processes such as revegetation and regrading are successful; however, the loss of habitat will result in a permanent displacement or loss of wildlife and associated services. Terrestrial habitat at the off-site disposal areas is limited, and little displacement of species is expected to occur.

Wetlands and associated natural resource services will not be injured by the selected remedy. Long-term direct impacts to the floodplain resulting in changes of flood elevations will not occur. Engineering controls would be implemented to minimize or eliminate any indirect impacts. There will be no impacts to wetlands or floodplains with disposal at the off-site disposal areas.

Consumptive use of geological resources (e.g., quarried rock, sand, and gravel) and petroleum products (e.g., diesel fuel and gasoline) will be required for removal, construction, and disposal activities of the selected remedy. Supplies of these materials will be provided by the construction contractor. Additional fuel use will result from off-site transport of the materials. However, adequate supplies are available without affecting local requirements for these products.

The treatment processes for the selected remedy will require the consumptive use of materials and energy. The vitrification process will be energy-intensive and require commitment of a considerable supply of electricity. Electricity can be obtained from the local utility.

Maintenance activities will be performed as necessary. Long-term environmental impacts would not be expected to occur from the Operable Unit 4 selected remedy. Monitoring and periodic site inspections would be performed to ensure long-term protection of human health and the environment.

11.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The FS/PP-DEIS for Operable Unit 4 was released for public comment in March 1994. The DOE reviewed all written and oral comments submitted during the public comment period. Upon review of these comments, it was determined that no significant changes to the remedy, as was originally identified in the FS/PP-DEIS, were necessary. However, it should be noted that the repromulgation of 40 CFR §191 by the EPA, did result in minor changes in the comparative analysis of alternatives presented in the FS/PP-DEIS. The following discussion addresses the nature and extent of these changes.

11.1 REPROMULGATION OF 40 CFR §191

Repromulgation of the 40 CFR §191 requirements for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Wastes has caused changes to be made to the ARARs as described in the Draft Final FS/PP-DEIS, conditionally approved by the EPA on February 9, 1994. DOE chooses not to submit revision pages to the FS/PP-DEIS; all changes to the ARARs for that document and any impacts from the repromulgation are discussed in this section of the ROD. Since the repromulgation resulted in relevant and appropriate, rather than applicable requirements, the repromulgation of 40 CFR §191 will not impact the proposed off-site alternative for disposition of the K-65 material. However, the on-property disposal alternatives (Alternatives 2A/Vit and 2A/Cem) that were previously retained, having passed the threshold criteria of the detailed analysis, are no longer able to meet the threshold criteria of compliance with ARARs, and are consequently dropped from further consideration. Subsequently, all references to Alternative 2A are therefore deleted from reference in the text of the ROD, and in Appendix A.

The only relevant and appropriate requirement from 40 CFR §191 that is retained as an ARAR in this ROD (Appendices A and B) for the proposed alternative is 40 CFR §191.03(b), which establishes dose limits for management and storage of the K-65 material. However, since this ARAR is relevant and appropriate, rather than applicable, it will pertain only to the on-property portions of the remedial activities conducted under this action.

11.1.1 Background

The United States Department of Energy - Fernald Field Office (DOE-FN) received conditional approval of the Draft Final FS/PP-DEIS for Operable Unit 4 from USEPA on February 9, 1994. Included in the FS/PP-DEIS applicable or relevant and appropriate requirements (ARARs) was a reference to 40 CFR

§191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Wastes". This reference to 40 CFR §191 was modified in the Operable Unit 4 FS/PP-DEIS, submitted in February 1994 in response to the conditional approval letter, to reflect the changes to the regulation that occurred upon its repromulgation on December 20, 1993. It still accommodates the specific direction previously provided by the USEPA regarding incorporation of the 40 CFR §191 requirements as an ARAR/TBC ("Operable Unit 4 Screening Dispute Resolution U.S. DOE Fernald", Catherine McCord, USEPA, to Andy Avel, DOE, dated October 18, 1990). The final rule became effective on January 19, 1994, during final revision of the Operable Unit 4 FS/PP-DEIS, and agency comments did not address the repromulgation of the rule. This fact was discussed with the USEPA, and a DOE position paper on the incorporation of 40 CFR §191 as an ARAR for Operable Unit 4 remediation was submitted to the USEPA for concurrence. The USEPA disagreed with the draft position proposed by DOE, and responded with a directive to incorporate the substantive elements of the repromulgated rule into the ROD, with an option to resubmit change pages to the FS/PP-DEIS ("Application of 40 CFR §191 to OU #4", Jim Saric, USEPA, to Jack Craig, DOE, dated April 25, 1994). DOE elected not to revise the FS/PP-DEIS, but rather to describe in this section of the ROD changes to the table of ARARs and associated impacts on selection or implementation of remedial alternatives that have occurred between the time the Draft Final FS/PP-DEIS was conditionally approved, and the submittal of the ROD to the USEPA and OEPA. The list of ARARs in the ROD, and proposed approach to compliance with the substantive elements thereof, once approval by the USEPA is obtained, will be the final approved list of applicable or relevant and appropriate requirements for final remediation of Operable Unit 4.

11.1.2 Impacts of Repromulgation

Since 40 CFR §191 cannot be considered a legally "applicable" class of ARAR for this CERCLA remediation, §191 is not applicable to any Operable Unit 4 waste streams. Since compliance with only applicable requirements is required to be demonstrated for off-site remedial alternatives proposed under CERCLA, these requirements will not impact the proposed off-site alternative for disposal of the treated K-65 material at the NTS.

DOE previously included 40 CFR §191 Subpart A as a relevant and appropriate requirement, and Subpart B as to be considered (TBC) criteria for management of K-65 material in accordance with guidance received from the USEPA. Subpart A of §191, entitled "Environmental Standards for Management and Storage" includes public dose rate standards for protection of the public from radiation hazards posed by spent nuclear fuel, high-level, or transuranic waste material. The repromulgation of the Final Rule did not materially affect the sections of Subpart A referenced in the Operable Unit 4 FS/PP-DEIS; the Subpart A requirement referenced in the Operable Unit 4 FS/PP-DEIS remains unchanged in the table of ARARs as a relevant and appropriate requirement for the on-property portion of the remedial activities to be conducted on the K-65 material.

Prior to repromulgation, Subpart B requirements were in remand, and were therefore considered TBCs in the FS/PP-DEIS submitted to the agencies. Since Subpart B of §191, entitled "Environmental Standards for Disposal", has been repromulgated, the USEPA has directed that sections must now be considered as relevant and appropriate requirements for any on-property disposal alternatives. Since it could not be demonstrated that the on-property disposal of treated K-65 material would comply with specific requirements of this Subpart, those alternatives involving on-property disposal (Alternatives 2A/Vit and 2A/Cem) were no longer able to meet the threshold criteria of compliance with these ARARs, and were consequently dropped from further consideration. All descriptions to Alternative 2A are therefore deleted from reference in the text of the ROD, and in Appendix A.

A new Subpart C of §191 "Environmental Standards for Groundwater Protection", was created by the repromulgated rule. As with Subpart B, this new Subpart pertains only to disposal systems. The elements of this Subpart must now be considered as relevant and appropriate requirements; however, since the on-property disposal alternatives to which this Subpart pertains were dropped from further consideration on the basis of non-compliance with Subpart B requirements, and since Subpart C will not pertain to any off-site disposal alternatives, these requirements will not be included in the Appendix A or B tables of ARARs. Subpart C will therefore have no effect on the selected alternative, which includes off-site disposal.

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REFERENCES

International Agency for Research on Cancer (IARC), 1987, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Vol. 1 to 42. Preamble. Supplement 7. World Health Organization: Lyon, France, pp. 17-34.

National Council on Radiation Protection and Measurements, 1991, "Effects of Ionizing Radiation on Aquatic Organisms, "NCRP Report No. 109, NCRP, Bethesda, MD.

U.S. Army Corps of Engineers, 1987, "Wetlands Delineation Manual".

U.S. Dept. of Energy, 1992, "Risk Assessment Work Plan Addendum, "Final Draft, FEMP, Remedial Investigation and Feasibility Study, DOE, Fernald Field Office, Fernald, OH.

U.S. Dept. of Energy, 1993a, "Remedial Investigation Report for Operable Unit 4, "U.S. Department of Energy, Fernald Field Office, November 1993.

U.S. Dept. of Energy, 1993b, Site-Wide Characterization Report FEMP, Fernald, OH, Remedial Investigation and Feasibility Study, Draft, DOE, Fernald Field Office, Fernald, OH, March 1993.

U.S. Dept. of Energy, 1994, "Feasibility Study Report for Operable Unit 4, "U.S. Dept. of Energy, Fernald Field Office, February 1994.

U.S. Dept. of Energy, 1994, "Proposed Plan for Remedial Actions at Operable Unit 4, "U.S. Dept. of Energy, Fernald Field Office, February 1994.

U.S. Environmental Protection Agency (EPA), 1986, Guidelines for Carcinogen Risk Assessment. Federal Register 51(185) pp. 33992-34003.

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

U.S. Environmental Protection Agency (EPA), 1989b, "Guidance on Preparing Superfund Decision Documents: The Proposed Plan, the Record of Decision, Explanation of Significant Differences, the Record of Decision Amendment," Interim Final, EPA/540/G-89/007, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1992a Integrated Risk Information System (IRIS), on-line data service. EPA, Washington, DC.

U.S. Environmental Protection Agency, 1992b Health Effects Assessment Summary Tables, Annual Update FY 1992, including Supplement A, July 1992, OERR 9200.6-303 (92-1)

U.S. Environmental Protection Agency (EPA), 1992c, "Community Relations in Superfund: A Handbook," EPA/540/R-92/009, EPA, Office of Emergency and Remedial Response, Washington, D.C.

Volf, M.B. 1984, "Chemical Approach to Glass (Glass Science and Technology: Vol. 7)," Elsevier, New York.